University Hospitals of Leicester NHS
NHS Trust

Cardiology Guidelines

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UHL CARDIOLOGY GUIDELINES

UHL Guideline C268/2016.

University Hospitals of Leicester NHS
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1. Introduction and Who Guideline applies to

This guideline is intended to assist staff in the management of the common cardiac conditions likely to be encountered in an acute hospital setting.

2. Guideline Standards and Procedures

This guideline is based on the recommendations of National Cardiac Societies, NICE guidance and local best practice as recommended by senior cardiology consultants.

3. Education and Training

None.

4. Supporting References

References are included at the end of the text.

5. Key Words

Cardiology, STEMI, NSTEMI, atrial fibrillation, heart failure, arrhythmias, valvular heart disease, cardiac.

CONTACT AND REVIEW DETAILS	
Guideline Lead (Name and Title) Dr Ian Hudson (Consultant Cardiologist)	**Executive Lead** Suzanne Khalid
Details of Changes made during review: Various sections updated and brought into line with standardised UHL format. All web links verified as safe and valid.	

CONTENTS

ACKNOWLEDGEMENTS

A number of individuals have contributed over many years to the development of this guideline. In this latest edition there have been new contributions from Dr Elved Roberts in structural interventions. Dr Sandilands, Stafford and Somani assisted in reviewing the arrhythmia section and review of the DOACs. Dr Nicolson updated the device sections. Professor Gerry McCann advised on imaging guidelines. Dr Loke and Professor Squire reviewed the heart failure guidelines, Dr Stanley hypertension management. The ACHD section was written by Dr Simon MacDonald. Special thanks must go to the various cardiology consultants, registrars, cardiac services and CCU staff.

Guideline is the important word, as this booklet is not intended to be the definitive text of the management of cardiac patients. It is simply meant to guide medical and nursing staff in the management of acute cardiac problems presenting to the cardiology wards or medical admissions units. The guidelines should also assist more widely across the trust in other disciplines.

If anyone using this guideline has any suggestions for additions, improvements or have identified errors, then please let me know.

Most of the text is based on information gathered from published guidelines from sources such as the various British societies, ESC, ACC/AHA, NICE and UpToDate®.

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Resuscitation Council (UK) for permission to reproduce the Advanced Life Support algorithms.

IH
November 2018

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DISCLAIMER

Medical knowledge is constantly changing. The author has, as far as it is possible, taken care to ensure that the information given in this text is accurate and up to date. However, readers are strongly advised to confirm that the information, especially with regard to drug usage, complies with current legislation and standards of practice.

USEFUL LINKS

Coronary Disease

ESC 2017 Guidelines on the management of STEMI:
https://www.escardio.org/Guidelines/Clinical-Practice-Guidelines/Acute-Myocardial-Infarction-in-patients-presenting-with-ST-segment-elevation-Ma
AHA/ACC 2013 Guidelines on the management of STEMI:
http://circ.ahajournals.org/content/127/4/e362.full.pdf+html
ESC 2015 Guidelines on the management of NSTEMI:
https://www.escardio.org/Guidelines/Clinical-Practice-Guidelines/Acute-Coronary-Syndromes-ACS-in-patients-presenting-without-persistent-ST-segm
AHA/ACC 2014 Guidelines on the management of NSTEMI:
http://circ.ahajournals.org/content/130/25/2354.full.pdf+html
ESC 2013 Guidelines on the management of stable coronary disease:
https://www.escardio.org/Guidelines/Clinical-Practice-Guidelines/Stable-Coronary-Artery-Disease-Management-of
AHA/ACC 2013 Guidelines on the management of stable coronary disease:
http://circ.ahajournals.org/content/126/25/e354.full.pdf+html
ESC 2014 Guidelines on revascularisation:
http://eurheartj.oxfordjournals.org/content/ehj/35/37/2541.full.pdf
NICE 2017 Lipid Modification Quality Standard:
https://www.nice.org.uk/guidance/qs100
NICE 2013 Management of STEMI:
http://www.nice.org.uk/guidance/cg167
NICE 2010 Guidance on chest pain of recent onset:
http://www.nice.org.uk/guidance/cg95
NICE 2013 secondary prevention guidance:
http://www.nice.org.uk/guidance/cg172
British Association of cardiac rehabilitation standards 2012:
http://www.bacpr.com/resources/46C_BACPR_Standards_and_Core_Components_2012.pdf

Arrhythmias and Heart failure

ESC 2013 Guidelines on cardiac pacing and resynchronisation therapy:
https://www.escardio.org/Guidelines/Clinical-Practice-Guidelines/Cardiac-Pacing-and-Cardiac-Resynchronization-Therapy
ESC 2016 Guidelines on acute and chronic heart failure:
https://www.escardio.org/Guidelines/Clinical-Practice-Guidelines/Acute-and-Chronic-Heart-Failure
ACCF/AHA 2013 guidelines on heart failure:
http://circ.ahajournals.org/content/128/16/e240
ESC 2016 guideline on the management of atrial fibrillation:
https://www.escardio.org/Guidelines/Clinical-Practice-Guidelines/Atrial-Fibrillation-Management
AHA/ACC 2014 Guidelines on the management of atrial fibrillation 2014:
http://circ.ahajournals.org/content/130/23/e199.full.pdf+html

Hypertrophic cardiomyopathy

ESC 2014 Guideline for hypertrophic cardiomyopathy:

https://www.escardio.org/Guidelines/Clinical-Practice-Guidelines/Hypertrophic-Cardiomyopathy
ESC risk calculator for device therapy in HOCM:
http://www.doc2do.com/hcm/webHCM.html

Hypertension

ESC 2013 Guidelines on the management of hypertension:
https://www.escardio.org/Guidelines/Clinical-Practice-Guidelines/Arterial-Hypertension-Management-of
NICE/BSH 2011 guideline on the management of hypertension:
https://www.nice.org.uk/guidance/cg127

Pulmonary embolism

ESC 2014 Guidelines for the diagnosis and management of pulmonary embolism:
https://www.escardio.org/Guidelines/Clinical-Practice-Guidelines/Acute-Pulmonary-Embolism-Diagnosis-and-Management-of

Valvular Heart Disease

ESC 2017 Guidelines for valvular heart disease:
https://www.escardio.org/Guidelines/Clinical-Practice-Guidelines/Valvular-Heart-Disease-Management-of

Non-cardiac surgery

ESC 2014 Guidelines for the management of patients undergoing non-cardiac surgery:
https://www.escardio.org/Guidelines/Clinical-Practice-Guidelines/ESC-ESA-Guidelines-on-non-cardiac-surgery-cardiovascular-assessment-and-managem
AHA/ACC 2014 Guidelines for the management of patients undergoing non-cardiac surgery:
http://circ.ahajournals.org/content/116/17/1971.full.pdf

Syncope

ESC 2018 Guidelines on the diagnosis and management of syncope:
https://www.escardio.org/Guidelines/Clinical-Practice-Guidelines/Syncope-Guidelines-on-Diagnosis-and-Management-of

Driving and flying and cardiovascular disorders

DVLA Guidance:
www.dft.gov.uk/dvla/medical/ataglance.aspx
CAA guidance on assessing fitness to fly:
http://www.caa.co.uk/Passengers/Before-you-fly/Am-I-fit-to-fly/Guidance-for-health-professionals/Assessing-fitness-to-fly/
Investigation of pilots with cardiovascular disease:
http://www.caa.co.uk/Aeromedical-Examiners/Medical-standards/Pilots-(EASA)/Conditions/Cardiology/Cardiovascular-system-general/
BCS Fitness to fly for passengers with cardiovascular disease:
https://www.bcs.com/documents/BCS_FITNESS_TO_FLY_REPORT.pdf

Contacts for UK cardiologists and cardiac units (requires free registration):

http://www.cardiodirectory.co.uk/

Useful cardiology websites

British Cardiovascular Society:
http://www.bcs.com/pages/default.asp
British Cardiovascular Intervention Society:
http://www.bcis.org.uk/pages/default.asp
British Society for Heart Failure:
http://www.bsh.org.uk/
British Hypertension Society:
http://www.bhsoc.org/
British Heart Rhythm Society:
http://www.bhrs.com/
British Society of Echocardiography:
http://www.bsecho.org/home/
British Society of Cardiovascular Magnetic Resonance:
http://www.bscmr.org/
British Society of Cardiovascular Imaging:
http://www.bsci.org.uk/
British Heart Foundation:
https://www.bhf.org.uk
British Association for Nursing in Cardiovascular Care:
http://www.bancc.org/pages/default.asp
British Association for Cardiovascular Prevention and Rehabilitation:
http://www.bacpr.com/pages/default.asp
European Society of Cardiology:
http://www.escardio.org/Pages/index.aspx
American College of Cardiology:
http://www.acc.org/
American Heart association:
http://www.heart.org/HEARTORG/

BNF

https://www.medicinescomplete.com/mc/bnf/current/

Cardiovascular Calculators

Syntax Score calculator:
http://www.syntaxscore.com/calculator/start.htm
EuroSCORE II calculator:
http://www.euroscore.org/calc.html
Mehran risk score for CIN:
http://www.renalguard.com/educational/contrast-induced-nephropathy-risk-calculator
Grace risk score:
http://gracescore.org/WebSite/WebVersion.aspx
TIMI Risk score:
http://www.timi.org/index.php?page=calculators.
CRUSADE Bleeding score:
http://www.crusadebleedingscore.org
CHA_2DS_2 - VASc Score:
http://clincalc.com/cardiology/stroke/chadsvasc.aspx
HAS-Bled score:
http://clincalc.com/cardiology/anticoagulation/hasbled.aspx
Creatinine clearance calculator:

http://clincalc.com/Kinetics/CrCl.aspx
DAPT Risk calculator:
http://www.acc.org/tools-and-practice-support/mobile-resources/features/dapt-risk-calculator
Precise DAPT:
http://www.precisedaptscore.com/predapt/
HCM sudden cardiac death risk calculator:
http://www.doc2do.com/hcm/webHCM.html
General cardiovascular risk calculators:
https://qrisk.org/2017/
http://www.jbs3risk.com/JBS3Risk.swf
Wells criteria for DVT:
http://reference.medscape.com/calculator/dvt-probability-wells-score
Corrected QT interval (QTc):
http://reference.medscape.com/calculator/qt-interval-correction-ekg
BMI calculator:
http://www.medical-calculators.co.uk/bmi_met.html
Weight conversion calculator:
http://www.stonetokg.co.uk/
Height conversion calculator:
http://www.simetric.co.uk/feet_to_metres.php
SI unit conversion calculator:
http://www.soc-bdr.org/rds/authors/unit_tables_conversions_and_genetic_dictionaries/e5196/index_en.html

All of these links have been verified as safe and active at the time of publication.

CCU ISSUES

Patients of all ages may be admitted to the Coronary Care Unit with suspected or proven acute myocardial infarction, unstable angina or serious conduction defects/cardiac arrhythmias, if regarded as suitable for intensive medical management.

Patients may be admitted directly via paramedic crews, the Emergency Department or other wards. The designated CCU medical team should see patients without delay.

Suspected myocardial infarction patients contacting the 999 service in Leicester will be seen by the paramedic service who will record a 12 lead ECG at the patient's location. If the ECG reveals acute infarction or ischaemia the paramedic crew will arrange direct admission to CCU. In the case of ST-elevation myocardial infarction (STEMI), a pre-alert will be broadcast to the CCU team and catheter labs.

Eligible patients for admission to the CCU may include but not be limited to:

- Patients with STEMI
- Patients with moderate or high-risk acute coronary syndromes (dynamic ECG changes, haemodynamic instability or significantly elevated Troponin I)
- Patients after cardiac arrest (will need HDU/ITU if requiring respiratory support)
- Cardiogenic shock or severe heart failure requiring inotropic support
- Complex cardiac arrhythmias (especially those associated with major symptoms and/or haemodynamic compromise)
- Patients requiring temporary pacing
- Patients receiving medication and/or treatments requiring continuous cardiac monitoring including inotropic and ***antiarrhythmic*** agents
- Patients with aortic dissection
- Patients with hypertensive emergencies
- Patients with cardiac tamponade
- Patients following complex procedures (TAVI, complex ablation, complicated PCI)

Acute myocardial infarction or unstable angina should be considered in all patients with chest pain admitted to the various admissions units. The ECG should be repeated and reviewed several times within one hour of admission and as appropriate thereafter. If patients develop signs of ischaemia or infarction on the ECG they should be transferred to the CCU. Patients identified as having a STEMI should, after confirmation with CCU, have a 'STEMI alert' put out via switchboard to alert relevant personnel.

Consultant responsibility on CCU is arranged on a rotational scheme. SpR cover is readily available. Patients should be seen first thing each morning and reassessed later in the day. It is appropriate for most patients to be discharged to the wards within 24 to 48 hours. In the case of bed shortages, the SpR or consultant should prioritise discharges. A decision should also be made as to the appropriate

destination of the patient following discharge from CCU. Any patient inappropriately placed on CCU should be transferred out as quickly as possible.

It is important that a CCU bed is always free to take an admission without delay. In the case of bed shortages the unit should liaise with both medical staff and bed managers in order to maintain CCU bed availability. Forward planning is important as only in exceptional circumstances should patients be transferred after 22:00hrs.

It is the responsibility of the CCU team to clerk all admissions. If there is ever uncertainty, ASK FOR HELP. The covering SpR should always be advised of new admissions immediately. Investigations should be performed as listed later. Clerking should be done employing the yellow CCU proforma even if patients have already been clerked elsewhere. **All patients require a DVT assessment** to be made. Please ensure this has been done.

The yellow clerking sheets should be filled in even when patients are transferred from other wards as the design allows quicker assessment of pertinent issues such as risk factor profile and previous cardiac events. The yellow sheets are multidisciplinary and so nursing and medical staff document relevant issues in them for improved communication.

Ward rounds take place first thing each morning and generally again later in the day. It is essential that a full hand-over is performed every day to the next doctor on duty for the unit. Discharging patients should generally be on the advice of the SpR or consultant. The receiving team should be informed as soon as possible. Electronic discharge summaries (EDS) must be done for all patients being discharged home and also when being transferred to other units (both internal and external).

There is a registrar or speciality doctor responsible, with the CDU consultant, to review all cardiology patients on CDU. This includes patients who have already been ‘accepted for cardiology admission’ as their status may have changed and they may be fit for discharge. It should not be confined to new referrals only.

It should be remembered that not all patients in CCU end up having a primary cardiac diagnosis. The differential diagnosis of the patient with chest pain includes:

- Pulmonary embolism
- Pneumonia
- COPD
- Cholecystitis/biliary colic
- Renal colic
- Pancreatitis
- Peptic ulcer disease
- Oesophagitis
- Pneumothorax
- Musculoskeletal pain
- Aortic aneurysm
- Aortic dissection

In addition, there are CARDIAC AND NON-CARDIAC conditions which may present with ST changes and raised ***Troponin I*** levels (see page 46).

REGISTRAR ISSUES

When accepting patients from other units it is important that the transfer is appropriate and, if there is any doubt, the relevant consultant should be contacted by the SpR. For patients with major co-morbidities it is mandatory that they are discussed at the highest level.

If imaging has been performed by the referring unit (angiography, echo, TOE) every effort should be made to have the images sent with the patient or urgent transfer arranged to avoid unnecessary duplication and delays in Glenfield.

Out of hours, when there is a STEMI alert, the SpR must take personal responsibility to ensure ALL staff have been notified and are on their way in. The STEMI alert is internal only, and the bleeps are not carried by all staff including the cardiac catheter team and consultant.

In clinics do not simply bring patients back for follow up unless clinically indicated. This is a recurring issue and clogs up clinics with stable asymptomatic patients.

Do not routinely list patients with possible ACS for angiography, especially if there is no ***TnI*** rise and the ECGs are normal. Imaging may be appropriate but on an outpatient basis rather than urgent inpatient basis. If there is any doubt, they should be discussed with an interventional cardiologist. When listing ensure issues like vascular access are evaluated and the patient's ability to lie flat is established. Out of hours decisions regarding listing for angiography may be best deferred if unclear; it is harder to tell a patient later that they do not need an angiogram when they have previously been told they do.

WARD ISSUES

It is the responsibility of the ward based doctors to ensure all patients are seen on at least a daily basis. Senior review should be sought on all new admissions within hours of admission and certainly on the same day. A management plan should be made as soon as possible. Do not leave messages with secretaries etc to get a review, speak to the SpR or consultant directly. Financial penalties are incurred if patients' length of stay is prolonged and so it is in everyone's interests (not least the patient) to ensure discharge as soon as safe to do so. If patients are only staying in waiting for investigations that are not going to directly impact on their inpatient management, they should be considered for discharge for the test to be done as an outpatient.

For patients admitted overnight from other centres it is mandatory for them to be clerked and a drug chart written.

All patients require a DVT assessment to be made. Please ensure this has been done. DNAR forms need to completed as appropriate.

A recurring theme across the unit is a delay in discharge summaries being written and is a regular cause for complaints and patient and family dissatisfaction. TTOs should be done as soon as possible and when requested to do so. Making drafts in advance saves time. **Please ensure summaries are copied to referring hospitals in the case of patients transferred in from other units**. Ensure duration of medication is documented (e.g. 12 months ***clopidogrel*** or ***ticagrelor*** or ***prasugrel*** after PPCI). Note that pharmacy closes at 6pm and so TTOs should be done as early as possible to facilitate discharge. Accuracy is clearly mandatory in discharge letters and these are audited on a regular basis. Death summaries should be written for patients who die so the GP has some understanding of the admission and final outcome.

Attention should be given to day case patients where prompt discharge is crucial to allow day case lists to run smoothly. If morning patients are not discharged promptly it delays the afternoon lists. There are occasions when planned day case patients have to stay overnight. Please check and ensure a drug chart is written for them. Make it your business to know when your consultant has day case procedures happening and ensure you get involved in their care. Visiting cardiologists utilise beds on day ward for their day cases. Please help by assisting with the production of the EDS. Traditionally visiting consultants are paired with an in house cardiologist and so their juniors will be the first port of call. Dr Gill and Dr Martos-Martinez paired with Professor Gershlick. These pairings are not set in stone and if you are available to help – please do so. New consultants in other hospitals may have sessions here during the lifetime of this guideline, new pairings will be arranged. Adult congenital patients may be admitted into your ward base. These are your responsibility under the supervision of the adult congenital cardiologist.

Care should be taken to ensure drug histories are accurate and drug charts completed to the standard expected. These are also audited on a regular basis. A common failing is documenting the reason for the prescription. Antibiotic prescriptions are frequently below the standard required so please ensure familiarity with what is expected by accessing the antimicrobial website on Insite. During the lifetime of this guideline electronic prescribing (ePMA) may be widespread across all three hospital sites.

ACS (suspected and confirmed) patients transferred from CDU often have only one or two ECGs done. Ensure these are repeated as appropriate. Many will not have had lipids or glucose checked – ensure they are done. In patients who require procedures, consent must be obtained before listing them on ICE. Consent is the responsibility of the SpR or consultant. For patients undergoing PCI a 'group and save' should be considered for selected patients.

Patients who are referred for surgery should be discussed at a senior level. Referrals are done by a 'blue form' or 'pink form' referral system. This should become an ICE referral in due course. This should not replace discussion at SpR or consultant level with the cardiac surgeons. Consider whether additional investigations or treatment are needed prior to referral such as carotid Dopplers in those with bruits or a prior history of stroke, and dental assessments in those who require valve surgery (if they have teeth). Patients will need cross matching prior to surgery. ***Antiplatelets*** (especially ***ticagrelor***) may need stopping - so check.

Regular audits take place and we encourage juniors to get involved. Some are mandatory (documentation audits, prescribing audits, discharge letter audits) and your contribution is crucial.

Please be aware of infection control issues and familiarise yourself with hospital policy. Comply with hand washing recommendations and the absence of clothing and watches below elbow level.

1	BEFORE TOUCHING A PATIENT	WHEN?	Clean your hands before touching a patient when approaching him/her.
		WHY?	To protect the patient against harmful germs carried on your hands.
2	BEFORE CLEAN/ ASEPTIC PROCEDURE	WHEN?	Clean your hands immediately before performing a clean/aseptic procedure.
		WHY?	To protect the patient against harmful germs, including the patient's own, from entering his/her body.
3	AFTER BODY FLUID EXPOSURE RISK	WHEN?	Clean your hands immediately after an exposure risk to body fluids (and after glove removal).
		WHY?	To protect yourself and the health-care environment from harmful patient germs.
4	AFTER TOUCHING A PATIENT	WHEN?	Clean your hands after touching a patient and her/his immediate surroundings, when leaving the patient's side.
		WHY?	To protect yourself and the health-care environment from harmful patient germs.
5	AFTER TOUCHING PATIENT SURROUNDINGS	WHEN?	Clean your hands after touching any object or furniture in the patient's immediate surroundings, when leaving – even if the patient has not been touched.
		WHY?	To protect yourself and the health-care environment from harmful patient germs.

OUTPATIENT CONSIDERATIONS

Outpatients can be daunting for the inexperienced and attempts should be made to sit in on clinics with an experienced doctor before being thrown in at the deep end.

An awareness of the time allocated to appointments is crucial to try and keep a clinic running to time. Focus should be on the cardiac issue being addressed. That does not mean that a holistic approach is wrong, it means that your responsibility is to deal with the cardiac problem. Patients should be encouraged to discuss non-cardiac issues with their GP, and issues of concern can be addressed in the correspondence. Referrals to other specialities should be discussed with the consultant in charge of the clinic as this can result in financial penalties.

If tests need requesting, request them. Do not ask the GP to do them. As with inpatients, only request a test if it is going to alter the management of the patient. Some investigations (especially echo) are requested when the indication is unclear. Please be aware of the indications for follow up echoes outlined elsewhere in this guideline. Do not request in-house echoes if the patient has had a recent community echo with InHealth as these scans can be viewed online.

For patients presenting with chest pain, a baseline chest X-ray is usually warranted - but check on PACS or iCRIS whether this been one done recently. A recent chest X-ray is mandatory when requesting perfusion scans. Avoid unnecessary X-rays and be aware of previous and potential future radiation exposure. The same applies for any investigation involving radiation exposure.

The Trust has previously been 'fined' for following patients up. The commissioning process for outpatient activity is currently under review. If a new referral is unlikely to have significant pathology, it is reasonable to send the results to the patient and the GP following their initial appointment rather than bringing them back for review (i.e. formally identify a VIRTUAL follow-up). If patients are stable, symptom-free, and have received definitive treatment, consideration should be given to discharge back to the GP with instructions in the correspondence as to the indications for re-referral. If in doubt, check with the consultant.

Do not arrange outpatient follow up for inpatients unless the consultant requests you to do so.

Cardiac specialist nurses may well ask for advice regarding patients seen in the rapid access clinic. Please ensure that they are seen promptly and courteously.

THE CARDIOLOGISTS

All of Glenfield's consultant adult cardiologists see patients with any cardiac condition, but they all have sub-speciality interests.

The interventional cardiologists are those who provide the angioplasty service and structural programme * (TAVI, valvuloplasties, ASD closures). The team comprises of Professor Tony Gershlick, Professor Jan Kovac *, Dr Ian Hudson, Dr Shazia Hussain, Dr Andrew Ladwiniec, Dr David Adlam * and Dr Elved Roberts *. Professor Gershlick and Dr Ladwiniec sub-specialise in treating chronically occluded arteries (CTOs).

The electrophysiologists (arrhythmia experts) are Dr Peter Stafford, Professor Andre Ng, Dr Alastair Sandilands and Dr Riyaz Somani.

The device team (pacemakers, defibrillators) comprise Dr Ravi Pathmanathan, Dr Ian Loke, Dr Will Nicolson and Dr Rajesh Chelliah. Dr Loke and Dr Nicolson are also members of the heart failure team along with Professor Iain Squire. Professor Gerry McCann leads the cardiac MRI service. Dr Jeffrey Khoo is an imaging expert. Dr Khoo and Dr Chelliah provide the stress echo service and also the TOE service alongside Dr Sharaf. Dr Adrian Stanley specialises in hypertension and is education lead for the unit.

Dr Aidan Bolger, Dr Frances Bu'Lock and Dr Simon MacDonald are the adult congenital specialists.

Dr Martin Behounek, Dr Rajesh Chelliah and Dr Hala Sharaf are the cardiology consultants for CDU.

CARDIOLOGY TESTS & IMAGING

Most cardiac investigations can be requested using the appropriate request forms. Increasingly requests are being made electronically via ICE. Requests for more complex tests (stress echocardiography, transoesophageal echocardiography, cardiac CT or MRI and coronary angiography) must be made via one of the consultant cardiologists or SpRs. Currently all isotope perfusion requests and CMR requests are consultant ONLY. For all investigations the clinical information is of crucial importance and should be detailed and accurate. If there is a doubt as to which test may be the most appropriate (especially in imaging) ask the imaging consultants for advice. Results for all cardiac investigations other than 12 lead ECG are posted on iCRIS (available via Insite). It is sensible and time saving to have the shortcut to iCRIS on your desktop log in page. Results should also be available on ICE.

It is worth emphasising that before requesting any tests it is worthwhile ensuring that these have not been performed before by checking on iCRIS or ICE. This is particularly true for imaging and functional studies which are expensive and not infrequently involve exposure to radiation (MPS, CT etc). If a previous test has been indeterminate or a false positive, there is no point in repeating it. For instance some patients have poor echo windows and so alternative imaging may be more appropriate. In addition, some patients have had a previous MPS showing apparent inferior ischaemia but have then gone on to have a normal coronary angiogram.

It is also worth stating that it is helpful to discuss any test with an imaging consultant if it is particularly urgent, there is a specific question to be answered or it lies outside the guidelines.

Electrocardiography

Most ECGs can be done by the cardiology nursing staff.

Chest X-Ray

A chest X-ray can exclude pulmonary oedema and may uncover non-cardiac causes of chest pain. Should be considered on all acute admissions.

24 - 48hr ECG Monitoring

Inpatients that require ECG monitoring are usually more appropriately assessed with telemetry or continuous monitoring on the CCU or wards. Please determine whether an inpatient 24hr ECG is considered essential before requesting. Three electrodes are applied attached to a small recorder. It is a useful investigation for frequent symptoms of palpitations and for assessing rate control for specific arrhythmias such as atrial fibrillation or flutter. A request for inpatients is via ICE. For outpatients, requests should be sent (via the generic form) to cardiac investigations.

More Prolonged ECG Monitoring

This is an outpatient investigation which should be reserved for patients who have more intermittent symptoms suspected to be due to arrhythmia. A cardiac Looper (SpiderFlash) involves attachment of electrodes. It is a patient activated recording device operated by the simple press of a button. There is a programmable recording time pre and post button activation allowing the onset of the event to be recorded. It is well suited for patients with rare brief symptoms or loss of consciousness as the device can be activated on regaining awareness. It is not suitable for patients with

sensitive skin because the electrodes are attached for prolonged periods. It is usually issued for 1-2 weeks. An automatic loop recorder is similar but with an additional automatic recording facility suitable for asymptomatic patients with suspected arrhythmias. Tape requests for inpatients are via ICE.

A cardiac memo recorder involves no electrodes. It is a patient activated device that is applied to the chest at time of symptoms. It records 1 or 2 channels of ECG. The memo only stores events after patient activation so is not suitable for short lasting symptoms. It requires a level of patient understanding and co-operation. A memo is usually issued for 1 week.

In patients with recurrent palpitations, particularly associated with pre-syncope or syncope, an implanted Looper recorder (ILR) should be considered. Referral can be made using the device referral forms.

Tilt Studies

Requests are sent to the respiratory department at GGH (orange form). A useful investigation for recurrent syncope (see page 117). Ensure patients do not have significant carotid disease.

24hr Blood Pressure Monitoring

This can be a useful investigation for assessing patients with uncontrolled hypertension, highly variable BP readings or where you suspect the patient is over-treated. It is not indicated on an inpatient basis. Referral is to the Respiratory Physiology Department (white form, blue print). Remember to fill in whether the patient is an infection risk or requests will be returned.

Treadmill Testing

Inpatient treadmill testing is available for potentially ‘at risk’ patients who require risk stratification before discharge. Requests for an inpatient ETT must be discussed personally with a cardiac technician and medical cover must be arranged. Early post-infarct stress tests are usually limited to stage 2 of the Bruce protocol or equivalent. Technicians supervise most outpatient stress tests, as long as there are no specific contraindications (see referral forms). Treadmill tests have a moderately high false positive rate, especially in middle aged women. They are difficult to interpret in patients with resting ECG abnormalities and in those patients taking digoxin. All requests are currently made via a referral form (generic) for outpatients and via ICE for inpatients. See page 75. The weight limit for the treadmill is 135kg.

Transthoracic Echocardiography

Transthoracic echocardiography outpatient requests should be sent to Cardiac Investigations (generic form). Inpatients can be requested via ICE. Please provide ALL relevant clinical details; requests without adequate information are liable to be returned. Echocardiograms are performed in the departments unless otherwise requested - if you require a bedside echo, you must speak personally to one of the cardiac technicians. Echoes are invariably less informative when performed at the bedside, so please do not request a portable echo unless it is strictly necessary. Urgent echoes should be performed by the cardiology SpR if a technician is unavailable. At LGH and LRI, all requests for echoes out of hours must be ratified via the non-interventional cardiology consultant on-call. Echoes should not be requested unless the result will alter management. There is a community provider that GPs can access for patients who need echoes. These echoes can be viewed online

via www.ultraling.co.uk by those with a username and password (contact Marion Campton in cardiology services if you require access).

Stress echocardiography

The service is led by Dr Khoo. All requests must be made in writing directly to the relevant consultant (Chelliah, Khoo). Factors that need to be borne in mind include the patient's body habitus – do they have good enough echo windows? It is a time consuming expensive investigation and the clinical need should be appropriate. It is less well tolerated than MPS and is contraindicated in patients with VT and recent ACS (< 5 days).

It is useful for a variety of indications. If the ECG or exercise test is uninterpretable, or patients cannot exercise, a stress echo is good at detecting coronary disease in patients with symptoms suggestive of ischaemia. It is useful in patients with documented LV dysfunction where underlying coronary disease is suspected. In patients with known coronary disease stress echo can help determine whether lesions need attention in terms of viability or ischaemia. In patients with significant coronary calcification documented on CT, it can help determine whether this is associated with significant underlying stenoses. It is a good test for pre-operative risk assessment in cardiac patients undergoing non-cardiac surgery. It is helpful in the evaluation of equivocal aortic stenosis, especially where there is low cardiac output. It helps in the evaluation of patients with asymptomatic but severe aortic or mitral regurgitation in order to aid decisions to refer. Sensitivity, specificity and accuracy are 80%, 84% and 80%.Sensitivity increases to 92% in three vessel disease. 74% in single vessel disease. For circumflex disease sensitivity is lower (55%) [(1)].

Transoesophageal Echocardiography

Transoesophageal echocardiography (TOE) is invaluable when high-resolution cardiac imaging is required (e.g. significant valvular disease, suspected infective endocarditis, intracardiac tumours, cardiac source of emboli etc.). Requests for outpatient or urgent inpatient TOE should be made to the relevant cardiology consultant who will arrange the study. Patients on ***warfarin*** need their INR to be below 3. Consultants who provide the service are Drs Chelliah, Khoo and Sharaf).

Nuclear Cardiology (MPS)

Stress myoview scanning (MPS or SPECT) is a sensitive investigation for the detection of myocardial ischaemia. However it does involve a large exposure to radiation (9 mSv). Requests for myoview scans should be made using the appropriate form (green sheet) or via ICE. All requests must be countersigned by a consultant. A recent chest X-ray should be available. Myoview scanning is rarely available on an urgent inpatient basis because of the need to order the necessary radioisotopes in preparation for the procedure. Patient's weight must be documented. It is useful if patients are unable to exercise. The stressor agents are ***adenosine*** or ***regadenoson*** (patients with conditions such as asthma or significant arrhythmias may require prior discussion). Pulmonary function studies should be arranged in patients with known airways disease.

MPS require considerable post-processing and has many artefacts due to patient size, atrial fibrillation, LBBB etc. It can show fixed and reversible ischaemia but not viability. Sensitivity ~ 85 - 95%, specificity 61%. Diagnostic accuracy is reduced in obese patients because of attenuation from breast tissue or the diaphragm. Prognostic disease can be missed in the situation of balanced ischaemia (left main

disease in a left-dominant system or three vessel disease). All scans are performed at GGH. Scans should not usually be performed within the first two to three months of an acute coronary event.

Patients referred for ***adenosine*** or ***regadenoson*** stress should abstain from caffeine. All requests must be countersigned by a consultant.

The weight limit for the D-SPECT camera (MPS) is 246kg for static imaging and 175kg for dynamic imaging.

Cardiac MRI (CMR)

CMR involves no radiation. It is a good test for viability and function but a stress CMR is required for ischaemia. It cannot be performed in patients with many implanted devices: pacemakers (although some pacemakers are MRI-safe and even older devices are probably safe), cerebral clips and spinal stimulators. Patients with severe claustrophobia may struggle with the investigation. Scans can take up to 45 minutes. All requests must be countersigned by a consultant.

CMR is good at assessing cardiac function especially in assessment of patients with LV dysfunction and cardiomyopathies. It is good for excluding ventricular tumours and thrombus (not atrial). It is probably the best test for constrictive pericarditis. CMR immediately post infarct may overestimate non-viable myocardium and, in these circumstances, delaying the scan may be a better option.

Gadolinium is the contrast agent used. First pass perfusion sequences look for ischaemia. Late gadolinium scanning identifies scar tissue. Gadolinium cannot be used to if the eGFR is < 30 ml/min (risk of nephrogenic systemic fibrosis). Stress CMR utilises pharmacological stressors, usually ***adenosine***, and cannot be performed in patients with severe asthma or higher degrees of AV block (same for any test using ***adenosine***, and remember NO CAFFEINE). ***Dobutamine*** stress can be employed in certain cases. CMR is difficult to interpret in the presence of multiple ectopics or poorly controlled atrial fibrillation. The test is time consuming and expensive. Sensitivity is 91% and specificity 80% for the diagnosis of obstructive coronary disease. A normal scan is associated with a three year event rate of 2·3%.

Cardiac CT

The latest imaging modality for coronary disease. It does not demonstrate ischaemia. The test requires a high specification scanner (> 64 slices) and often administration of IV ***β-blocker***. Attempts should be made to ensure a resting heart rate below 60. Radiation dose is relatively low (3 - 5 mSv per scan). Good in low and intermediate probability disease but can overestimate stenoses. Excellent for assessing grafts and can be useful for left main stem imaging if there is not significant calcification. If combined with MPS has high specificity and sensitivity. CI: Tachycardia, arrhythmia, eGFR < 30 ml/min, contrast allergy.

Coronary artery calcium (CAC) scoring (***Agatston score***) quantifies calcium in coronary arteries. It is now recommended as a first line test in low probability disease. A result of zero is associated with a 10 year survival rate of 99·4% in asymptomatic patients [(2)]. A score of zero does not rule out coronary disease and consideration should be given to undertaking a CT coronary angiogram (CTCA).

A negative CTCA for atheroma carries an annual all-cause mortality rate of 0·6%; those with non-obstructive atheroma have an event rate of 1·1% [(3)].

Coronary Angiography: see next section.

Figure 1: Radiation exposure with different diagnostic modalities.

Diagnostic modality	Typical effective radiation dose (mSv)	Equivalent number of chest X-rays	Approximate equivalent period of natural background radiation
Chest (single PA film)[1-9]	0.02	1	3 days
Echocardiography[2]	0	0	0
Electron-beam CT[4,5]	1.5–2	75–100	7–9 months
Multi-slice CT[4–7]			
Calcium score	1.5–2.7	75–135	7–14 months
CTCA (16 slices)	6.5–10.7	325–535	2.7–4.4 years
CTCA s/p CABG (16 slices)	12.9	645	5.3 years
CTCA (64 slices)	10.5	400	3 years
Magnetic resonance imaging[1–3]	0	0	0
Catheterisation laboratory			
Diagnostic coronary study (Coronary angiography and ventriculography)[1,8,9,11]	2.1–7	105–350	0.9–2.9 years
Angiography s/p CABG[8]	6.3	315	2.6 years
Aortography[8]	4	200	1.6 years
Coronary angioplasty[1,3,8,9,11]	7.5–57	375–2,850	3–23 years
Carotid stenting[8,11]	10	500	4.1 years
Nuclear cardiology[1–3]			
^{201}Thallium-Cl (2 mCi)	17	850	7 years
^{99m}Technetium tetrofosmin (30 mCi)	8.5	425	3.5 years
^{99m}Technetium sestamibi (30 mCi)	8.9	445	3.7 years
Non-cardiology imaging			
X-ray[1]			
Mammogram	0.13	6	18 days
Barium enema (10 images, 137 second fluoroscopy)	7.0	350	2.9 years
CT head	2.0	100	9 months
CT abdomen	10	500	3 years
Nuclear medicine[1-3]			
Bone (^{99m}Tc MDP [20 mCi])	4.4	220	1.8 years
Lung perfusion/ventilation (^{99m}Tc MAA and ^{133}Xe [5 & 10 mCi])	1.5	75	6 months
Kidney (^{99m}Tc DTPA [20 mCi])	3.1	155	1 year
Tumour (^{67}Ga [3 mCi])	12.2	610	5 years
PET CT (^{18}F FDG [10 mCi])	5–25	250–1,250	2.3–11.5 years

Key: CA = coronary angiography; CABG = coronary artery bypass graft; CT = computed tomography; DTPA = diethylenetriamine-pentaacetic acid; FDG = fluorodeoxyglucose; MAA = macroaggregated albumin; mCi = millicurie (radiopharmaceutical, nuclear isotope activity); MDP = methylene diphosphate; PA = posterior-anterior; PET = positron emission tomography; s/p = status post

PRE- AND POST-PROCEDURAL CARE

Angiographic Procedures

This is an invasive investigation involving a moderate radiation dose (~ 5 mSv or higher). It requires skill to perform and accurately interpret. It is the gold standard for investigation of coronary disease if performed well. The test can be combined with pressure wire studies for greater sensitivity. Patients need to be properly counselled and consented. The bulk of elective procedures can be performed as day cases. All patients require a full prescription chart to be completed. Patients should be starved of food for 4 - 6 hours beforehand and clear fluids until admission or 2 hours before the procedure. Patients need to lie flat for anywhere up to a couple of hours for the procedure in complex cases, and their ability to do so must be ascertained before listing.

Standard blood tests are required including renal function, liver function, lipid profile and in appropriate patients, a coagulation profile. Platelet counts need to above 50. If lower, haematology advice is required. These allow risk assessment for CIN and bleeding risk. A recent chest x-ray is sensible in the following circumstances: patient is a smoker / ex-smoker and has not had a CXR in last 12 months, pain could be musculoskeletal / atypical or if there are other specific reasons for a CXR.

Cardiac catheterisation involves aseptic placing of a sheath in one or more of the femoral or radial arteries under local anaesthetic. This can ultimately cause bleeding or bruising and, following femoral access, there is approximately a 0·7 per 1000 risk of significant damage requiring intervention/surgical repair. Manipulation of catheters may cause TIAs or stroke and similarly can damage coronary arteries. For this reason patients will be required to consent for PCI and/or CABG at the time of cardiac catheterisation.

As a rule of thumb remember the following:

- Death 1 in 1000 (0·1%)
- Myocardial infarction 1 in 1000 (0·1%)
- Stroke 1 in 1000 (0·1%)
- Significant arterial complications 1 in 500 (0·2%), less if radial

It is worth explaining that the procedure may cause some palpitations, especially during LV angiography. In addition, patients may experience a hot flush about 10 seconds after the LV angiogram due to contrast being injected rapidly. They may also feel that they have urinated, but this is rarely the case. Various catheters are used to locate the coronary arteries. Patients do not usually feel the catheters being moved. Many images are acquired, and this may involve the patient holding their breath at various times.

In outpatients, remember to explain that the groin needs to be shaved. Patients on ***warfarin*** need to stop it for 3 - 4 days beforehand (unless undergoing a radial angiogram where the procedure can be performed safely if the INR is < 3). Patients taking ***metformin*** should ideally not take it on the day of the procedure (and preferably not for 48 hours afterwards). The major risk is with patients with impaired renal function, those with severe heart failure, and in the context of dehydration.

After the procedure the patient will have the sheath removed. For femoral procedures, pressure will be applied to the groin for 20 - 30 minutes unless a special

closure device has been employed. Patients should be advised to take only gentle activity for the rest of the day and cannot drive for 24 hours. If patients have received ***UFH*** during the procedure the sheath can be removed once the ACT is below 150 - 180 s. Many patients will have had a vascular closure device (for example: Angio-Seal™) employed following femoral access and they can be mobilised sooner.

The majority of angiograms (~80%) are performed via the radial artery. When listing in clinic, ensure the radials are palpable (sometimes radial arteries occlude following previous procedures). This will ensure only appropriate patients are listed for a 'radial lounge' procedure (ambulatory patients who do not require a bed or trolley). Mostly the right radial is employed. It is therefore important to generally place peripheral venous access catheters in the left arm but ideally check with the operator. Some radial procedures are performed from the left arm if the patient has a LIMA graft (getting to a LIMA from the right radial is challenging) or if the right radial is occluded. Most patients with previous grafts however will have a femoral procedure. In patients with ESRF access may have to be femoral if they have a fistula or if fistula construction is a probability in the future. In the vast majority of day cases IV access is obtained by the nursing staff. Doctors may however be called if IV access is difficult. It is imperative that you try to do this job without delay as failure to have working IV access can significantly delay a busy list and lead to patient cancellation. IV cannulae should ideally be 18G green, placed in the antecubital or brachiocephalic vein. A pink catheter is less good but an acceptable alternative in patients with difficult IV access. Avoid veins around the back of the hand or wrist as these will interfere with radial arterial access.

This radial route will obviously not result in groin (and exceedingly rarely retroperitoneal) complications. Placement of the radial arterial sheath is done under local anaesthetic and may be slightly uncomfortable. An injection of ***verapamil*** (2·5 mg) and ***isosorbide dinitrate*** (1 - 2 mg) is often given via the sheath to counter radial artery spasm and causes a transient burning sensation from the elbow to the hand. Following radial procedures, pressure is applied to the vessel for 2 - 3 hours, usually employing special splints (TR band). The lowest pressure required for haemostasis should be aimed for - employing a pulse oximeter on the hand will indicate if arterial flow is present along with haemostasis. This will reduce the risk of radial occlusion. If bleeding occurs, the splint should be reapplied. Patients undergoing radial angiography are administered 5000 U of ***UFH*** during the procedure to reduce the risk of radial artery thrombosis (risk ~ 3-25%).

Sometimes radial spasm can be so intense that the sheath cannot be removed with traction. Excessive force must NEVER be applied. If the radial 'cocktail' of ***verapamil*** and ***nitrate*** fails to relax the vessel, sedation usually works employing either ***diazepam*** or ***midazolam***. Rarely a general anaesthetic may be required. Often simply waiting a while does the trick.

Post procedure the patient's vascular access site needs to be checked to exclude significant bleeding or potential aneurysm development. Some patients may require imaging with ultrasound and occasionally CT if a retroperitoneal bleed is suspected (usually associated with hypotension) Patients with renal impairment should have their renal function checked post-procedure and potentially again after 72 hours (via the GP if day cases).

Patients admitted with ACS who are at moderate or high risk should be considered for early in-patient angiography (< 72 hours) with a view to revascularisation. The

procedure should be done more urgently if there is on-going angina especially if associated with dynamic ST-deviation, heart failure, life threatening arrhythmias, or haemodynamic instability.

Many elective as well as ACS patients will undergo PCI immediately following angiography. PCI involves catheters being positioned in the coronary artery ostia and fine wires being manipulated down the artery. A balloon is then passed to the site of the lesion and inflated. It is common to experience chest pain during PCI and there is a risk of about 1 in 500 that myocardial infarction may occur necessitating urgent CABG.

As a rule of thumb remember the following complication rates for PCI:

- Death < 1 in 500 (0·3%). UK average ~ 0·7%
- Myocardial infarction (usually minor) < 1 in 100 (< 1%)
- Stroke < 1 in 100 (< 1%)
- Emergency CABG 1 in 200 (< 0·5%) – GGH stats for last 10 years is 0·02%.
- Significant arterial complications 1 in 200 (0·5%)

Most patients will have stents deployed to reduce the risk of restenosis. For elective, non-acute patients following bare metal stents (BMS), patients require treatment with ***clopidogrel*** (page 50) for 1 month, in addition to their usual medication. In ACS ***clopidogrel***, ***prasugrel*** or ***ticagrelor*** should ideally be administered for 12 months.

Drug-eluting stents (DES) reduce the risk of restenosis. The procedure is the same, but all patients need to be on ***DAPT*** for longer than with BMS. ***Prasugrel*** (page 50) or ***ticagrelor*** (page 51) will be given in most PPCI cases and should also be prescribed for 12 months unless instructed otherwise. ***Ticagrelor*** will be used for most NSTEMI patients and should also be prescribed for 12 months. For elective PCI employing DES, duration of DAPT may be 3 - 6 months dependent upon the preferences of the operator and stent employed. Some latest generation stents are licensed for only 4 weeks DAPT.

In patients with thrombocytopenia DAPT can be used as long as the platelet count is > 40-50 and there are no mucocutaneous bleeding symptoms. For lower platelet counts haematology advice is needed.

Bare metal stents include Vision™, Driver™, Integrity™, Coroflex™ and Integrity™. Drug-eluting stents include Xience Sierra or Alpine™, Biomatrix Flex™, Resolute Onyx™, Ultimaster and Promus Premier™. The latest introduction is that of bioresorbable stents. The Abbott bioresorbable vascular scaffold (BVS) ‘stent’ elutes evorolimus and requires DAPT in the same way as standard DES.

Variations of the theme of PCI include rotablation; this involves a high speed drill bit being placed against very hard coronary lesions. The patient should be warned of the noise (like a dentist’s drill). In addition, laser atherectomy will be introduced during the lifetime of this guideline.

It is sensible to remind patients that they may be subsequently better served with bypass surgery and so may not undergo PCI at the same sitting.

Ensure patients have been consented prior to listing. Ensure patients who may undergo PCI are established on ***aspirin*** and ***clopidogrel*** or ***ticagrelor*** employing the usual loading doses as outlined later (page 69). If patients have been treated

with ***enoxaparin*** the latter does **not** need to be discontinued for the procedure. Additional ***UFH*** does NOT need to be administered in the cath lab for the benefit of PCI if the last dose of ***enoxaparin*** was given within 6 hours. After 6 hours an additional 0·3 mg/kg IV can be given. Check with the operator.

If the patient has significant co-morbidities these should be discussed with the operator beforehand. If patients have had previous procedures every effort should be made to get hold of the details.

Patients and doctors should be aware of the potential impact of contrast media on renal function. In patients approaching end-stage renal failure, procedures should be performed in close liaison with the renal unit in case dialysis support is required. In patients who dialyse already, arrangements need to be made for early haemodialysis following the procedure. Patients on CAPD should bring their own exchange bags and warmers.

Coronary anatomy

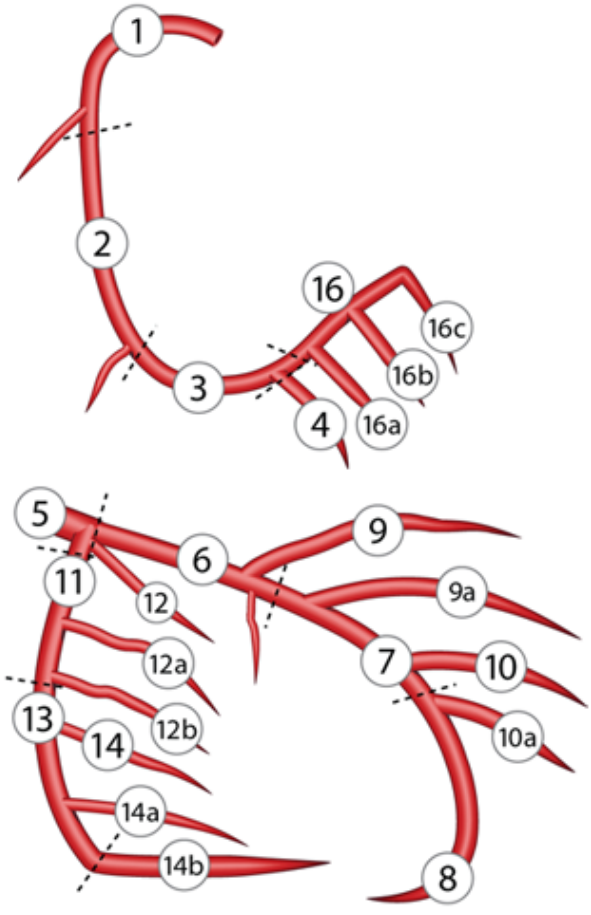
It is worth familiarising yourself with the basic coronary anatomy – in this (more common) example of right coronary dominance.

Right coronary artery

Proximal	1
Mid	2
Distal	3
Posterior descending	4
Posterolateral from RCA	16
Posterolateral from RCA	16a
Posterolateral from RCA	16b
Posterolateral from RCA	16c

Left coronary artery

Left main	5
Proximal LAD	6
Mid LAD	7
Apical LAD	8
First diagonal	9
Additional first diagonal	9a
Second diagonal	10
Additional second diagonal	10a
Proximal circumflex	11
Intermediate	12
Obtuse marginal	12a
Obtuse marginal	12b
Distal circumflex	13
Left posterolateral	14
Left posterolateral	14a
Left posterolateral	14b



(Images and segments taken from Syntax calculator)

Post Catheter Procedure Complications

Hypotension following angiographic procedures has a number of potential causes. Prompt diagnosis and treatment is vital.

Vasovagal reaction. This is common following femoral sheath removal but can occur at any time. It is predisposed by intravascular volume depletion. Symptoms include nausea, light-headedness and on occasion syncope with pallor, bradycardia (or more rarely tachycardia) and hypotension. Vasovagal reaction is essentially a diagnosis of exclusion and it is crucial to consider and specifically exclude other causes of hypotension, especially if the BP drop persists despite treatment. Initial measures include IV fluid bolus, ideally via a large bore IV cannula, placing the patient in the Trendelenburg (head down) position and possibly IV ***atropine*** 0·6 - 3 mg. It is important to have someone pressing over the femoral puncture site during this time in case of femoral access site bleeding. Have a high index of suspicion of active bleeding. Anything other than very brief self-terminating vagal reactions must be discussed with the operator/SpR.

Haemorrhage. Most common from femoral arterial access and can be superficial and local into the subcutaneous tissue of the groin, or concealed intra-abdominal/ retro-peritoneal bleeding. Signs include femoral haematoma in the former case and may be absent in the latter case of retro-peritoneal (RP) bleed. RP bleeding may present as cardiovascular collapse with or without an abdominal (usually RIF) mass. RP bleed is potentially life-threatening and must be confirmed by an urgent CT abdomen after IV fluid resuscitation. **Continued uninterrupted pressure must be applied over the access site and liaison with blood bank as directed by the operator ensured. DO NOT STOP ANTIPLATELETS without consultant advice due to the risk of fatal stent thrombosis**. Emergency vascular surgery may be needed.

False aneurysms develop when a hematoma maintains continuity with the arterial lumen. The incidence is between 0·5 - 2·0% after diagnostic angiography and has been reported in as many as 7·7% following PCI. Suspicion should be raised if there is a pulsatile mass and bruit. Immediate scanning with ultrasound is diagnostic and allows the interventional radiologist to inject thrombin and thrombose the aneurysm. In a small number, vascular surgery may be required. Arteriovenous fistulas can also occur and are mostly managed conservatively.

Cardiac tamponade. An uncommon but recognized complication of cardiac catheterisation, and in particular of PCI. Delayed (> 30 minutes post procedure) tamponade can occur as the result of micro-perforation of a coronary artery during the procedure, often by the angioplasty guide wire. Symptoms may be initially insidious prior to cardiovascular collapse and include chest pain, (atrial) tachyarrhythmias and relative hypotension. Classical signs (i.e. Beck's triad of raised JVP, muffled heart sounds and hypotension) are rarely relevant to acute procedural tamponade. The key message is that this diagnosis must be considered in any hypotensive patient post cardiac procedure and specifically excluded by an urgent bedside echocardiogram if suspected. Liaise with seniors as prompt treatment may be lifesaving (see page 87).

Access site complications. Most femoral sheaths are removed by nursing staff but you should endeavour to at least observe this process early on in the job. Sheaths are only pulled when the activated clotting time (ACT) is < 150 -180 s in heparinised

patients. Severe systolic hypertension (e.g. BP > 180 systolic) should ideally be treated prior to pulling the sheath - often this is a matter of giving mild sedation and should be discussed with seniors. Ask the SpR for advice on how to pull sheaths if unclear. Femoral arterial sheath sizes (French size) refer to internal diameter where French size divided by 3 gives the internal diameter in millimetres. Femoral arterial punctures require at least 10 - 15 minutes firm digital pressure using 2 fingers 2 - 3 cm proximal to skin puncture in line with the arterial impulse to achieve haemostasis. Sometimes prolonged pressure is required and is the first thing to do in expanding haematomas.

Nursing staff are adept at dealing with minor superficial groin haematomas. Liaise with seniors as to whether these patients can go home or need overnight stay. Common sense prevails and a proportion of tender groin haematomas will overly a femoral arterial pseudo-aneurysm. Thus very tender groin lumps or those with a prominent expansile impulse require ultrasound scanning prior to discharge and may require thrombin sclerotherapy to resolve the false aneurysm. This is performed by radiologists.

Radial access is associated with dramatically fewer serious access site bleeds. The most common closure device is the 'trans-radial' or 'TR' band which is deflated by the nurses according to protocol. This is generally effective, but sometimes a forearm haematoma may develop which can rarely lead to a forearm compartment syndrome. As ever, the operator must be immediately informed but first-aid involves elevating the arm and application of firm pressure over the forearm. A manual sphygmomanometer cuff inflated just above systolic pressure for 5-10 minutes at a time has been advocated. These are temporising measures pending vascular review if things fail to improve.

Chest pain. Very common following PCI. The key is to obtain ECGs every 15 - 30 minutes while the patient is in pain and to liaise early with the operator who has knowledge of the procedure and anatomy to help guide management. In general a subsiding mild 'bruised' sensation for up to an hour post PCI with no major ECG ischaemia is common and a consequence of procedural angioplasty-induced transient ischaemia. Progressive, recurrent or sudden angina with or without ECG changes is a cause for concern and should be discussed urgently. Opiate analgesia with anti-emetic should be given IV for severe ischaemic pain in the absence of contra-indications.

Stroke/TIA. Fortunately uncommon but may occur during or shortly after cardiac catheterisation. Any new focal neurological deficit will require a CT brain scan. The majority of events are embolic TIAs but will necessitate a period of in-patient investigation. Major intra-cerebral haemorrhage is rare. Cases should be discussed with the on call stroke team (consultant or SpR) at LRI. For ischaemic stroke, thrombolysis may be an option within the first 4 - 5 hours ([4]). Other embolic phenomena can occur due to cholesterol embolisation.

Contrast Induced Nephropathy (CIN). Patients with pre-existing renal impairment (eGFR < 60) are clearly at higher risk of developing CIN but other factors increase the risk as well: hypotension, CCF, Age > 70, previous renal transplant, nephrotoxic drugs, anaemia, diabetes, IABP use. In addition, the higher the volume of contrast used increases the risk. The Mehran Risk Score [(5)] can determine the likelihood of CIN and has been recently validated [(6)](see **Table 1**, page 36) . Excel based

calculators are loaded on the cath lab PCs and web based calculators are also available:

http://www.renalguard.com/educational/contrast-induced-nephropathy-risk-calculator

In patients with increased risk, ensure drugs like ***NSAIDs*** and ***metformin*** are stopped 48 hours prior to contrast exposure. To further reduce the risk of CIN patients at high risk should receive hydration. For non-urgent in-patients use 0·9% ***sodium chloride*** 12 hours prior to angiography and continue for 12 hours after (1 ml/kg/hr). For elective outpatients use 0·9% ***sodium chloride*** (3 ml/kg/hr 1 hour before and continued for 6 hours after the procedure). The role of ***sodium bicarbonate*** as an alternative to 0·9% ***sodium chloride*** remains uncertain (1·4% ***sodium bicarbonate*** run at 3 ml/kg/hr for one hour prior to the procedure and continuing at 0·93 ml/kg/hr for six hours post-procedure [7;8]. There is some evidence that the short-term use of high-dose high-intensity ***statins*** reduce the risk of CIN ([9]): ***rosuvastatin*** 20-40 mg OD or ***atorvastatin*** 80 mg OD.

Low or iso-osmolar iodinated contrast medium should be used in patients with risk factors for developing CIN.

Check serum creatinine after 48 hours. If no more than 25% above baseline, restart any withheld medications. If creatinine increases > 25% from baseline, continue withholding drugs and recheck in a further 24 hrs. If creatinine increases > 50% from baseline, discuss with renal SpR on call.

Table 1: Mehran risk score to determine likelihood of CIN.

Risk Factor	**Score**
Hypotension (< 80 mmHg)	5
IABP	5
CCF	5
Age > 75	4
Anaemia	3
Diabetes	3
Contrast Volume 1 for each 100 ml	
eGFR 40 - 60	2
20 - 40	4
< 20	6

	Risk of CIN	**Risk of Dialysis**
Score ≤ 5	7·5%	0·04%
Score 6 - 10	14%	0·12%
Score 11 - 16	26·1%	1·09%
Score ≥ 16	57·3%	12·6%

BCIS recommends staging of acute kidney injury after contrast.

Stage	Serum creatinine (Cr) criteria	Urine output criteria
1	Increase ≥ 26 µmol/L within 48hrs or increase ≥ 1·5- to 1·9 X baseline Cr	< 0·5 ml/kg/hr for > 6 consecutive hrs
2	Increase ≥ 2 to 2·9 X baseline Cr	< 0·5 ml/kg/hr for > 12 hrs
3	Increase ≥ 3 X baseline Cr or * increase 354 µmol/L or commenced on renal replacement therapy (RRT) irrespective of stage	< 0·3 ml/kg/hr for > 24 hrs or anuria for 12 hrs

Non-allergic contrast reactions. A diagnosis of exclusion. X-ray contrast is hyperosmolar and cerebral fluid shift is thought to be responsible for vasoactive mediated neurological symptoms which range from minor visual symptoms (similar to migraine aura) to symptoms mimicking CVA. Usually self-limiting but firm neurological signs need to be investigated urgently.

Anaphylaxis. Consider anaphylaxis in refractory hypotension, especially if there is wheeze/rash. This is most commonly due to IV contrast. Discuss urgently with seniors prior to commencing treatment. For mild reactions (hives, urticaria) consider ***chlorpheniramine*** 10 - 20 mg IV slowly over 1 minute. For more severe urticaria, ***chlorpheniramine*** 10 - 20 mg IV slowly over 1 minute and consider ***adrenaline*** 1:1,000, give 0·1 - 0·3 ml IM.

In patients with known contrast allergy, prevention with medication is not proven to be of benefit. Use of non-ionic low or iso-osmolar contrast is advised. In very high risk patients consideration can be given to administering IV ***hydrocortisone*** 200 mg and ***chlorpheniramine*** 10 - 20 mg IV slowly over 1 minute.

Emergency treatment of anaphylaxis includes administration of ***adrenaline*** 1:1000 0·5 mg IM which may need to be given more than once along with IV fluids. ***Oxygen*** should be given and the crash team called.

Device Procedures

Pacemakers and defibrillators are usually implanted in the region of the deltopectoral groove of the non-dominant shoulder. The procedures are performed aseptically under light sedation employing local anaesthesia. Occasionally patients will require general anaesthetic, particularly patients who are listed for lead extraction.

Pacemaker procedures last approximately 40 - 90 minutes. Biventricular devices may take considerably longer to implant. There is a small risk (1:50) of a pneumothorax; often these do not require drainage. Early haematomas requiring drainage/re-do amount to approximately 1 per 100. Lead displacement may occur in the first few weeks requiring re-positioning. Infection may occur any time in the first

few months, rarely later. There is a small risk of tamponade and this should be considered urgently as a differential if the patient has any suggestive symptoms or signs.

Patients on ***anticoagulant*** therapy should usually either have their ***anticoagulants*** stopped or have their INR (on ***warfarin***) adjusted to 1·8 – 2·0. While patients are waiting for their pacemaker implant, the area under the collar bones should be kept clean and free from ECG electrodes. Most operators prefer a green or at least pink venous catheter in the left antecubital fossa, with a long extension line connected. This is to allow a venogram to be performed if there is difficulty in venous access. All patients should have a set of recent blood tests especially FBC, U&E, clotting and CRP. If the patient has signs or symptoms of underlying sepsis, this should be fully treated before implanting the pacemaker.

Antibiotics are administered pre- and post-procedure. Standard regimen: ***flucloxacillin*** 1 g IV and ***gentamicin*** IV 120 mg followed by three further doses of ***flucloxacillin*** PO 500 mg at 6 hourly intervals. For patients with known or previous MRSA: ***teicoplanin*** IV 400 mg and ***gentamicin*** IV 120 mg. For ***penicillin*** allergic patients: ***teicoplanin*** IV 400 mg and ***gentamicin*** IV 120 mg.

A chest X-ray is required post-implant to confirm lead position and exclude a pneumothorax (not seen after cephalic only implants). You will be required to review the CXR prior to the patient's discharge. If you are unsure about the pacemaker lead positions, consult a senior to ensure that they are appropriate. Pacing checks will be done prior to discharge and at 1 month. Additional checks and device manipulation may be required with defibrillators and biventricular devices. Please check the procedure report for any additional instructions, such as instructions regarding ***anticoagulation*** or change in medication (such as recommencing rate-limiting drugs in patients with tachycardia-bradycardia syndromes).

EP Procedures

Patients undergoing simple diagnostic EP procedures should be prepared in much the same way as those undergoing angiography. Although the risks of groin complications are lower, there is still a risk. Patients should be advised of the risk of palpitations and possible syncope during the procedure.

For patients undergoing ablation procedures the risks of complications should be discussed. Simple ablation is normally a day case procedure. Patients may need an overnight stay, depending on when the procedure finishes, and have adult accompaniment when discharged. Access is usually via the right groin and ablation normally performed on the right side of the heart.

Post procedure check there is no bruit and look for a haematoma. If there are any concerns, consider an ultrasound of the groin. There is also risk of heart block, so check an ECG post ablation for any changes from pre-procedure. Some patients have ablation on the left side via the aorta, patent foramen ovale or trans-septal approach. Some will require an overnight stay but many are now performed as day case procedures. In these patients an echocardiogram will be required to confirm there is no pericardial effusion. Also there is a risk of thromboembolism - therefore ***antiplatelets*** will be required in most patients treated with ablation unless already anticoagulated.

Most patients will have had ablation for atrial fibrillation and flutter. However ablation for VT, atrial tachycardia and patients with adult congenital heart disease fall in the category of complex ablation. The care is the same as for simple ablation but consider these issues:

Blood pressure may fall due to sedation but also rule out pericardial effusion as a cause. Also vascular tear or injury and retroperitoneal bleed may have to be investigated with USS of the groin or CT of the abdomen. Dizziness can be due to dehydration and sedation, but think of stroke.

A post discharge plan should be written in the procedure report. All patients undergoing a complex ablation procedure or left-sided procedure must have an echo pre-discharge to exclude an effusion. Post procedure anti-arrhythmics are usually continued for 3 months after AF ablation.

Patients undergoing an AF ablation are usually anticoagulated prior to the procedure with ***warfarin*** with the procedure carried out with a therapeutic INR (2·5 - 3·5). The ***warfarin*** should be continued uninterrupted. There is a significant increased risk of thromboembolic stroke in the period immediately following AF ablation and it is therefore vital that ***anticoagulation*** is not withheld unless there is a life-threatening bleed. These patients should be discussed with the relevant consultant involved in the patient's care. Increasingly, patients may be undergoing AF ablation with the use of direct oral ***anticoagulants: DOACs,*** also referred to as novel (***NOACs***) oral ***anticoagulants:*** (***dabigatran***, ***rivaroxaban***, ***apixaban, edoxaban***). There should be clear instructions in the patient's notes if/when the ***DOAC*** should be withheld prior to the procedure and if/when it should be recommenced after the procedure. In this case the drug is usually stopped the day before the procedure and must be restarted on the evening of the procedure. As experience with ablation in patients taking ***DOACs*** increases, these procedures are increasingly being undertaken with uninterrupted ***DOACs***.

Again check the plan in the notes and if any problems contact the consultant in charge.

Intra-aortic balloon pump (IABP) counterpulsation

An IABP is a circulatory assist device used in haemodynamically unstable patients. Indications include severe refractory ischaemia, hypotension (systolic blood pressure less than 90 mmHg or 30 mmHg below baseline mean arterial pressure) of cardiac origin that is not responsive to other interventions; cardiogenic shock that is not quickly reversed with pharmacologic therapy; acute mitral regurgitation, particularly due to papillary muscle rupture, or ventricular septal rupture. Occasionally it is used in patients with refractory VT/VF.

The contraindications to IABP are: moderate to severe aortic regurgitation; aortic dissection; aortic stent; end-stage cardiac disease with no viable other treatment options; bilateral femoral-popliteal bypass grafts. Relative contraindications: uncontrolled sepsis; abdominal aortic aneurysm; severe bilateral peripheral vascular disease; uncontrolled bleeding disorder; prosthetic ileofemoral grafts/iliac artery stents.

The device is passed via a femoral artery (preferably sheathless). The distal tip is positioned 1 - 2 cm distal to the origin of the left subclavian artery or at the level of the carina. The usual size of the balloon for an adult patient is between 25 cc (for patients < 5 feet tall) to 50 cc (for patients > 6 feet tall) but individual manufacturer's

guidance should be followed. Patients are bed-bound and can be nursed to a maximum elevation of 30°.

Pumping is initiated and controlled by a console using input from both the aortic pressure and the ECG. Inflation occurs immediately after aortic valve closure and deflation just before aortic valve opening. Inflation and deflation of the balloon has two major consequences:

- Blood is displaced to the proximal aorta by inflation during diastole.
- Aortic volume (and thus afterload) is reduced during systole through a vacuum effect created by rapid balloon deflation.

Common and potentially life threatening complications include: limb and renal ischaemia; vascular laceration necessitating surgical repair; major haemorrhage; and cerebrovascular accident. Rapid inflation and deflation of the balloon causes trauma to red blood cells and platelets, commonly resulting in anaemia and/or thrombocytopenia. A FBC should be performed daily. Device related thrombus formation and subsequent embolisation are also significant risks. Because of these factors, patients with an IABP in situ are usually systemically anticoagulated, resulting in an increased risk of bleeding at the insertion site. Deterioration in renal function may be due to distal migration of the catheter and this should be considered (and fluoroscopic screening arranged if necessary). Close monitoring of the peripheral pulses is mandatory (left arm and lower limbs).

Successful weaning from the IABP requires the patient to not be in cardiogenic shock and to have an adequate blood pressure whilst on little or no inotropic support. Reasonable target values to aim for prior to weaning are a mean arterial pressure of 65 mmHg. IABP counterpulsation is usually weaned by reducing the ratio of augmented to non-augmented beats. This can be done by reducing the augmentation frequency every 1 - 6 hours, from ratios of 1:1 to 1:2 to 1:3. If a ratio of 1:3 is tolerated for 6 hours then the device should be put into standby and removed without delay. The balloon should never be left in standby mode for more than 20 minutes because of the risk of thrombus formation on the balloon. Most patients will be anticoagulated employing ***UFH***.

TAVI Procedures and other “structural” interventions

Transcatheter aortic valve implantation (TAVI) is predominantly carried out for elderly patients with severe aortic stenosis and significant comorbidities. Mortality rate is 2 - 5%, stroke risk 2 - 3%, vascular complications 3 - 5%, pericardial tamponade 0·2 – 4·3%, aortic rupture < 1 %, valve embolisation 1%, conversion to open heart surgery 1%, requirement for pacemaker post TAVI 15 - 40% (depending on type of valve – greater with self-expanding prostheses). There are additional risks which will be discussed in detail with patients by the TAVI team during the consent process. TAVI can only go ahead for patients who have:

1. Symptomatic severe aortic stenosis
2. Been turned down by a surgeon for surgical valve replacement
3. Feasible access routes to implant the valve
4. Been accepted after consideration by the TAVI MDT

The most common TAVI access route is trans-femoral, for which there needs to be a relatively disease free channel along the femorals, iliacs, and aorta, with femoral

artery diameter at least 5 mm, sometimes more. TAVI cannot be carried out if the aortic annulus is < 18 mm or > 30 mm, although oval shaped annuli with one axis slightly outside the range can be considered. The trans-apical, trans-axillary, and direct aortic routes are alternative options. Almost all patients will have had a CT aortogram ("TAVI protocol") plus coronary +/- peripheral angiography. In exceptional cases when CT is contraindicated (renal function) patients will have sizing done by 3D transoesophageal echocardiography either prior to procedural hospitalisation or peri-procedurally. All investigations should have been completed prior to admission for elective cases but a proportion of cases have TAVI during their index admission with severe aortic stenosis.

The majority of trans-femoral cases are done under local anaesthetic +/- sedation, other cases under general anaesthesia (especially if there is need to delineate anatomy further for precise valve sizing or if it is a valve in valve procedure, i.e. TAVI into a failed surgical prosthesis). It is important to determine from the records whether the patient is to have the procedure via a trans-femoral, subclavian, trans-apical, or trans-aortic approach as clearly the consent procedure is different. Pre-procedure FBC, clotting screen, biochemistry, and cross match (4 units) are required. Patients taking ***warfarin*** will need to discontinue 3 days prior to the procedure if taking it for atrial fibrillation unless otherwise specified. Antibiotics are required pre-procedure: ***flucloxacillin*** 1 g IV and ***gentamicin*** IV 120 mg followed by three further doses of ***flucloxacillin*** PO 500 mg at 6 hourly intervals. For patients with known or previous MRSA: ***teicoplanin*** IV 400 mg and ***gentamicin*** IV 120 mg. For ***penicillin*** allergic patients: ***teicoplanin*** IV 400 mg and ***gentamicin*** IV 120 mg.

Most patients will also have DAPT for 3 months (***aspirin*** 75 mg and ***clopidogrel*** 75 mg) followed by ***aspirin*** long term. If bleeding or there are intolerance concerns, ***aspirin*** or ***clopidogrel*** alone may be used. There are trials underway to assess the merit of alternative ***antiplatelet*** or ***anticoagulants***, but at the moment this is an accepted pragmatic approach. If a patient is on ***anticoagulant*** beforehand (i.e. ***warfarin*** or ***DOAC*** for AF, or ***warfarin*** for existing mitral prosthesis for example, they do not need to start ***antiplatelets*** and simply continue back on their ***anticoagulant***).

Following the procedure patients must be assessed carefully for signs of complications. ECG monitoring is mandatory and patients need to be considered for permanent pacing if there is development of new LBBB (if associated bradycardia) or AV node block. In general terms, balloon expandable valves and non-metallic valves have a lower rate of permanent pacing requirements (Edwards Sapien), while Evolut Corevalve and Lotus valve rates are higher. Monitoring/telemetry of patient on the ward is typically for 2-3 days to make a decision if the patient requires permanent pacing or not.

An echocardiogram is usually performed immediately after the procedure but sometimes needs to be repeated pre-discharge. Typical follow up is around 6-8 weeks after implant and then annually in the valve or general clinic.

In addition to TAVI, interventions such as balloon aortic valvuloplasty, balloon mitral valvuloplasty or other mitral valve interventions (MitraClip), left atrial appendage occlusion, inter-atrial septal defect closure, and paravalvular leak closure are carried out in this unit. These will be dealt with on a case by case basis by members of the structural team (Kovac, Khoo, Roberts), who will make investigation and treatment plans clear to ward teams. To refer to the TAVI MDT or for specific information about

TAVI or structural intervention patients, phone or email Di Baker (ext 3358) or Kelly Moore, secretary to Professor Kovac and Dr Roberts (ext 2780).

ACUTE CORONARY SYNDROMES

Definitions

The categorisation of acute coronary syndromes (ACS) underwent substantial changes in the late 1990s, largely as a result of the introduction of **Troponin** testing. **Troponin I and T** are proteins found in cardiac myocytes and even a small amount of myocardial necrosis can lead to a significant elevation in circulating blood levels. ***High sensitivity Troponin I*** (***hs-TnI***) is used in UHL.

The latest universal classification of myocardial infarction was published in 2012 ([10]) and is as follows:

Type 1: Spontaneous myocardial infarction: Spontaneous myocardial infarction related to atherosclerotic plaque rupture, ulceration, fissuring, erosion, or dissection with resulting intra-luminal thrombus in one or more of the coronary arteries leading to decreased myocardial blood flow or distal platelet emboli with ensuing myocyte necrosis. The patient may have underlying severe coronary artery disease (CAD) but on occasion non-obstructive or no CAD.

Type 2: Myocardial infarction secondary to an ischaemic imbalance: In instances of myocardial injury with necrosis where a condition other than CAD contributes to an imbalance between myocardial oxygen supply and/or demand. For example but not an exhaustive list: coronary endothelial dysfunction, coronary artery spasm, coronary embolism, tachy/brady-arrhythmias, anaemia, respiratory failure, hypotension, pulmonary embolism, sepsis syndrome, and hypertension with or without LVH.

Type 3: Myocardial infarction resulting in death when biomarkers are unavailable: Cardiac death with symptoms suggestive of myocardial ischaemia and presumed new ischaemic ECG changes or new LBBB, but death occurring before blood samples could be obtained, before cardiac biomarker could rise, or in rare cases cardiac biomarkers were not collected.

Type 4a: Myocardial infarction related to percutaneous coronary intervention: Myocardial infarction associated with PCI is arbitrarily defined by elevation of ***TnI*** values > 5 times 99th percentile of upper reference limit in patients with normal baseline values (≥ 99th percentile upper reference limit) or a rise of ***TnI*** values > 20% if the baseline values are elevated and are stable or falling. In addition, either

(i) Symptoms suggestive of myocardial ischaemia or
(ii) New ischaemic ECG changes or new LBBB or
(iii) Angiographic loss of patency of a major coronary artery or a side branch or persistent slow or no-flow or embolisation or
(iv) Imaging demonstration of new loss of viable myocardium or new regional wall motion abnormality.

Type 4b: Myocardial infarction related to stent thrombosis: Myocardial infarction associated with stent thrombosis is detected by coronary angiography or autopsy in the setting of myocardial ischaemia and with a rise and/ or fall of cardiac biomarkers values with at least one value above the 99th percentile upper reference limit.

Type 5: Myocardial infarction related to coronary artery bypass grafting: Myocardial infarction associated with CABG is arbitrarily defined by elevation of cardiac biomarker values >10 times 99th percentile upper reference limit in patients

with normal baseline ***TnI*** values (≥ 99th percentile upper reference limit). In addition, either:

(i) New pathological Q waves or new LBBB or
(ii) Angiographic documented new graft or new native coronary artery occlusion or
(iii) Imaging evidence of new loss of viable myocardium or new regional wall motion abnormality.

Cardiac Enzymes

Elevation of ***TnI*** strongly suggests myocardial necrosis. ***TnI*** levels begin to rise 3 to 4 hours after myocardial damage and stay elevated for up to two weeks. ***CK*** **should also be measured in STEMI patients.**

We now employ an assay for ***high-sensitivity TnI***. There are different cut off levels for men and women. These cut off levels may alter as we gain more knowledge about the assay.

Males: ***hs-TnI*** levels greater than **34 ng/L** for men suggests a **high likelihood** of myocardial necrosis.

Females: ***hs-TnI*** levels greater than **16 ng/L** for women suggests a **high likelihood** of myocardial necrosis.

Levels five-fold above the upper limit have a very high predictive value for type 1 myocardial infarction (>90%). Elevations up to three times the upper limit have limited predictive value (50-60%) and can be associated with many other conditions.

Rising and/or falling cardiac troponin levels differentiate acute from chronic cardiomyocyte damage (the more pronounced the change, the higher the likelihood of acute MI). A **rise** greater than **5 ng/L** may indicate ACS.

In order to achieve a quick diagnosis we recommend a ***hs-TnI*** level is taken on admission and again at 1 hour. **Only one *hs-TnI* level is required if the onset of symptoms was 3 or more hours previously**. If there is uncertainty, a further sample can be taken a further 2 hours later (3 hours after the first). Second ***hs-TnI*** levels can be useful to assess whether the elevation is static, rising or falling.

Hs-TnI assays in UHL allow for earlier measurement rather than old regime of relying on the 12 hour ***TnI***. Several studies have shown that earlier sampling allows for earlier diagnosis or exclusion of acute coronary syndromes [11;12]. Clinical judgment must still apply and a normal ***hs-TnI*** series should not always result in automatic discharge.

Levels that remain less than **5 ng/L** make ACS very **unlikely**.

Hs-TnI should be assessed in patients with typical ischaemic symptoms in the setting of ST depression, T wave inversion or even a normal ECG. ***Hs-TnI*** can also be useful in LBBB or paced ECGs when doubt exists as to whether there has been significant recent ischaemia. Measurement of ***hs-TnI*** should be restricted to appropriate patients, and specifically when an acute coronary syndrome is suspected. It is not appropriate to use ***hs-TnI*** as a 'rule out ischaemia' test.

It is important that the result of the ***hs-TnI*** should be acted upon. In the setting of suspected acute coronary syndromes, a normal ***hs-TnI*** series (or an intermediate level with no rise), suggests a good prognosis. If these patients are being treated

with ***LMWH***, the treatment can be discontinued and the patient considered for discharge. Patients with a normal ECG in this scenario almost certainly have a good prognosis. In those patients with a fixed abnormal ECG (i.e. fixed T wave inversion) but negative ***hs-TnI***, clinical judgement has to be used as to whether further in-patient assessment is required.

If patients are deemed to warrant further investigations in the form of functional imaging or angiography, a judgment needs to be made as to whether these tests have to be done as in-patients. In patients with no rise in ***hs-TnI***, outpatient investigations should be seriously considered.

Hs-TnI is NOT mandatory to diagnose straightforward STEMI as results are usually very high and of limited value. **In all STEMI CK should be measured. CK should be measured on admission and at 12 and possibly 24 hours.** The only exception to this rule is when there is a suspicion that the ST segment elevation is thought to be longstanding (i.e. due to LV aneurysm), but a more recent acute event is suspected where ***hs-TnI*** can be valuable. ***Hs-TnI*** **should only be measured if it is going to alter the management of the patient.**

Using the presenting symptoms, ECG and subsequent ***hs-TnI*** level, patients presenting acutely with cardiac chest pain can be grouped as follows:

ST-elevation MI (STEMI): Patients presenting with cardiac-sounding chest pain with persistent ST segment elevation (or new LBBB) on their ECG. ST elevation should be > 1 mm in limb leads and 2 mm in chest leads. Subsequent ***hs-TnI*** will frequently be > 100 ng/L (and CK usually > 400).

Non-ST elevation MI (NSTEMI): Patients presenting with cardiac-sounding chest pain. ECG may show ST segment depression, T wave inversion or may be normal. Subsequent ***hs-TnI*** will frequently be > 100 ng/L. Previously established ECG changes such as old MI, LV hypertrophy or atrial fibrillation may be present. The hallmark of acute coronary syndrome is labile ECG changes.

Unstable angina: Patients presenting with cardiac-sounding chest pain. ECG may show ST segment depression, T wave inversion or may be normal. Subsequent ***hs-TnI*** will be within the normal reference range.

Terms such as non-q wave MI and subendocardial MI are outdated, imprecise and should be avoided.

The key decision to make when a patient is admitted is whether they require urgent revascularisation, based upon the history and the ECG (guidelines on the management of STEMI can be found on page 49). It is vital to understand that virtually **ALL** of the evidence underpinning inpatient angiography guided revascularisation in apparent NSTEMI is derived from trials which dealt with patients fitting into the category of Type 1 and Type 4B MI. A number of patients with coronary spasm and coronary embolism will also have been included. The benefit of urgent revascularisation (stent-based) treatment is predominantly through treatment of culprit (plaque rupture) lesions coupled with the more diffuse action of drugs. Consider carefully if your patient has had an MI due to one of these conditions before assuming angiography is needed. **A SIGNIFICANT PROPORTION OF THOSE WITH ELEVATED TROPONINS DO NOT NEED INPATIENT ANGIOGRAPHY.**

The distinction between NSTEMI and unstable angina is retrospective - it can only be made when the ***hs-TnI*** result is available later. Patients presenting with cardiac sounding chest pain but no persistent ST elevation should be treated as unstable angina, and can be formally diagnosed as NSTEMI or unstable angina once the result of the ***hs-TnI*** test is available. The overall approach to the management of unstable angina and NSTEMI is the same (see page 68).

There may be an incidence of false positive elevation of ***hs-TnI*** in patients with advanced renal failure and positive results in these patients should be viewed with caution (especially if creatinine is over ~ 221 µmol/L [13;14]. A rise in serial ***hs-TnI*** levels in patients with renal failure is however likely to be due to myocardial injury. ***Hs-TnI*** may also be elevated in the context of large pulmonary embolism [15]. Occasionally, elevated ***hs-TnI*** may be seen in patients with severe congestive cardiac failure [16] and in myocarditis [17] and following prolonged tachyarrhythmias (i.e. type 2 MI). Other conditions in which ***hs-TnI*** may be elevated are aortic dissection, aortic stenosis, hypertrophic cardiomyopathy, Takotsubo cardiomyopathy [18;19], malignancy, stroke and severe sepsis ([20]). Generally, ***hs-TnI*** levels do not seem to rise in the majority of patients who have undergone cardioversion [21;22]. ***Hs-TnI*** levels may remain elevated for several days and care should be taken in their interpretation in the context of re-admissions within a couple of weeks of a myocardial infarction. A couple of serial ***hs-TnI*** levels will help by determining whether the level is falling (older event) or rising (recent event).

ECG

The diagnosis of STEMI is established by the presence on the ECG of ST elevation (> 0·1 mV, two or more contiguous leads). Patients presenting with left bundle branch block that is thought to be of new onset, and in the context of symptoms consistent with myocardial infarction should be treated in the same manner. All patients presenting within 12 hours of the onset of symptoms should be considered for urgent revascularisation (see page 50).

Patients with ST depression confined to leads V1 to V4 may have true posterior myocardial infarction and should be treated in the same manner as STEMI. All patients should routinely have **POSTERIOR** (V7 - V9) and **RIGHT VENTRICULAR LEADS** recorded **ON OR SOON AFTER ADMISSION**, especially those with inferior STEMI, as diagnostic changes may be transient [23]. ST elevation in RV4 is highly sensitive for right ventricular infarction [24].

Transfer to catheter lab in the case of STEMI should not be delayed by performing further ECGs unless there is a doubt as to diagnosis. A bedside echo looking for regional wall motion abnormalities (RWMAs) can help the decision.

ECG electrodes should generally be left in position for the first 24 - 48 hours to eliminate position changes on subsequent ECGs.

In the case of unstable angina and NSTEMI the ECG changes may manifest as transient ST segment depression or elevation, T wave inversion or flattening, T wave pseudo-normalisation (or even no change at all). Previously established ECG changes such as old MI, LV hypertrophy and ***digoxin*** effect need to be considered.

You can't have too many ECGs. Any patient admitted with possible ACS should have ECGs repeated several times over the first couple of days, especially if there is any doubt as to the diagnosis. Particularly relevant is when the initial ECGs have been normal but the ***hs-TnI*** is elevated. If the pain is entirely convincing, ECGs

should be repeated as frequently as every 30 minutes in order to establish the diagnosis as quickly as possible. ECGs and enzymes performed 'next day' in the 'ROMI: rule out myocardial infarction' fashion is totally unacceptable.

Certain conditions may mimic STEMI on the ECG. Early repolarisation causes up-sloping ST elevation, particularly in leads V1 and V2 (and sometimes V3). It is seen more commonly in younger, especially athletic patients. It is also seen in some Afro-Caribbeans. There may be concave ST elevation in pericarditis and the ST changes may be very widespread. Brugada syndrome may also be misdiagnosed as anterior STEMI (see page 110). Takotsubo cardiomyopathy (page 131) can also mimic STEMI and NSTEMI.

Blood Tests

All patients should have a full biochemical screen on admission including lipid profile, random glucose and an HbA1c assay performed. A full blood count is mandatory.

Cardiac enzymes including ***hs-TnI*** should be done on admission as outlined previously (page 44). A ***CK*** at 24 hours helps give an estimation of infarct size, especially in STEMI.

Other causes of elevated ***CK*** include: surgery, myopathic disorders (rhabdomyolysis, polymyositis, dermatomyositis, myocarditis, alcoholism), muscular dystrophy, significant muscle trauma, malignant hyperpyrexia, hypothyroidism, pulmonary emboli, convulsions, and cerebral infarction. Drugs can also cause an elevation and these include ***colchicine***, ***haloperidol***, ***prochlorperazine***, ***quinidine***, ***tricyclics*** and lipid lowering drugs (including ***statins*** and ***fibrates***). Healthy asymptomatic Afro-Caribbeans have a higher ***CK*** level than Caucasians or Hispanics.

Urea and electrolytes should be measured on days 1 and 2 to determine renal function and, in particular, to determine potassium levels. More frequent and/or prolonged assessment is required in patients with low output cardiogenic shock, pre-existing renal disease or hypotension. Liver function tests may be abnormal in patients with significant right heart failure and should be measured on the initial sample and thereafter if abnormal.

Thyroid function tests should be performed on selected patients including those with atrial fibrillation and those on or about to receive ***amiodarone*** (if there is no record of the latter being done in recent weeks - check iLab, or ICE).

For younger patients presenting with myocardial infarction, consider asking the lab to store samples for possible exclusion of drug abuse. Cocaine, amphetamines, ecstasy and marijuana have all been implicated in coronary spasm and ultimately myocardial infarction. Screening on admission may need to be considered.

Echocardiography

Echocardiography is essential to assess left ventricular function. It can detect regional wall motion abnormalities (RWMAs) which are likely to be due to coronary disease. Valve disease can be assessed. Daily auscultation will occasionally detect new murmurs following myocardial infarction. Left ventricular thrombus may occur after extensive anterior myocardial infarction (although can be missed on echo). Requests for urgent (especially out of hours) echocardiography should be discussed with the cardiology SpR or non-interventional cardiology consultant if the patient is at LRI or LGH.

Chest X-Ray

A chest X-ray should be arranged on most patients as soon as possible after admission. It should not however delay any proposed revascularisation therapy.

Exercise Testing & Functional Imaging

An exercise test may be helpful and should be considered in all active, otherwise fit patients if the cause of chest pain is unclear. It can be helpful when deciding whether further interventions are required and as a means of risk stratification. Functional imaging however is being used increasingly to guide future therapy. Options are stress echo, CMR and perfusion studies. Whether these can be done as inpatients or outpatients should be decided by the consultant.

Angiography

See page 30.

Intravenous Access

A peripheral venous catheter should be sited in all patients. The use of antecubital and small hand veins should, if possible, be avoided. Because an increasing number of angiographic procedures are performed via the right radial artery, peripheral venous catheters should not be sited in or around the right wrist. Catheters should be removed and/or changed if there are clear signs of phlebitis (pain, erythema, induration). They should be flushed with saline after use and Hep-lock employed if they are not likely to be used for > 8 hours.

Analgesics & Pain Relief

Early and adequate reduction in pain is important, both for symptomatic reasons and to improve myocardial ischaemia, as severe pain itself has a deleterious effect on the oxygen supply/demand relationship after myocardial infarction.

Acute pain should be controlled with ***morphine*** (2·5 - 5 mg) until symptomatic relief has been achieved. An anti-emetic should always be given with the initial dose (***metoclopramide*** 10 – 20 mg IV or ***cyclizine*** 50 mg IV) as nausea and vomiting are likely with an opiate given alone.

Mild post-infarction chest discomfort is not uncommon on the second or third day, and a milder oral analgesic such as ***cocodamol*** (***paracetamol*** 500 mg + ***codeine phosphate*** usually 30 mg) or ***paracetamol*** alone may be appropriate. ***NSAIDs*** should generally be avoided where possible, although may have a role to play when pain is consistent with pericarditis.

For anxious patients, short-term use of anxiolytics such as ***diazepam*** is not inappropriate.

Oxygenation

Oxygen therapy is only beneficial in patients who have significant hypoxaemia, in particular those with pulmonary oedema or low output cardiogenic shock. There is no evidence that routine ***oxygen*** therapy is beneficial ([25]). In this situation ***oxygen*** should be administered using a 35% mask or nasal cannula unless there is a contra-indication. CPAP may be of value in severely hypoxic patients (arterial PO_2 < 8.0 kPa/60 mm Hg, despite 100% ***oxygen*** at flow rate of 8 - 10 L/min.). Discuss the need with duty SpR/anaesthetist before using this, as mechanical ventilation may be more appropriate. Taking blood gases should generally be avoided in patients whom thrombolytic or ***glycoprotein IIb/IIIa inhibitors*** (***GP2b3al***) are being employed or contemplated. ***Oxygen*** saturations should be monitored in this situation with pulse oximetry.

Aspirin

Aspirin should be given to nearly all patients with myocardial infarction as this has a significant impact on mortality [(26)]. For every 1000 patients treated, ***aspirin*** started within 24 hours of onset of infarct symptoms prevents around 40 vascular events (vascular deaths, non-fatal re-infarctions or strokes) in the first month and about 40 more over the next two years. If not already administered, all patients should be given ***aspirin*** 300 mg and instructed to chew the tablet. Thereafter ***aspirin*** 75 mg OD should be prescribed. There is a considerable body of evidence supporting the role of ***aspirin*** in secondary prevention of myocardial infarction [(27)]. If dyspepsia is a

problem this can occasionally be overcome by the concomitant use of ***H_2 blockers*** such as ***ranitidine*** 150 - 300 mg BD or a ***PPI*** such as ***lansoprazole*** 15 - 30 mg OD. All patients with known or suspected coronary disease should be taking ***aspirin*** unless contraindicated. In elderly patients taking dual ***antiplatelet*** therapy there should be a low threshold to introduce a ***PPI***.

Prasugrel

Prasugrel is a thienopyridine and works in a similar way to ***clopidogrel***, by inhibiting platelets' ADP receptors to achieve its ***antiplatelet*** effects. The onset of action is significantly quicker with ***prasugrel*** compared to ***clopidogrel***. ***Prasugrel*** is administered as a loading dose of 60 mg followed by 10 mg daily (for up to 12 months). There is recent evidence that crushing ***prasugrel*** leads to faster drug absorption, and consequently, more prompt and potent antiplatelet effects compared with whole tablet ingestion.

Guidance from the National Institute of Clinical Excellence (NICE) states that ***prasugrel*** should be used alongside ***aspirin*** in place of ***clopidogrel*** in patients presenting with STEMI who require treatment with PPCI ([28]), and in those who have suffered stent thrombosis whilst on ***clopidogrel*** therapy.

The pivotal trial for ***prasugrel***, TRITON-TIMI 38, focused on patients with ACS who were referred for PCI ([29]). A weakness of the trial was that the loading dose of ***clopidogrel*** in the comparison group was 300 mg whereas most recommendations now are that the loading dose of ***clopidogrel*** should be 600 mg ([30]).

Nevertheless, particular benefit is apparent in patients with diabetes and those under the age of 75. **It is contraindicated in patients who have had prior stroke or TIA and should be avoided in patients who weigh less than 60kg.**

In UHL its use is restricted to patients undergoing PPCI for STEMI who are under the age of 75 and who weigh more than 60kg and who have not had a prior TIA or stroke.

Clopidogrel

Clopidogrel can be administered to patients with STEMI undergoing PPCI who do not fulfil the criteria for ***prasugrel***, using a loading dose of 600 mg ([30]). ***Ticagrelor*** is generally preferred however in this situation. Consideration should be given to administering ***clopidogrel*** at a dose of 150 mg for the first week and then 75 mg daily [(31)]. Duration will usually be for 12 months regardless of the stent deployed, but check with the consultant responsible. The evidence for routine ***clopidogrel*** (75 mg OD) in patients who do not undergo PCI for STEMI is weaker and certainly there is little evidence that continuing ***clopidogrel*** beyond 4 weeks is helpful ([32-34]). ***Clopidogrel*** should be used for the few patients treated with thrombolysis.

There has been considerable controversy regarding the use of ***proton pump inhibitors*** (***PPIs***) with ***clopidogrel***. Some retrospective studies had raised concerns that such treatment might reduce the cardiovascular efficacy of ***clopidogrel*** ([35;36]). A randomised controlled trial of 3627 patients taking ***aspirin*** and ***clopidogrel*** randomised to ***omeprazole*** or placebo found no difference in vascular outcomes between groups ([37]). Other studies support these findings ([38;39]) suggesting that ***PPIs*** have little, if any, effect on the in vivo efficacy of ***clopidogrel***. A recent North American cardiology and gastroenterology consensus guideline has now recommended that patients taking ***clopidogrel*** and ***aspirin***, who were deemed at

risk of upper GI bleeding, should be co-prescribed ***PPIs***, because of their protective effect ([40]).

Patients on ***warfarin*** who require ***aspirin*** and ***clopidogrel*** therapy should be discussed at consultant level before any antiplatelet platelet or anticoagulation medication is discontinued. Management decisions need to be made on a case-by-case basis (see later '***triple anticoagulation***' page 59).

Ticagrelor

Ticagrelor is a non-thienopyridine ADP receptor blocker causing reversible inhibition of platelet function and has been compared with ***clopidogrel*** in the PLATO study [(41)]. It confirmed a significant improvement of combined clinical endpoints including mortality. ***Ticagrelor*** is given as a loading dose of 180 mg daily followed by 90 mg BD. For patients who cannot have ***prasugrel*** (prior stroke, weight < 60 kg, age > 75) in STEMI, ***ticagrelor*** should be considered in preference to ***Clopidogrel***. ***Ticagrelor*** is the first choice drug in patients with confirmed acute coronary syndrome (NSTEMI) whether or not they undergo PCI. It should be given for 12 months in the context of ACS. A side effect to be aware of is dyspnoea which can occur at rest.

Primary Angioplasty (PPCI)

Primary angioplasty is defined as PCI (percutaneous coronary intervention) performed as the primary (without thrombolysis) therapeutic measure in patients presenting with myocardial infarction. Restoration of normal flow in the culprit artery is achieved in over 95% in most studies with significant long-term benefits ([42-45]).

PPCI should be considered in all patients presenting with STEMI if symptom onset is within 12 hours. PCI should also be considered if there is clinical and/or ECG evidence of on-going ischaemia, even if, according to the patient, symptoms started > 12 hours before as the exact onset of symptoms is often unclear. Ideally PPCI should be performed within 2 hours of first medical contact. If it is likely that delay to treatment is going to be greater than 2 hours serious consideration should be given to administration of a lytic agent ([46]).

In office hours patients should be taken directly to the catheter lab and an assessment made en route. The procedure needs to be explained to the patient ready for obtaining consent. Written consent is NOT mandatory. All delays need to be minimised. An effort should be made to document timings as follows: time of onset of symptoms, time of call for help, time of crew arrival and time of arrival in hospital and time of arrival in the lab. **Auscultation of the heart and chest is mandatory before the procedure**.

Patients should be administered ***aspirin*** and ***prasugrel*** (or ***clopidogrel*** or ***ticagrelor***) as outlined previously (page 49). In most cases ***aspirin*** should be subsequently given for life.

PPCI usually involves the use of anticoagulants which may include ***UFH***, ***abciximab*** or ***tirofiban***. ***UFH*** should still be administered to patients who are on anticoagulant therapy already but stopped immediately on completion of the procedure. ***GP2b3aI*** should generally be avoided in this scenario. It is worth noting at this point that in patients undergoing elective PCI who are on oral anticoagulant therapy, additional parenteral ***anticoagulation*** is NOT indicated (as long as INR > 2·5).

If ***UFH*** is used alone, the dose is usually 70-100 IU/kg aiming for an ACT of 250 - 330s.

Abciximab is used occasionally if there is clear evidence of thrombus. (0·25 mg/kg IV bolus followed by infusion of 0·125 µg/kg/min up to a maximum of 10 µg/min for 12 hours). ***UFH*** is also given as a bolus dose of 60 IU/kg. The ACT should be maintained at 200 - 250s). ***Tirofiban*** (25 µg/kg bolus over 3 minutes followed by continuous infusion of 0·15 µg/kg/min) has been evaluated in a number of trials involving patients with STEMI and is an alternative to ***abciximab***.

Patients should be assessed carefully after procedures for signs of bleeding, especially from sites of vascular access. Unexpected hypotension may be due to occult blood loss related to retroperitoneal bleeds, haemopericardium or GI bleeds and these conditions need to be considered. Groin complications are not uncommon and imaging with ultrasound may be indicated to exclude false aneurysms etc. CT scanning may be necessary. Similar assessment should follow elective angiographic procedures. Vascular complications from radial procedures are unusual but patients must still be assessed carefully. Many patients can be discharged within 2 to 3 days after treatment with PPCI if they do not have evidence of heart failure and have not demonstrated any significant arrhythmias.

Out of Hospital Cardiac Arrests

Patients who have sustained a cardiac arrest in the community are admitted directly to Glenfield if thought to be cardiac (documented VT/VF or ECG changes consistent with ACS). Patients are pre-alerted by the paramedic crews and cardiology anaesthetic teams are activated.

Many patients are taken directly to the catheter lab if there is ROSC in much the same way as for PPCI in usual STEMI cases. Some patients will be undergoing CPR with a LUCAS device.

There are however specific issues pertaining to ventilated patients. Blood gases should be obtained as soon as possible - but this should not delay the undertaking of the angiogram as gases can be obtained after vascular access has been achieved. Severely acidotic patients have a poor prognosis.

The administration of DAPT poses particular challenges.

- NG tubes are <u>not</u> to be inserted in CCU for DAPT.
- NG tubes can be inserted in the catheter lab if it doesn't delay the angiography procedure by several minutes.
- DAPT is to be administered only after confirmation of NG position by X-ray screening and confirmation the case is a STEMI requiring PCI.
- If there is a potential for major delay the NG tube can be inserted in ITU and DAPT administered after screening or confirmation with pH testing (time critical – so must be done as soon as possible).

Ventilated patients are cared for on ITU and are usually cooled to reduce the risk of brain injury. The responsible interventionist should continue to provide cardiology input. If unavailable, the CCU consultant on call should be involved.

Thrombolysis

Thrombolysis is now rarely administered in UHL. A tiny proportion of patients will however have received thrombolysis by a referring hospital.

If given within 6 hours there is proven benefit in patients with ECG evidence of STEMI ([47-50]). **THE EARLIER TREATMENT IS GIVEN, THE GREATER THE BENEFIT** ([51;52]). ***TNK (tenecteplase)*** is the agent available in CCU. The dose is weight adjusted:

- Less than 60 kg: 30 mg IV bolus administered over 10 seconds
- 60 to less than 69 kg: 35 mg IV bolus administered over 10 seconds
- 70 to less than 79 kg: 40 mg IV bolus administered over 10 seconds
- 80 to less than 89 kg: 45 mg IV bolus administered over 10 seconds
- 90 kg or greater: 50 mg IV bolus administered over 10 seconds

In patients treated with thrombolysis, verbal consent should be obtained and recorded in the notes. Patients should be aware that there is a 0·5% risk of major haemorrhagic complications, including stroke.

Absolute contra-indications to thrombolysis are:

- Recent stroke (2 months)
- Recent head trauma (4 weeks)
- Uncontrolled hypertension (BP >180/110 mmHg)*
- Aortic dissection
- Recent surgery - including dental extraction
- Acute pancreatitis
- Lumbar puncture (within 4 weeks)
- Concurrent ***anticoagulation*** (unless INR < 2·0)
- Pregnancy or < 18 weeks postnatal
- Active GI blood loss
- Active pulmonary disease with cavitation
- Severe liver disease or clotting disorder
- Cerebral neoplasm
- Oesophageal varices

* Significant hypertension should be controlled as quickly as possible employing IV antihypertensive agents such as ***atenolol*** (5 - 10 mg), ***metoprolol*** (5 - 15 mg), ***labetalol*** (see page 197), ***sodium nitroprusside*** (0·5 - 10 µg/kg/min, see page 199), ***GTN*** (10 - 200 µg/min), or ***isosorbide dinitrate*** (1 - 10 mg/hr).

CPR is not an absolute contraindication, especially if the resuscitation was not significantly prolonged or traumatic, neither is diabetic retinopathy.

Bleeding Problems after Thrombolytic Therapy

The major serious complication associated with thrombolysis is haemorrhage and, if intracranial, this may be fatal. The incidence of major haemorrhagic complications is in the region of 0·5%.

If major bleeding complications occur the infusion should be stopped (including ***UFH*** if given) and a full coagulation screen taken (FBC, INR, APTT, thrombin time, fibrinogen and D-dimers). The haematologist on-call should be consulted.

If bleeding is serious and life-threatening give ***tranexamic acid*** 1g IV over 15 minutes whilst awaiting coagulation indices.

When thrombin time and INR are prolonged but fibrinogen > 1 g/L give 15 ml/kg of ***FFP*** and 1 adult therapeutic dose (ATD ~ 330 ml) of ***cryoprecipitate***.

When thrombin time is prolonged and fibrinogen is low (< 1 g/L), give 1 ATD of ***cryoprecipitate***.

If on-going bleeding occurs ***tranexamic acid*** can be given at 8 hourly intervals.

Recognition & Management of Failed Thrombolysis

Some patients will have continuing symptoms and/or ECG changes following thrombolysis. They form a subgroup in which management decisions are not straightforward.

Even with the best thrombolytic regimen, normal (TIMI 3) flow in the culprit coronary artery is achieved and maintained in less than 50% of patients treated. ST segment resolution is currently the most useful simple guide to vessel patency after thrombolysis and also correlates with outcome (30 day mortality in the INJECT study) [53]. Analysis from data in the GISSI-2 trial suggested that reduction of ST-segment elevation by > 80% accurately determined which patients had successfully reperfused [54]. This data is based on mortality statistics however, rather than angiographic findings. Overall, the changes are not sensitive and specific enough for clinical purposes [55]. In one study it was suggested that a 20% decrease in ST-segment elevation predicted coronary artery patency with a high degree of accuracy [56].

It is recommended that a 12 lead ECG is performed at 60 - 90 minutes following lytic therapy and if there has not been greater than 50% resolution of ST elevation and there are on-going symptoms, patients should be considered for rescue PCI as the REACT study revealed clear benefit from this strategy ([57;58]). Patients within 6 hours of myocardial infarction are those most likely to benefit.

Please be aware that some patients will have chronic ST elevation following previous infarction and will subsequently be found to have normal cardiac enzymes.

Early SpR or consultant input is required in the decision-making processes.

Rescue PCI

This is defined as PCI following perceived failed thrombolysis. Rescue PCI should be considered in those patients who have received thrombolytic therapy who have on-going ischaemic chest pain with failure of resolution of the ST elevation of more than 50% at 60 - 90 minutes (and who are within 12 hours of the onset of symptoms). Patients should be treated as for PPCI and preloaded with ***clopidogrel***, ***prasugrel*** or ***ticagrelor*** (they should already have had ***aspirin***, but check).

A recent meta-analysis, including REACT, showed that rescue PCI is associated with a significant reduction in heart failure and reinfarction and a trend towards lower all-cause mortality when compared with a conservative strategy, at the cost, however, of an increased risk of stroke and bleeding complications ([59]). Patients should be assessed carefully post-procedure to look for bleeding as patients undergoing rescue PCI are at much higher risk of haemorrhagic complications.

Treatment of Patients Who Do Not Receive Lysis or PPCI

If it is decided that reperfusion therapy is not appropriate on admission, give ***aspirin*** as for usual STEMI management and ***enoxaparin***. In OASIS-6, ***fondaparinux*** was superior to ***UFH*** in a subgroup of 1641 patients and might be the preferred antithrombin for this indication ([60]). In most patients who did not receive reperfusion therapy, angiography before hospital discharge should be considered if there are no

major contraindications (co-morbidity, frailty etc), similar to patients after successful lysis (see below).

Delayed Angiography/PCI

Patients who appear to have had successful lysis should still be considered for angiography ideally within a few hours of admission. In the CARESS trial, a strategy of sending patients for angiography only in the case of failed lysis was associated with a worse clinical outcome when compared with a strategy of referring all patients for angiography and (if indicated) PCI ([61]). A time window of 3 - 24 hours following lysis is recommended ([62-65]). In patients presenting days after the acute event with Q waves, only patients with recurrent angina and/or documented ischaemia with proven viability benefit from revascularisation.

Management of No Reflow in the Catheter Lab

No reflow is seen not uncommonly in the context of PPCI and also in PCI for NSTEMI patients. It is associated with worse outcomes. Management includes the use of intracoronary ***isosorbide dinitrate*** (1 - 2 mg boluses) ***adenosine*** (30 - 60 µg) or ***verapamil*** (0·5 - 1·0 mg). ***Nitroprusside*** given as boluses of 0·6 µg/kg is an alternative. ***Abciximab*** may also have a role to play. There is some evidence that aspiration of thrombus may improve outcomes ([66]).

Emergency CABG

Emergency surgical revascularisation should be considered in the context of STEMI where there is failed PCI or unfavourable anatomy only when there is a large area of myocardium at risk and surgery can be performed within 3 - 4 hours of onset (before myocardial necrosis). In the absence of persistent pain or haemodynamic deterioration, a waiting period of 3 - 7 days appears to be the best compromise ([67]).

Medications

Beta Blockade

β-blockade is currently underused nationally and **SHOULD BE CONSIDERED IN ALL SUITABLE CASES LIKELY TO BENEFIT**. There is good evidence that early ***β-blocker*** therapy is beneficial [(26;68)], although patients with extensive myocardial infarction and a bradycardia may deteriorate. Benefit is probably greater if ***β-blockade*** is given early and is possibly due to a reduction in cardiac rupture on day one. If the patient is haemodynamically stable (heart rate > 80, systolic BP > 110 mmHg, and no overt signs of failure) a ***β-blocker*** should be administered at the first opportunity.

β-blockade may be particularly beneficial in patients with a tachycardia (rate > 110) and hypertension (systolic BP > 160 mmHg) on admission when treatment reduces cardiac oxygen demand (and therefore reduces infarct size and peri-infarct ischaemia) and also reduces the risk of cardiac rupture and cerebral haemorrhage in patients who have received thrombolysis. ***β-blockade*** is also indicated in all patients with unstable angina or post-infarct angina.

There is evidence of benefit from long-term ***β-blockade*** after hospital discharge. Trials of ***metoprolol*** and ***propranolol*** have also been favourable ([68;69]). ***Bisoprolol*** is the main ***β-blocker*** employed in UHL post-MI, and is licensed for use in the context of LV dysfunction. Patients with myocardial infarction should usually be

discharged on a ***β-blocker*** unless there are contraindications or unacceptable side effects. Treatment should be continued for at least 12 months.

β-blockers should initially be avoided if sinus tachycardia is secondary to cardiac failure, shock or hypotension. They should still be considered prior to discharge in patients who have had transient failure. In patients with evidence of significant LV dysfunction, only two ***β-blockers*** are licensed for use: ***Bisoprolol*** and ***carvedilol*** (see page 124).

β-blockers should be avoided in severe airways disease (relative contraindication in COPD although usually well tolerated), patients with second or third degree heart block, and severe peripheral vascular disease (relative contraindication).

Calcium Antagonists

There is weak evidence that ***verapamil*** 120 mg TDS is an alternative to ***β-blockers*** in secondary prevention after myocardial infarction in patients in whom ***β-blockade*** is contraindicated [70]. ***Verapamil*** should be used with caution in patients with impaired LV function and should NOT be used in combination with a ***β-blocker***.

Diltiazem, a non-dihydropyridine ***calcium antagonist***, has showed possible benefit in patients with NSTEMI [71]. In patients who have received thrombolysis, ***diltiazem*** may reduce further non-fatal events and the need for revascularisation, but does not appear to impact on mortality [72].

The dihydropyridine group of ***calcium antagonists*** (***nifedipine***, ***nicardipine***, ***amlodipine***, ***lercanidipine***, ***felodipine***) should generally <u>not</u> be used after myocardial infarction and may cause adverse effects.

Nitrates

IV ***nitrates*** should be used in patients with unstable angina and in patients with angina post infarction. Both ISIS 4 and GISSI 3 have shown no benefit from the <u>routine</u> use of ***nitrates*** after myocardial infarction ([73;74]). They are also useful in patients with heart failure following myocardial infarction and in the management of hypertension in the setting of myocardial infarction. Care should be taken in patients with suspected right ventricular infarction as giving ***nitrates*** may result in hypotension.

ACE Inhibitors

ACE inhibitors (***ACEI***) have been shown to reduce the development of progressive LV dilatation and reduction in LV performance seen following myocardial infarction. Studies have also suggested a reduction in late cardiac failure, myocardial infarction and death ([73-76]).

In general, patients with anterior myocardial infarction or clinical signs of heart failure should receive treatment with an ***ACEI*** unless there is a contraindication. Similarly, patients with a history of prior infarction should receive an ***ACEI*** prior to discharge. Of proven benefit after myocardial infarction are ***captopril*** (6·25 mg increasing in stages to a maintenance dose of 12·5 - 50 mg TDS), ***enalapril*** (2·5 - 10 mg BD or 2·5 - 40 mg OD), ***lisinopril*** (2·5 - 40 mg OD), ***ramipril*** (2·5 - 5 mg BD or 5 - 10 mg OD) and ***trandolapril*** (0·5 - 4 mg OD). It is likely that there is a class effect and other available ***ACEI*** including ***perindopril*** (2 - 8 mg OD) may be equally effective.

Treatment should generally be started after 24 - 48 hours and certainly should be used in any patients subsequently shown to have impairment of LV function (EF <

40%) on echo. Generally speaking, the dose of the ***ACEI*** should be increased to the maximum dose according to tolerability. Gentle titration over a few weeks is advisable.

Any patients with a high risk of vascular events should be considered for treatment with an ***ACEI*** in light of data from the HOPE study [77;78]. Diabetic patients in particular may benefit from this strategy [78].

Angiotensin Receptor Blockers

Trial evidence suggests that ***angiotensin II receptor antagonists*** (***ARBs***) such as ***losartan*** 25 -150 mg OD, ***valsartan*** 40 - 160 mg BD and ***candesartan*** 4 - 32 mg OD are an effective alternative to patients intolerant of ***ACEI*** ([79-81]). ***Valsartan*** has been shown to be as effective as ***captopril*** in patients post-myocardial infarction who have LV dysfunction or symptomatic heart failure ([82]), and is licensed for use in this situation. As with ***ACEI***, the dose of ***valsartan*** should be started low (at 20 - 40 mg BD) and titrated up to the maximum dose of 160 mg BD over the first few weeks according to tolerability. ***Candesartan*** is also licensed for use in patients with heart failure ([81]).

Lipid Lowering Therapy

Lipids should be measured in ALL patients on admission and therapy started with a ***statin*** (***simvastatin*** 40 mg OD, ***atorvastatin*** 10 - 80 mg or ***rosuvastatin*** 5 - 10 mg OD). In patients presenting with a recent acute coronary syndrome there is evidence that high intensity ***statin*** therapy for a period is beneficial employing ***atorvastatin*** 80 mg or ***rosuvastatin*** 5 - 10 mg OD ([83]). Patient selection is important and caution should be applied in the elderly. In Asian patients ***rosuvastatin*** should be started at 5 mg OD and doses of 40 mg OD are contraindicated.

There is now evidence that all cardiac patients, regardless of the cholesterol level, benefit from ***statin*** therapy. The Heart Protection Study showed that treatment with ***simvastatin*** 40 mg reduced the rates of myocardial infarction, of stroke, and of revascularisation by at least one-quarter irrespective of the initial cholesterol concentration [84].

The target is to reduce LDL-C < 1·8 mmol/L or a 40% reduction in non-HDL-C. Total cholesterol target should ideally be < 4·0 mmol/L.

In patients already established on a full dose ***statin*** (especially a more potent ***statin***), whose lipid profile is still not within target range, co-administration of the ***statin*** with ***ezetimibe*** 10 mg OD (which inhibits intestinal absorption of cholesterol) should be considered ([85;86]). A recent trial (IMPROVE-IT) presented at the AHA in November 2014 showed that adding ***ezetimibe*** to ***simvastatin*** reduces cardiovascular events in high-risk patients with ACS ([87]).

In patients intolerant of ***statins***, ***fibrates*** should be considered (***bezafibrate****:* ***Bezalip-Mono***® 1 tablet OD or ***fenofibrate*** 160 mg OD). They are particularly useful in patients with low HDL levels or high triglyceride levels. Trials have shown the benefit in using these drugs as secondary prevention after acute cardiac events [88;89]. It is worth emphasising however that in patients who have been intolerant of ***statins*** previously, may not be intolerant of all ***statins***, and may be successfully reintroduced to ***statins*** if lower doses are employed than previous. In addition, ***rosuvastatin*** may be better tolerated in this scenario. ***Ezetimibe*** monotherapy should also be considered if statin intolerant.

Patients with raised lipids who cannot take statins, and patients with familial hyperlipidaemia, should be referred to the lipid clinic for consideration of the administration of monoclonal antibodies that inhibit PCSK9 (NICE have approved two agents in the UK: ***evolocumab*** and ***alirocumab***).

Management of Diabetic Patients

Impaired control of pre-existing diabetes is common in the setting of an acute cardiac event and is associated with poorer outcomes ([90;91]). As a result attempts should be made to ensure good glycaemic control. This is usually achieved by the use of ***insulin*** infusions in patients presenting with a laboratory (not glucose meter) blood glucose on admission > 11·0 mmol/L (even if not known to be diabetic).

Although tight glycaemic control appeared to improve mortality in the DIGAMI Trial ([91]), in the DIGAMI-2 study mortality did not differ between patients subsequently left on ***insulin*** and those changed to oral agents ([92]).

From extrapolating data from a variety of studies and publications, the main benefit is seen by keeping glucose levels within normal ranges (5 and 7·8 mmol/L). In patients not previously on diabetic therapy oral agents should probably be preferred. Care needs to be taken to avoid blood glucose levels below 4 mmol/L. In patients who are critically ill, such as those with cardiogenic shock, blood glucose levels should be ideally kept between 7·8-10 mmol/L with ***insulin*** infusions.

An HbA1c should be measured on all known or suspected diabetic patients on admission. HbA1c is now expressed in percentages. A level > 6·5% is diagnostic of diabetes. A level between 6·0 and 6·4% is consistent with impaired glucose tolerance.

Target for Type 1 diabetes is < 7% and type 2 diabetes 6·5 - 7·5%.

Advice of the diabetes nurse specialist or team should be sought.

In patients started on ***insulin*** for the first time, ***insulin*** should probably be continued for a minimum of three months and then reviewed in the diabetes clinic. Referral to the local diabetes Clinical Nurse Specialist Team is essential to arrange education and follow-up as necessary. Ensure discharge letters go to the diabetologist.

Metformin should be recommenced with caution in any patient with evidence of LV dysfunction.

Hypertension

Patients with coronary artery disease should have strict control of blood pressure. Secondary prevention guidelines recommend blood pressure should be maintained at 130/80 or less ([93]).

For diabetic patients, particularly those with renal impairment, tighter control of 130/80 or less should be aimed for. How this is achieved is obviously tailored according to the needs of the individual patient, although ***β-blockers*** and ***ACEI*** should be used as first line agents in patients who have sustained a myocardial infarction. What matters most is that blood pressure is controlled.

Anticoagulation

The benefit of routine ***anticoagulation*** in all patients following myocardial infarction is unproven. A period of ***low molecular weight heparin*** (***LMWH***) may be worthwhile in extensive anterior infarction to reduce the risk of mural thrombus, and in obese

immobile smokers to reduce the risk of DVT/PTE. It is mandatory to assess all patients for DVT risk.

Continued ***anticoagulation*** with ***warfarin*** is indicated in proven mural thrombus (3 months ***anticoagulation*** or until thrombus resolution) or in patients with atrial fibrillation.

The use of ***GP2b3aI*** in combination with thrombolysis cannot be recommended as routine in the setting of STEMI. In two major trials, there was no reduction in thirty-day mortality. Although lower rates of in-hospital reinfarction were observed, this was at the expense of an excess of bleeding complications ([94;95]). They do have a role to play in the setting of primary and rescue angioplasty however. In addition, they are used in the setting of unstable angina and NSTEMI (see page 68).

'Triple Anticoagulation'

Many patients who require dual antiplatelet therapy (DAPT) after PCI will either be established on long term ***warfarin*** or a ***DOAC*** or will subsequently require ***anticoagulation*** after DAPT, most commonly for atrial fibrillation.

So-called '***triple anticoagulant***' or '***triple therapy'*** regimes employing ***aspirin***, ***clopidogrel*** and ***warfarin*** or ***DOAC*** are associated with an increased risk of bleeding which is not nullified completely by the addition of antacid therapy, although all patients in this situation should have gastric protection with a ***PPI***. Triple therapy with ***prasugrel*** or ***ticagrelor*** should generally be **avoided** because of the increased risk of bleeding compared with ***clopidogrel***.

One option is to use bare metal stents so the duration of DAPT can be reduced. That is reasonable for elective PCI procedures, but there is still evidence of benefit when DAPT is continued for 12 months after PCI for ACS. Some of the latest generation drug-eluting stents also have accumulating evidence for reduced duration DAPT therapy (BioFreedom, Synergy, Xience Alpine, Lumeno Free).

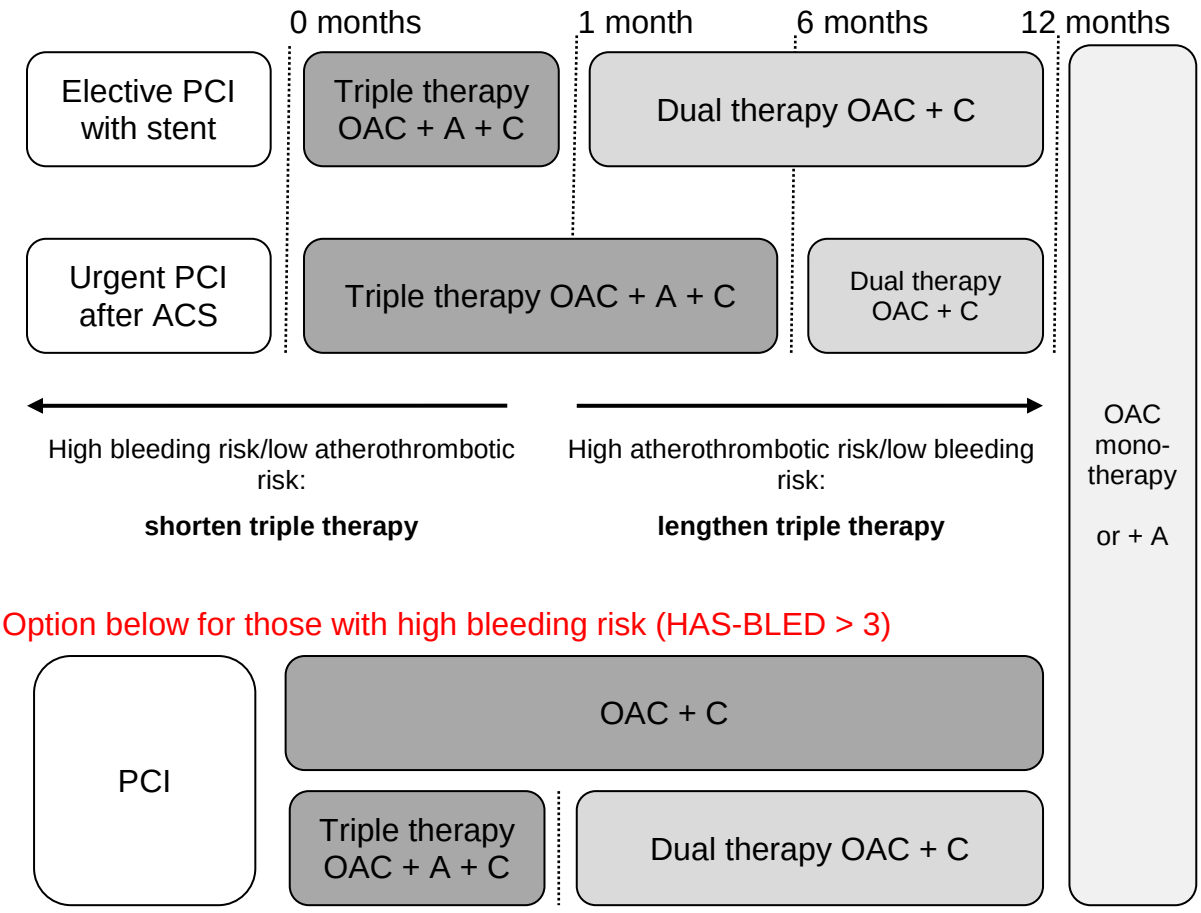
The decision needs to be based on the individual patient and the need for ***anticoagulation*** (partly dependent upon the CHA_2DS_2-VASc score in AF). In patients with recurrent PTE disease or particularly metallic valves, ***warfarin*** is essentially mandatory (although the ***DOACs*** should be considered in PTE disease). In this situation, consideration, when using ***warfarin***, should be given to keeping the INR strictly between 2 and 2·5 for PTE patients (or change to a ***DOAC***), and 2·5 and 3 for metallic valves.

Essentially the duration of triple therapy should be decided by weighing up the bleeding risk on triple therapy versus the ischaemic risk. Risk calculators for DAPT are available online and as smartphone apps (DAPT Risk calculator and Precise DAPT) which determine bleeding risk on DAPT alone. The HAS-Bled score (see page 103) gives additional information on bleeding risk with ***anticoagulation***. Smartphone apps are available.

The ischaemic risk is higher in those with prior stent thrombosis, stenting of the last remaining patent artery, diffuse multivessel disease (especially diabetics), CKD, multiple stents, multiple stented lesions, bifurcation stenting, long stented segments (> 60 mm) and CTO PCI.

Generally speaking the aim should be to minimise the duration of triple therapy. In the following table 'OAC' refers to drugs that have current trial evidence

(***rivaroxaban*** and ***dabigatran***), and these ***DOACs*** should be preferred. In patients where ***warfarin*** is mandatory similar considerations should apply.



There is some evidence from the WOEST Trial that using ***clopidogrel*** alone with ***warfarin*** is safe with no increased risk of stent thrombosis, stroke or MI compared to the triple therapy of ***aspirin***, ***clopidogrel*** and ***warfarin*** ([96]). A more recent study ISAR-TRIPLE, indicate that 6 week duration of triple therapy is not superior to 6 month duration of triple therapy in patients undergoing PCI, who also had an indication for ***anticoagulation*** use ([97]).

Emerging information is available about the use of ***DOACs***. ***Rivaroxaban*** was studied in the ATLAS Trial in ACS patients ([98]). The concern however is that the dose used was lower (2·5 mg BD) than the standard dose indicated in patients who do not require DAPT. A more recent trial, from the same investigators, suggested a lower incidence of stent thrombosis and a reduction in mortality ([9]). The Pioneer AF-PCI study looked at using ***rivaroxaban*** 2·5 mg BD with DAPT, versus ***rivaroxaban*** 15 mg OD (a dose used in AF) with a single ***antiplatelet*** (mostly ***clopidogrel***) versus ***warfarin*** (INR 2-3) and DAPT ([99]). DAPT duration was 1, 6 or 12 months. The ***rivaroxaban*** strategy was associated with a lower risk of bleeding. There is therefore the option to consider particularly the option of ***rivaroxaban*** 15 mg OD and ***clopidogrel*** alone.

It is likely that reduced dose ***DOAC*** with a $P2Y_{12}$ inhibitor will be an option as the recently published RE-DUAL PCI study employing reduced dose ***dabigatran*** (110 mg BD) with mostly ***clopidogrel*** had similar safety and efficacy as the PIONEER AF-PCI study ([100]).

Studies of ***edoxaban*** and ***apixaban*** are ongoing.

Switching $P2Y_{12}$ receptor drugs (Clopidogrel, Prasugrel and Ticagrelor)

There are occasions when there may be reason to consider switching $P2Y_{12}$ drugs. Reloading with the new drug is recommended for all agents in the acute setting. Switching to ***prasugrel***/***ticagrelor*** can be done irrespective of prior ***clopidogrel*** timing and dosing. Switching ***prasugrel*** and ***ticagrelor*** to other agents has to be done 24 hours after last dose.

In the chronic setting reloading with ***clopidogrel*** is always required. If switching from ***ticagrelor*** to ***prasugrel***, the latter needs to be reloaded.

MANAGEMENT OF LEFT VENTRICULAR FAILURE

Early LVF

Basal crepitations on auscultation and/or minor changes on CXR (without significant dyspnoea) are rapidly treated with oral diuretic therapy with ***furosemide*** 40 - 80 mg or ***bumetanide*** 1 - 2 mg. If there is concern about low serum potassium, ***co-amilofruse 5/40*** (combined ***amiloride*** and ***furosemide***) is an alternative. If there is clear evidence of LVF associated with an extensive myocardial infarction (and large enzyme rise) start treatment with an ***ACEI*** 24 hours post MI [101] while awaiting confirmation with echocardiography. For those intolerant of ***ACEI***, an ***ARB*** (***valsartan***, ***candesartan***) can be used.

Eplerenone is a selective aldosterone antagonist licensed for use in stable patients with systolic dysfunction and evidence of heart failure after a recent myocardial infarction ([102]). Initial dose is 25 mg OD.

Established Pulmonary Oedema

Significant dyspnoea associated with orthopnoea and often a productive cough with white, frothy sputum. The patient should be sat up and given ***oxygen*** together with **IV** loop diuretics ***furosemide*** 50 - 100 mg and ***morphine*** (2·5 - 5·0 mg) plus an anti-emetic. ***Furosemide*** may need to be re-administered at regular intervals. Oxygen saturations need to be monitored.

In more severe cases, IV ***GTN*** (starting at 2 mg/hr) should be given if systolic BP can be maintained above 90 mmHg. ***GTN*** should be avoided if there is evidence of right ventricular infarction. IV ***digoxin*** 0·5 mg over 30 minutes may occasionally help, but in the absence of atrial fibrillation should probably be avoided (see page 197). If there is associated bronchospasm, ***salbutamol*** 0·5 mg via nebuliser can be beneficial, as can ***aminophylline*** 250 mg IV slowly over at least 10 minutes can similarly be helpful but should be avoided if tachycardic. An urgent echo is indicated.

Non-invasive ventilation should be considered in more intractable cases and possibly mechanical ventilation if recovery is thought possible. Alternatively ***intraaortic balloon pump (IABP)*** support is likely to benefit the patient (see page 39).

LVF with Hypotension (Cardiogenic Shock)

In this scenario, cardiac output is low and dyspnoea may not be a dominant problem. Systolic BP is usually below 90 mmHg, and the patient may be pale and drowsy, with cool peripheries and oliguria. The JVP may be elevated and a gallop rhythm heard on auscultation. Specific management is warranted for severe mitral regurgitation which may be silent - and therefore echocardiography is indicated. Mortality is high (70%) with cardiogenic shock, and is usually inevitable if treatment and correction is delayed, so urgent active management is essential.

Intensive monitoring is important and should include an initial CXR, central line, urinary catheter, frequent automated BP measurement and a baseline echocardiogram. Renal function should be checked. Full invasive monitoring using a Swan-Ganz catheter (despite published limitations) and a radial artery cannula may be helpful in some cases.

Recommended management:

In addition to an **IABP**,

High concentration ***oxygen***. In the context of severe dyspnoea and acidaemia, CPAP should be considered.

Diuretics. Modest doses of IV ***furosemide*** (25 mg) may reduce pulmonary congestion without further reducing the BP.

Inotropes including ***dopamine*** and ***dobutamine*** may be beneficial.

Dopamine at lower doses (2·5 - 5·0 µg/kg/min) has a specific effect on dopaminergic receptors producing dilatation of renal, coronary, splanchnic and cerebral arteries and, at a higher dose (5 - 15 µg/kg/min); β_1-receptors are activated with positive inotropic and chronotropic effects. A true 'renal dose' is 1 - 3 µg/kg/min. At high dose (> 15 µg/kg/min), α receptors are also activated with undesirable vasoconstriction and reduced renal blood flow (see page 165).

Dobutamine (1 - 15 µg/kg/min) is a β_1-receptor agonist that does not activate dopaminergic receptors and has predominant positive inotropic effects with only a moderate activity on heart rate (see page 209).

Both ***dobutamine*** and particularly ***dopamine*** should ideally be infused via a central line.

Other inotropes such as ***digoxin*** may be beneficial, but should be avoided if there is significant bradycardia, ventricular arrhythmias or renal impairment.

Isoprenaline, ***adrenaline***, ***glucagon*** and ***salbutamol*** infusions have been used in the past, with limited benefit, and are not normally recommended in cardiogenic shock.

Vasodilators reduce peripheral resistance, improving cardiac output and organ perfusion, thus reducing ventricular work and myocardial oxygen consumption. In cardiogenic shock, arterial or combined arterial/venous dilators should be chosen. Their use should be monitored carefully and dosage reduced or stopped if the systolic BP cannot be maintained above 85 - 90 mmHg.

GTN (2 - 6 mg/hr) by infusion pump is the treatment of choice, especially if there is evidence of on-going ischaemia. ***GTN*** should be avoided if there is evidence of right ventricular infarction. Clearly care needs to be taken as all patients may subsequently drop their blood pressure.

Sodium nitroprusside should be reserved for when there is significant hypertension in the setting of myocardial infarction. ***GTN*** should be used in preference because of the possibility of coronary steal associated with the use of ***sodium nitroprusside*** [(103)]. If used the latter should be started at 10 - 15 µg/min and increased to a maximum of 400 µg/min. The infusion set should be foil wrapped and used within 24 hours.

ACEI given orally are preferable in chronic low output failure when the situation is more stable.

In patients who are not responding to diuretics, consideration should be given to the use of haemofiltration.

In severe intractable cases in which recovery is deemed possible, especially younger patients, ***ECMO*** should be considered.

All patients with cardiogenic shock should be commenced on prophylactic ***LMWH*** as the risk of thromboembolic complications is high. Consideration should be given to early revascularisation.

Right Ventricular Myocardial Infarction

Isolated RV infarction is uncommon but may complicate a large inferior myocardial infarction. Hypotension with an elevated JVP and absence of pulmonary oedema is suggestive. RV leads on admission are essential in the diagnosis and the most sensitive lead is RV4 [(24)]. Q waves with ST elevation in V1 - V3 is also a marker of RV infarction. Right ventricular leads should always be recorded in any patient presenting with an inferior or infero-posterior infarct immediately ON ADMISSION. Echo may also help and will exclude pericardial effusion and tamponade.

More commonly RV infarction causing hypotension occurs together with LVF and the management and diagnosis becomes far more complex. In this scenario, Swan-Ganz monitoring can prove useful. It helps to maintain the wedge pressure ~ 15 mmHg. To achieve this IV 0·9% ***sodium chloride*** needs to be given (200 - 250 ml over 10 minutes, followed by up to 2 litres in the first few hours and 200 ml/hr thereafter) to increase RV filling pressure [(104)]. If there is co-existing LVF (wedge pressure > 15 mmHg), inotropes (especially ***dobutamine***) should also be used [(105)]. Diuretics and vasodilators such as ***nitrates*** and ***ACEI*** should be avoided.

Pericarditis and Dressler's Syndrome

A localised pericardial rub is sometimes present within a few hours of anteroseptal infarction, and is usually transient and asymptomatic. A more generalised pericardial friction rub commonly occurs at 2 - 5 days following extensive STEMI, and is associated with typical pericarditic chest pain (sharp, worse on inspiration and on reclining). The pain usually responds readily to ***NSAIDs*** although their use (apart from ***aspirin***) should be strictly limited if possible in and around the time of myocardial infarction as ***NSAIDs*** may exacerbate infarct expansion [(106)]. In medium to long term use, ***Naproxen*** has been identified as having the safest CV risk profile of all ***NSAIDs***. ***Anticoagulation*** in these patients should be used with caution or with echo monitoring because of the theoretical risk of tamponade.

Dressler's syndrome occurs between 2 and 10 weeks following myocardial infarction. It is clinically indistinguishable from postcardiotomy syndrome. The pain is associated with a pericardial rub, transient pleural effusions, pyrexia, anaemia, and elevated ESR. ***NSAIDs*** are helpful, but occasionally ***steroids*** or ***colchicine*** may be required.

Tamponade is relatively rare following myocardial infarction and with Dressler's syndrome. If suspected clinically (elevated JVP, low BP with pulsus paradoxus – drop in BP on inspiration, quiet heart sounds etc.), an urgent echocardiogram should be arranged. Drainage of post-infarct pericardial effusions or effusions in other settings (uraemia, carcinoma, rheumatoid, etc.) should generally be performed under X-ray screening by experienced cardiologists and with echocardiography equipment and sonographers immediately available.

Pyrexia post MI

Low grade pyrexia is very common following MI and does not necessarily indicate infection. The use of antibiotics should generally be avoided unless there are clear signs of infection.

MECHANICAL DEFECTS AFTER MYOCARDIAL INFARCTION

Severe Mitral Regurgitation

Mitral regurgitation is common in the first few days after STEMI. It can occur due to annular dilatation secondary to LV dysfunction, papillary muscle dysfunction or rupture following an inferior myocardial infarction (the posteromedial papillary muscle is supplied by the posterior descending artery branch of the RCA or circumflex). It is more commonly due to papillary muscle dysfunction rather than rupture. The patient usually presents 2 - 7 days post myocardial infarction with severe orthopnoea and PND, hypotension, and there is usually a loud pansystolic murmur at the apex and left sternal edge. In some patients the murmur may be very quiet or absent and therefore an index of suspicion is required. The CXR usually shows pulmonary oedema and echocardiography is usually diagnostic. Urgent referral to GGH is warranted, as surgical repair may be required following stabilisation using an ***IABP*** (page 39) and angiographic assessment.

Ventricular Septal Defect

This is a now uncommon complication (1 - 2%) of STEMI involving the septum. Anterior or anterolateral infarcts are slightly more common (apical VSD) than inferior infarcts (basal inferior VSD) [107;108]. There is usually profound and sudden haemodynamic deterioration with hypotension. Dyspnoea is not usually a major feature. The JVP is often elevated and there is a loud pansystolic murmur at the left sternal edge, often with a thrill, and pulmonary plethora on CXR. Echocardiography is usually diagnostic but occasionally they can be missed. Urgent referral is required, as ***IABP*** (page 39) is a useful supportive measure prior to surgical repair or device closure. If patients are very elderly or have significant co-morbidity conservative therapy may be indicated, as operative mortality is extremely high [108]. Patients with VSDs in association with inferior infarction have a particularly high mortality (70%) [108;109].

Free wall rupture is usually fatal within a few minutes.

Left Ventricular Aneurysm

True aneurysm formation after full thickness myocardial infarction is not uncommon and usually presents 2 - 3 months following infarction with dyspnoea, hypotension and an abnormal parasternal pulsation. Occasionally troublesome ventricular arrhythmias may occur. Echo and LV angiography are helpful in diagnosis. Surgical resection may prove helpful. Patients with anteroapical infarcts are at greatest risk. A discrete posterobasal aneurysm may less frequently develop following infero-posterior infarction.

Myocardial rupture is usually rapidly fatal, but occasionally the rupture is contained and a ‘false’ aneurysm develops, which may be amenable to surgery.

Intracardiac Thrombus

Mural thrombi typically develop within the first week following anterior STEMI with expanded or aneurysmal akinetic or dyskinetic segments, especially those involving

the LV apex. The major risk is systemic embolisation. If LV thrombus is suspected or visualised on echocardiography, ***anticoagulation*** with therapeutic ***UFH*** or ***LMWH*** followed by ***warfarin*** is indicated. ***Warfarin*** should be continued for 3 - 6 months [110] (or until thrombus resolution).

Patients with atrial fibrillation following myocardial infarction are at increased risk of emboli from left atrial thrombi. These patients should also be anticoagulated with ***warfarin*** [111;112]. Because of lack of data, ***DOACs*** should not be used in this setting as the safety with ***prasugrel*** and ***ticagrelor*** is unknown. If atrial fibrillation occurs early post MI early cardioversion should be considered if ***anticoagulation*** is undesirable (such as patients requiring dual antiplatelet therapy).

Cardiac Rehabilitation & Secondary Prevention

All patients who sustain a myocardial infarction (including NSTEMI) should be referred for cardiac rehabilitation (CR). Patients should be seen prior to discharge from hospital and appropriate and willing patients will subsequently be followed up as outpatients and enrolled into a programme combining exercise with education. CR provides a whole range of supportive services and education. For more information regarding the components of CR see the following link:

http://www.bacpr.com/resources/46C_BACPR_Standards_and_Core_Components_2012.pdf

All patients should be advised to have annual vaccination against influenza.

Smoking There is overwhelming evidence that smoking cessation results in more than halving of mortality compared to those who continue to smoke ([113]). One observational study in those with angina indicates the benefits of smoking cessation ([114]). Those who continued had around five times the risk of a coronary event over ten years than those who quit. The benefit falls with increasing age. Observational studies also show that patients post MI who continue to smoke are at an increased risk of death of around 50% over five years compared to those who stop [115;116]. Patients who have had CABG and who smoke have also been shown to have a reduced survival ([117]) and an increase in non-fatal MI and angina relative to non-smokers. Thus, there is observational evidence in various groups of CHD patients that smoking cessation is beneficial.

Gentle advice and strong support for the patient are required and should be initiated whilst in hospital, but continued following discharge. Referral to stop smoking services should be recommended. Concerns regarding the use of nicotine replacement therapy (NRT) are largely unfounded. Analyses have now documented the lack of association between NRT and acute cardiovascular events and the risks of NRT for smokers, even for those with underlying cardiovascular disease, are small and are substantially outweighed by the potential benefits of smoking cessation [118;119].

Varenicline tartrate (***Champix***) is a smoking cessation medication which can be helpful in smokers who have struggled to stop ([120]). Care needs to be taken with patients with previous psychiatric illness or suicidal ideas.

Diet and Dietary Supplements A Mediterranean type diet appears to result in a reduction of reinfarction in the following few years ([121]). All patients should be advised to take a diet low in saturated fat, high in polyunsaturated fat and high in fruit and vegetables. One study suggests that eating fatty fish at least twice a week

reduces the risk of reinfarction and death ([122]), although this may not be associated with a substantial benefit in the longer term ([123]).

In a large trial looking at dietary supplementation with fish oil n-3 polyunsaturated fatty acids, there appears to be a significant mortality reduction ([124]). There has been some evidence to suggest that they reduce the risk of sudden death ([125]). These supplements are expensive, and should not currently be used routinely.

Patients with typical cardiac chest pain and a normal ECG on admission should be assumed to have unstable angina (UA), although in a small percentage subsequent ECGs will be abnormal, and cardiac enzymes will be elevated confirming myocardial infarction. As with patients with definite myocardial infarction, cardiac enzymes should be repeated. ***Hs-TnI*** levels should be measured on admission and 3 hours after admission. A single ***hs-TnI*** level is enough if the onset of symptoms was 3 or more hours prior to presentation. Patients with elevated ***hs-TnI*** (NSTEMI) are at higher risk and identify themselves as patients who may benefit from a more aggressive approach including the use of ***GP2b3aI*** (***Tirofiban***: ***Aggrastat***®), and revascularisation [126-128].

Initial Management

All patients should receive ***aspirin*** 300 mg initially and then 75 mg daily [129] and ***LMWH*** (***enoxaparin***). The ECG should be repeated at frequent intervals after admission to assess resolution and exclude progression to infarction. If patients' ***hs-TnI*** levels remain normal, with a normal ECG, early discharge should be considered. If a high index of suspicion remains, pre-discharge treadmill testing or a functional test should be considered. In a large proportion of patients, angiography will be undertaken prior to discharge. This usually happens after risk assessment and medical stabilisation. Referral is via ICE and should include documentation of the GRACE risk score (see below).

Risk Assessment

In patients who have an elevated ***hs-TnI***, a decision needs to be made as to whether the individual is at medium or high risk. In patients presenting with acute coronary syndromes, there is a 2 - 5% risk of death within one month, and the risk of myocardial infarction is 5 - 15% over the same period. Recurrent symptoms requiring hospital readmission occur in 26 - 35% within one year. Overall 5 - 15% will have died at one year.

A variety of methods are available to assess risk. The GRACE risk score can be found online: http://gracescore.org/WebSite/WebVersion.aspx

Variables included are age, Killip class, heart rate, systolic BP, serum creatinine, presence of ST segment deviation, cardiac arrest at presentation and cardiac enzyme elevation (for in-hospital death but not 6 month death).

Care should be taken using this scoring system in younger patients as their risk can be underestimated and older patients their risk over-estimated Patients with a projected 6 month mortality greater than 3% should be deemed medium or > 6% high risk and should be considered for inpatient angiography. The TIMI risk score is easier to perform and can help to complement the GRACE risk score:

http://www.timi.org/index.php?page=calculators

Special attention should be paid to patients presenting with widespread deep and symmetrical anterior T wave inversion. These patients often have a critical lesion in the proximal LAD (so-called '***LAD syndrome'***) and the threshold for in-patient angiography should be lower.

In addition to stratifying risk, patients should be selected for their suitability for revascularisation. Patients with significant co-morbidity and in whom consent is impossible or not given should be managed medically.

In patients with end stage renal failure special arrangements need to be made with regards to ensuring early access to dialysis. A large proportion will be referred directly from the renal unit and so a discussion can take place regarding a treat and return plan. The catheter lab co-ordinator should be involved with regards to identifying a specific operating list for the patient to be allocated along with liaison with the bed managers to ensure bed availability. For those with ESRF transferred from other centres, an early discussion regarding subsequent dialysis support is mandatory.

Table 2: TIMI Risk Score.

TIMI Risk Score: 1 point Each for Presence of	
• Age > 65 years	• > 2 anginal events in last 24hr
• Prior stenosis > 50%	• ST deviation
• > 3 CAD risk factors	• Elevated biomarkers
• Aspirin in last 7 days	

5 - 7 points = High Risk, 3 - 4 points = Intermediate Risk, 0 - 2 points = Low risk

Antiplatelet Therapy

All patients should receive ***aspirin*** 300 mg initially and then 75 mg daily [(129)]. ***Ticagrelor*** should be considered as first choice for patients with a confirmed diagnosis of NSTEMI irrespective of any revascularisation strategy. When a diagnosis of NSTEMI has been confirmed with an elevated ***hs-TnI*** result, a loading dose of 180mg should be administered as a one-off followed by 90 mg twice daily for 12 months (plus ***aspirin*** 75 mg daily lifelong). In patients who have already been loaded with ***clopidogrel*** and who are selected to be switched to ***ticagrelor***, a loading dose is still required.

Because of the potential need for surgical revascularisation, it may be worth considering deferring ***clopidogrel*** or ***ticagrelor*** in selected very high risk patients who could be listed for angiography alone in the first instance. They could then potentially undergo surgical revascularisation sooner. If they are selected for PCI they could be subsequently loaded with the appropriate antiplatelet. ***Clopidogrel*** and <u>especially</u> ***ticagrelor*** should ideally be stopped for 5 days prior to CABG but is dependent on the preferences of the individual surgeon.

Anticoagulation Therapy

LMWH should be administered in medium and high risk patients for the first 48 hours and then stopped if pain free. (***Enoxaparin*** 100 IU/kg BD until pain-free for > 48 hours) [(130)]. Bleeding risk **MUST** be assessed: active bleeding, acquired bleeding disorder (such as acute liver failure, concurrent use of ***anticoagulants*** known to increase risk of bleeding, concurrent use of antiplatelets, recent head trauma).

There is a potential role for ***rivaroxaban*** in the setting of NSTEMI, in particular in patients who are managed medically and who do not undergo PCI. In the ATLAS trial patients with ACS were treated with ***aspirin***, ***clopidogrel*** and low dose

rivaroxaban (2·5 mg BD) [9;98]. Although a large proportion of patients underwent PCI in this trial, the trial utilised ***clopidogrel*** whereas we recommend ***ticagrelor*** in ACS patients undergoing PCI. In patients treated with ***clopidogrel*** however, ***rivaroxaban*** should be seriously considered. Patients bleeding risk should be assessed (see page 70) and the usual cautions with ***rivaroxaban*** should be applied (see page 103). Treatment is for 12 months.

Routine coagulation testing and monitoring is not required with ***LMWH*** but it is expensive and its continued use beyond admission should be reserved for patients with convincing ECG evidence of ischaemia or elevated ***hs-TnI***. Patients who are definitely ischaemic should also be managed on CCU or dedicated cardiology beds. With prolonged use, the patient's full blood count must be monitored.

Thrombolytic therapy is of no benefit in UA/NSTEMI, and may be associated with increased hazard in patients with prolonged chest pain and ST depression or T wave inversion on the ECG. This is true even for patients with ST depression of greater than 3 mm in whom myocardial infarction is almost always the ultimate diagnosis.

Glycoprotein IIb/IIIa Inhibitors

High risk patients should be treated with ***tirofiban*** and ***UFH*** (see page 207). These should be used for a minimum of 48 hours and a maximum of 108 hours if the patient remains unstable. These patients should all be discussed with senior cardiologists with a view to early in-patient angiography and potential revascularisation. Platelet counts should be monitored at least daily. If the ***tirofiban*** infusion is completed before the angiogram, the ***UFH*** should be continued. Further ***GP2b3aI*** can be administered at the time of intervention if necessary. This may take the form of ***abciximab*** (***ReoPro***®) or further ***Tirofiban***. Patients should be continued on ***clopidogrel*** or ***ticagrelor*** for 12 months following the revascularisation procedure.

Bleeding Risk

Bleeding risk should be considered in all patients presenting with ACS. Risk factors for bleeding and its adverse consequences include advanced age, low body mass, female sex, renal impairment, and pre-existing anaemia. It is also clear that bleeding in the context of ACS carries adverse prognosis. There are numerous bleeding classification systems and bleeding scores. The CRUSADE bleeding score is a means of quantifying the risk of major bleeding in ACS cohorts and can be used to estimate the risk in individual patients ([131]). There is a risk calculator available online at: http://www.crusadebleedingscore.org

Medical Therapy

Having anticoagulated the patient, manoeuvres to lower the resting heart rate below 60 and lower the blood pressure to less than 140/90 are required. In patients without contraindications, this is best achieved with IV ***atenolol*** (5 - 10 mg), or ***metoprolol*** (5 - 15 mg). ***β-blockers*** have been shown to reduce the risk of developing myocardial infarction [132;133]. If short-acting ***β-blockade*** is desirable because of concern over side effects, ***esmolol*** can be used (see page 196).

Early intravenous ***β-blockade*** should not be given in the presence of clinical signs of heart failure, hypotension (systolic BP < 100 mmHg), bradycardia (< 60 bpm) or 2nd/3rd degree heart block, a history of asthma or COPD, or audible bronchospasm, concurrent treatment with ***verapamil*** (risk of severe bradycardia).

Alternatively, AV nodal blocking ***calcium antagonists*** such as ***diltiazem*** (0·25 mg/kg over 2 minutes) or ***verapamil*** (5 - 10 mg IV over 2 minutes) may be employed. If less urgency is required and for maintenance, oral preparations should be used (eg. ***bisoprolol*** 1·25 - 10 mg OD, ***atenolol*** 25 - 100 mg OD, ***diltiazem*** 60 - 120 mg TDS or equivalent, ***verapamil*** 40 - 120 mg TDS or equivalent). ***Diltiazem*** may be beneficial [134]. In patients who already have a resting heart rate of 50 - 60, alternative anti-anginal therapy such as ***amlodipine*** (5 - 10 mg daily) can be tried although its onset of action may be delayed. ***Nifedipine*** should be avoided as monotherapy but may be beneficial when used with ***β-blockers*** [135].

For additional analgesia and control of ischaemia, ***nitrates*** can also be used. ***GTN*** (if using 0·1% solution, infuse at 1 - 10 ml/hr), or ***isosorbide dinitrate*** (1 - 10 mg/hr) can be used IV. The rate should be reduced if systolic BP drops below 100 mmHg. ***Nitrate*** tolerance is a problem and infusions should not generally be used for greater than 24 hours. Patients should be transferred to oral therapy with nitrate-free periods of 6 - 10 hours. Use of parenteral ***nitrates*** suggests that an early invasive strategy should be considered.

Nicorandil (5 - 30 mg BD) is an ATP-dependent ***potassium channel activator*** that has an uncertain role to play in the management of unstable angina. Its action is similar to that of ***nitrates***, but it may have a beneficial role in ischaemic preconditioning, reducing transient myocardial ischaemia. One study suggests that patients with stable angina have a reduction in coronary events when treated with ***nicorandil*** [136]. It has no role to play in patients already established on ***nitrates***.

Ivabradine (5 - 7·5 mg BD) is a sinus node blocking agent which may be an alternative rate controlling agent especially where a ***β-blocker*** is contra-indicated or not tolerated. Not to be introduced if heart rate is below 70 bpm. It can be used safely in patients with impaired LV function ([137]). Indeed, results from the recent Signify Study suggests caution in patients with preserved LV function ([138]). Use of the drug should be initiated by consultants only. Lower initial doses should be used in the elderly (2·5 mg BD). Do not use alongside ***diltiazem*** or ***verapamil***.

Ranolazine, a sodium channel inhibitor, is licensed as adjunctive therapy in patients who are inadequately controlled or intolerant of first-line anti-anginal drugs. The dose is initially 375 mg BD increasing to a maximum of 750 mg BD. Its use is mainly in patients with chronic stable angina rather than in the acute setting ([139]). A trial in the context of ACS showed ***ranolazine*** did not affect the composite of cardiovascular death, MI, or recurrent ischaemia, however, further analysis revealed a reduction in angina and improvement in exercise duration with an acceptable safety profile [140;141]. Initiation of the drug should be by consultants only. It is contraindicated if the GFR is < 30. ***Ranolazine*** can cause prolongation of the QT interval and this should be evaluated after commencement. Numerous drug interactions are possible (***simvastatin***, ***verapamil***, ***diltiazem***, ***digoxin*** and ***CYP3A4 inhibitors***) and so attention to the BNF advice is mandatory.

Additional Measures

It is important to address risk factor reduction in the same way as patients with STEMI. Lipids, blood pressure, glucose, smoking and lifestyle all need to be considered. It would therefore seem eminently reasonable to commence all patients on ***statins*** during their admission. **All patients should also be considered for an *ACEI***, even in the absence of LV dysfunction. The HOPE study [78] showed ***ramipril***

benefited patients with vascular disease, and EUROPA showed similar benefit employing ***perindopril*** in patients with stable coronary disease ([142]). It is likely that ***ACEI*** confer benefit in all patients with coronary disease.

Angiography

A large number of patients admitted with unstable angina and NSTEMI will need coronary angiography (see page 30). The decision to list is made by cardiology SpRs and consultants. Numerous factors need to be considered and it is not appropriate to simply undertake angiography in every patient. Co-morbidities and previous cardiac status must be taken into consideration.

Listing for procedures can be done via an ICE request AFTER the patient has been consented. Go to 'Requesting' and select 'Service Referrals'. The left hand tab selection is 'Cath Lab'. For ACS patients select 'Cardiac Angio Lt heart study' and for those with prior grafts 'Cardiac Angio LV and Coronary Graft'. Then select the appropriate procedure: 'Cath +/-' or (if angiography has already happened and the patient requires a PCI): 'PCI only'. Named consultant is default 'no' unless a specific consultant needs to do the patient.

Numerous fields require completion and it is useful having the relevant information to hand first:

- Brief summary of presentation
- Precise date & time of admission?
- Precise date & time of symptom onset?
- Peak troponin?
- Grace score (% risk at 6 months)?
- Smoking status?
- Hypertension?
- Hyperlipidaemia?
- Family history?
- Diabetes (and how treated)?
- Cholesterol level?
- Creatinine level?
- Haemoglobin level?
- Platelet count?
- INR (if applicable)?
- Allergies?
- MRSA status?
- Procedural risk factors (listed on ICE)?
- Antiplatelet regime?
- Prior angiogram?
- Previous PCI (details)?
- Previous CABG (details)?
- Echo (result)?
- Functional scan (result)?
- Warfarin?
- DOAC?
- Senior reviewer's name?
- Consented by?

STABLE ANGINA

Angina most commonly takes the form of chest discomfort provoked by effort or emotion and relieved by rest. Only radiated symptoms may be experienced such as isolated throat tightness or arm heaviness. Exertional breathlessness may likewise represent an anginal equivalent, especially in diabetics and/or hypertensives. When severe, angina may be accompanied by autonomic features such as fear, sweating and nausea. It may be difficult to distinguish patients with gastro-oesophageal reflux disease, musculoskeletal discomfort or pulmonary disease. The coronary risk factor profile may be helpful in this regard, as chest discomfort is more likely to represent coronary artery disease in an individual with two or more existing risk factors, e.g. cigarette smoking, hypertension, diabetes mellitus, hypercholesterolaemia, a family history of premature coronary artery disease, or the presence of other acquired vascular disease.

If angina is suspected, consideration should be given to further investigation in order to establish the likelihood and extent of underlying coronary disease. Potential associated cardiac and cardiovascular conditions such as valvular heart disease and hypertension should be identified, as these present important implications for both the investigation and management of angina.

Angina usually reflects coronary artery disease. However aortic stenosis, hypertensive heart disease and hypertrophic cardiomyopathy may cause typical symptoms in the absence of coronary disease. Also, there are patients who experience recurrent ‘angina’ despite being demonstrated to have a structurally normal heart with angiographically normal coronary arteries.

Assessment

Initial assessment should include a good history:

- precipitants of anginal attacks
- relieving factors
- stability of symptoms
- risk factors (smoking history, high BP, lipids, diabetes, prior CV disease)
- occupation
- assessment of the intensity, length and regularity of exercise
- basic dietary assessment
- alcohol intake
- drug history
- family history

Angina is unlikely if the pain is continuous or very prolonged, unrelated to activity, brought on by breathing or associated with other symptoms such as dizziness and dysphagia.

Examination:

- weight and height (to allow calculation of BMI) or waist / hip ratio
- blood pressure

- presence of murmurs, especially that of aortic stenosis
- evidence of hyperlipidaemia
- evidence of peripheral vascular disease and carotid bruits (especially in diabetes).

Investigations

Initial investigations should include a full blood count, biochemical screen including glucose (HbA1c if diabetes suspected) and a full lipid profile. Thyroid function is not essential as a routine.

A resting 12-lead ECG provides information on rhythm, presence of heart block, previous myocardial infarction and myocardial hypertrophy and ischaemia.

The presence of an abnormal ECG supports a clinical diagnosis of coronary artery disease ([143]). ST/T abnormalities have been correlated with abnormalities of left ventricular function and left anterior descending artery stenosis. QRS abnormalities have been associated with abnormal findings on angiography.

An abnormal ECG also identifies a patient at higher risk of suffering new cardiac events in the subsequent year. However, a normal ECG does not exclude coronary artery disease. In a review of 109 patients who had normal ECGs, 39% still had cardiac pain and 90% of those subjected to angiography showed significant coronary artery disease ([143]).

Before proceeding with further investigations, the likelihood of angina should be considered. Latest guidance from NICE (CG95, March 2010) suggests:

- If the estimated likelihood of CAD is 61 - 90%, offer invasive coronary angiography as the first-line diagnostic investigation if appropriate
- If the estimated likelihood of CAD is 30 - 60%, offer functional imaging as the first-line diagnostic investigation
- If the estimated likelihood of CAD is 10 - 29%, offer CT calcium scoring as the first-line diagnostic investigation
- Do not use exercise ECG to diagnose or exclude stable angina for people without known CAD

Table 3: Percentage of people estimated to have CHD according to typicality of symptoms, age, sex and risk factors (adapted [144]):

Age (yrs)	Non-anginal chest pain				Atypical angina				Typical angina			
	Men		Women		Men		Women		Men		Women	
	Lo	Hi	Lo	Hi	Lo	Hi	Lo	Hi	Lo	Hi	Lo	Hi
35	3	35	1	19	8	59	2	39	30	88	10	78
45	9	47	2	22	21	70	5	43	51	92	20	79
55	23	59	4	25	45	79	10	47	80	95	38	82
65	49	69	9	29	71	86	20	51	93	97	56	84

For men older than 70 with atypical or typical symptoms, assume an estimate > 90%. For women older than 70, assume an estimate of 61 - 90% EXCEPT women at high risk AND with typical symptoms where a risk of > 90% should be assumed.

Values are per cent of people at each mid-decade age with significant coronary artery disease (CAD).

Hi = High risk = diabetes, smoking and hyperlipidaemia (total cholesterol > 6·47 mmol/l).

Lo = Low risk = none of these three.

The shaded area represents people with symptoms of non-anginal chest pain, who would not be investigated for stable angina routinely. Note: These results are likely to overestimate CAD in primary care populations. If there are resting ECG ST-T changes or Q waves, the likelihood of CAD is higher in each cell of the table.

Exercise Testing Currently it is not possible locally to implement the NICE recommendation to effectively abandon the exercise tolerance test (ETT), and so an ETT can still be performed. The ETT has been shown to be of value in assessing prognosis of patients with known coronary artery disease [145;146]. An ETT is also helpful in patients at high risk of CHD, where a positive test can provide useful prognostic information [145]. There are more false positive tests in women [147] where perfusion imaging may be a better test.

Contraindications:

- Acute myocardial infarction (within two days)
- Unstable angina
- Uncontrolled cardiac arrhythmias causing symptoms or haemodynamic compromise
- Symptomatic severe aortic stenosis
- Uncontrolled symptomatic heart failure
- Acute pulmonary embolus or pulmonary infarction
- Acute myocarditis or pericarditis
- Active endocarditis
- Acute aortic dissection
- Acute non-cardiac disorder that may affect exercise performance or be aggravated by exercise (eg, infection, renal failure, thyrotoxicosis)
- Inability to obtain consent

Relative contraindications (consultant only requests):

- Left main coronary stenosis or its equivalent
- Moderate stenotic valvular heart disease (but can assist assessment of asymptomatic aortic stenosis)
- Electrolyte abnormalities
- Severe hypertension (systolic ≥ 200 mmHg and/or diastolic ≥ 110 mmHg (which are both reasons to consider terminating a test)

- Tachyarrhythmias or bradyarrhythmias, including atrial fibrillation with uncontrolled ventricular rate
- Hypertrophic cardiomyopathy and other forms of outflow tract obstruction
- Mental or physical impairment leading to inability to cooperate
- High-degree atrioventricular block

The ETT clearly should only be performed in patients who are able to exercise sufficiently - so is not possible in those with severe claudication, airways disease or those with physical disabilities etc. An ETT test that fails to achieve 85 - 90% of the patient's predicted maximal heart rate (generally 220 – age) is generally considered inadequate to rule out ischaemia.

The ETT is not helpful in patients with ECG changes at rest that can interfere with interpretation of the exercise:

- Ventricular pre-excitation (Wolff-Parkinson-White pattern)
- Ventricular paced rhythm
- Left bundle branch block
- Greater than 1 mm ST depression at rest
- ***Digoxin*** use with associated ST-T abnormalities
- Left ventricular hypertrophy with ST-T abnormalities
- Hypokalaemia with ST-T abnormalities

The usual protocol employed is the Bruce protocol:

Stage	Grade (%)	Speed (mph)	Total time (min)	O2 uptake (ml/kg/min)	METS
1	10	1.7	3	17	4.5
2	12	2.5	6	25	7
3	14	3.4	9	35	10
4	16	4.2	12	47	13

Patients should be given specific instructions on whether or not to take their usual medications. Patients undergoing exercise testing for diagnostic purposes should usually be instructed not to take anti-ischaemic medications or drugs that slow the heart rate. However, anti-ischaemic medications should be continued if the purpose of the test is to establish prognosis or adequacy of anti-ischaemic therapy.

Indications to stop the ETT:

- Patient determined:
  - Patient wants to stop
  - Significant chest discomfort
  - Marked fatigue or severe dyspnoea
  - Other limiting symptoms (dizziness, leg cramps, joint discomfort, etc)
- Protocol determined:

- Patient does not look well (eg, ataxia, confusion, pallor, cyanosis, etc)
- Exertional hypotension (systolic BP drop > 10 mmHg below standing systolic BP measured at rest prior to test)
- Severe angina
- Systolic BP >250 mmHg
- Diastolic BP >115 mmHg

- ECG endpoints
  - Marked ST segment depression (> 2 mm of horizontal or downsloping of ST segment depression)
  - New bundle branch block which cannot be distinguished from ventricular tachycardia
  - ST segment elevation (> 1.0 mm) in leads without diagnostic Q waves (other than V1 or aVR) - ST segment elevation in lead aVR is a strong predictor of obstructive coronary artery disease involving the left main coronary artery or the ostium of the LAD (sensitivity and specificity of 75 and 81 percent, respectively).
  - New high grade (i.e. Mobitz 2 or complete) AV block
  - Ventricular tachycardia or fibrillation
  - Increasing ventricular ectopy (premature beats, couplets or non-sustained ventricular tachycardia), especially if ischaemia present – mortality is higher in those only with frequent ectopy in recovery
  - Onset of supraventricular tachyarrhythmias
- Exercise and stress test indications of adverse prognosis:
  - Poor maximal exercise capacity [145;146;148].
  - Limited systolic blood pressure response i.e. fall or no rise from baseline [149;150].
  - ≥ 1 mm ST depression during stage 2 or less [146].
  - or ≥ 2 mm ST depression at any time [151].

Abnormalities may only become apparent during recovery. The ECG should be recorded every two minutes for 7 to 10 minutes until the heart rate falls below 100 or the ECG waveform returns to the control baseline pattern. Patients with positive stress tests need to be considered for coronary angiography.

An ETT is a low risk investigation even in patients with known ischaemic heart disease, but serious complications occur in 2 - 4 per 1,000 tests. Death may occur at a rate of 1 - 5 per 10,000 tests ([152]).

An ETT is a poor diagnostic test in low-risk populations. The CASS study concluded that the value of the test is limited in a heterogeneous population of patients with angina and that exercise testing should not be regarded as a screening test [148;153]. An exercise ECG was best performed with patients on treatment to improve the specificity of the test and to avoid angiography in those who are well controlled on medical treatment ([154]).

In people at lower risk of their chest pain being due to angina, a CT coronary calcium score is a useful non-invasive way of investigating.

Where an ETT is impractical (such as immobility), or where there is thought to be a higher likelihood of chest pain being due to angina, consideration should be given to arranging a stress myoview scan, stress perfusion CMR scan or stress echocardiogram. CT calcium scoring and/or CTCA should also be considered.

CT calcium scoring This should be considered when the likelihood of chest pain being due to angina is 1 - 29%. If the score is zero there is very minimal likelihood there is significant coronary disease. If the score is 1 - 400 consideration should be given to CTCA or stress perfusion imaging. Above 400, coronary angiography should be seriously considered if appropriate.

CT coronary angiography (CTCA) A low resting heart rate is essential and medication (usually ***β-blockers*** or ***ivabradine***) may need to administered, possibly temporarily, to achieve this (target 50 - 60). Patients need to hold their breath for about 20 seconds. CT has advantages over conventional angiography insofar as it gives information regarding plaque characteristics and composition. Difficulties still exist however when there is significant vessel calcification. NICE recommend this imaging modality in patients with an intermediate risk of coronary disease.

Perfusion Imaging Functional testing can be performed employing stress myoview scanning (see page 27), **stress perfusion CMR** scanning (see page 28) or **stress echocardiography** (see page 27). Previous radiation exposure and patient preferences need to be taken into account. NICE recommendations are patients with a risk of 30 - 60% should undergo functional imaging.

Angiography Patients with a risk of 61 - 90% should be considered for angiography if appropriate. In addition, patients who have had abnormal functional tests should also be considered for angiography, especially if the symptoms are not settling on medication and when revascularisation might be considered an option.

Drug treatment

All patients should be treated with ***aspirin*** 75 mg OD ([27]). For those allergic or intolerant of ***aspirin***, ***clopidogrel*** 75 mg OD should be used ([155]). Enteric coated ***aspirin*** does not prevent major gastrointestinal complications of ***aspirin*** therapy and are significantly more costly than standard dispersible formulations ([156]).

All patients should be prescribed sublingual ***GTN*** and instructed on its use.

For symptom control, ***β-blockers*** have been shown to be as effective in the prevention of long-term angina symptoms as the other available classes of drugs. Patients receiving these drugs (either singly or in combination therapy) benefited equally [157-159] or significantly more [160-162] in terms of anginal relief than patients on alternative monotherapies.

In addition, ***β-blockade*** in high risk patients reduces cardiovascular mortality and morbidity. Supporting evidence is drawn from post-myocardial infarction trials and trials of patients taking ***β-blockers*** for any reason [133;163]. Long term ***β-blockade*** remains an effective and well-tolerated treatment that reduces mortality and morbidity in patients after myocardial infarction. Patients who have had a myocardial infarction or currently have angina and are given ***β-blockers*** have a lower rate of mortality and morbidity.

β-blockers should not be stopped suddenly, as this may be associated with an increased risk of an adverse coronary event.

Rate limitation should be the goal in patients with a normal chronotropic response to exercise. This is best achieved with ***β-blockers*** and non-dihydropyridine ***calcium channel blockers*** (***diltiazem*** [164;165] or ***verapamil***). These are considered to be more effective than short-acting dihydropyridines, which may lead to tachycardia in some patients.

Long-acting ***nitrates*** (***isosorbide mononitrate*** ([166])) and potassium channel opening drugs (***nicorandil*** ([167])) are effective first line agents compared with placebo. Prescription of long-acting nitrates should be done in such a way as to avoid ***nitrate*** tolerance. There is no value in adding a ***nitrate*** to a patient established on ***nicorandil*** and vice versa.

There is evidence to support the use of ***isosorbide mononitrate*** or a ***calcium channel blocker*** as second line agent to a ***β-blocker*** [168-170]. Although one study demonstrated the effectiveness of adding ***diltiazem*** to a ***β-blocker*** ([171]), the cautions cited in the BNF should be observed ([172]).

Ivabradine (5 - 7·5 mg BD) is a sinus node blocking agent which may be an alternative rate controlling agent especially where a ***β-blocker*** is contra-indicated or not tolerated. Not to be initiated in angina if heart rate is below 70 bpm. It can be used safely in patients with impaired LV function ([173]). Latest advice is that it should NOT be co-prescribed with ***diltiazem*** or ***verapamil***.

Ranolazine is licensed as adjunctive therapy in patients who are inadequately controlled or intolerant of first-line anti-anginal drugs. The dose is initially 375 mg BD increasing to a maximum of 750 mg BD. Its use should be mainly in patients with chronic stable angina rather than in the acute setting. Initiation of the drug should be by consultants only. It is contraindicated if the GFR is < 30. Please refer also to page 71).

All patients should be commenced on a ***statin*** (see page 57). The addition of an ***ACEI*** should also be considered in light of the findings of the HOPE study ([77]).

Some patients with angina remain symptomatic despite maximal medication. If revascularisation is not possible consideration should be given to stellate ganglion block or surgical sympathectomy.

Other risk factors need to be controlled such as diabetes and hypertension. Lifestyle advice is mandatory.

Variant/Vasospastic Angina

Variant angina can present as an apparent STEMI as symptoms are often accompanied by transient ST elevation. Episodes often occur between midnight and early morning. Coronary angiography may show spasm in the absence of obstructive coronary disease. Smoking is a risk as is substance abuse (cocaine, marijuana, amphetamines). It is more common in people under the age of 50.

Treatment of variant angina reduces the frequency of symptomatic episodes and appears to decrease the frequency of serious complications. Although episodes may terminate spontaneously, sublingual ***GTN*** is effective in reducing the duration of each episode. As smoking cessation removes one of the triggers for variant angina

and leads to a significant decrease in the frequency of episodes, at least in the short term, smoking cessation should be encouraged.

Calcium channel blockers (***nifedipine***, ***diltiazem***, and ***verapamil***) and ***nitrates*** are effective as chronic therapies for variant angina. Both prevent vasoconstriction and promote vasodilation in the coronary vasculature

The use of a ***calcium channel blocker*** therapy may be an independent predictor of myocardial infarct-free survival in variant angina patients. Recommended is ***diltiazem*** at a dose of 240 to 360 mg per day. For patients who do not have acceptable improvement in symptoms on ***calcium channel blocker*** therapy, add a long-acting ***nitrate*** (eg, ***isosorbide mononitrate*** 30 or 60 mg once daily).

Angina with normal coronary arteries

This condition manifests as typical angina pain but with angiographically normal coronary arteries and without evidence of coronary spasm. It is sometimes known as cardiac syndrome X or microvascular angina. Ischaemia tests may be abnormal including exercise testing, perfusion imaging and stress echo and MRI. Patients tend to be younger and there is a dominance of females. Prognosis is good.

The use of ***GTN*** can be helpful but not always. ***β-blockers*** should be the first choice followed by ***calcium channel blockers*** (eg, ***amlodipine***) and long-acting ***nitrates*** (if ***GTN*** responsive). Many patients respond to the addition of an ***ACEI***, particularly in combination with ***calcium channel blockers***.

Other medications which have been used with varying success include low dose ***imipramine*** and ***ranolazine***. ***HRT*** may play a role in post-menopausal women.

NON-CARDIAC CHEST PAIN SYNDROMES

A number of patients are referred to clinic where it is clear after the history and examination that there is unlikely to be a cardiac cause of chest pain. A number will have had investigations to rule out a cardiac cause but have on-going symptoms.

Musculo-skeletal

There are a number of chest wall syndromes with chest pain associated with musculo-skeletal inflammation.

"Costochondritis" is one of the more common presentations of musculo-skeletal chest pain. It is a diffuse pain syndrome, in which multiple areas of tenderness are found that reproduce the described pain. The upper costal cartilages at the costochondral or costosternal junctions are most frequently involved, particularly on the left. The areas of tenderness are not accompanied by heat, erythema, or localized swelling. The pain is reproduced by palpation. Treatment is with simple analgesia and NSAIDs. Occasionally local injections are needed. Most cases follow a self-limited course with occasional exacerbations.

“Tietze syndrome” is a similar condition but more localised, usually involving costosternal, sternoclavicular, or costochondral joints of the second and third ribs. Tietze syndrome typically is characterized by localized swelling; septic arthritis should be considered in the differential diagnosis.

Fibromyalgia is a common chronic musculoskeletal pain syndrome, characterised by diffuse musculoskeletal pain, fatigue, sleep disturbance, and multiple periarticular tender points found on physical examination.

Chest wall pain occurring after CABG may be a result of incisional discomfort, of internal mammary artery grafting, or related to sternal wires.

Costovertebral joint dysfunction syndrome is an uncommon condition that causes posterior chest wall pain and may mimic a pulmonary embolism. Thoracic disk herniation is another unusual cause of posterior chest pain; the pain is sometimes dermatomal and "band-like," and retrosternal or retrogastric pain has also been described. Other isolated chest wall pain syndromes include sternalis syndrome, xiphoidalgia, and spontaneous sternoclavicular subluxation.

A number of rheumatic diseases can be associated with chest pain. Systemic causes should also be considered: stress or pathological fractures, neoplasia, sickle cell anaemia, myeloma, vitamin D deficiency, herpes zoster.

Gastro-oesophageal causes

The heart and oesophagus share some common neurologic innervation. Thus, it may be difficult to distinguish between chest pain due to myocardial ischaemia and pain originating from the oesophagus based upon the history alone. Oesophageal disease may cause symptoms thought "classical" for myocardial ischaemia, including a sensation of chest pressure, provocation with exercise or emotion, palliation by rest or ***nitrates***, or a crescendo pattern.

Myocardial ischaemia should be ruled out before any patient at risk for CAD, presenting with anginal-quality chest pain, is given a gastrointestinal diagnosis. Neither the clinical history nor the response of new chest pain to a ***PPI*** reliably differentiates the diagnoses, which often co-exist. There are, however, several clues that suggest an oesophageal aetiology: pain provoked by swallowing, pain provoked

by postural changes, pain helped by antacids, an inconsistent relationship to exercise, substernal chest pain that does not radiate, frequent episodes of spontaneous pain, nocturnal pain, severe onset of pain - continuing as a background ache for several hours, pain associated with heartburn and regurgitation of acid into the mouth.

GI causes of chest pain are primarily due to oesophageal disorders, and the most common GI cause of chest pain is gastro-oesophageal reflux disease (GORD). Peptic ulcer disease can cause pain referred to the chest. A motility disorder or oesophageal spasm should be entertained if chest pain is associated with dysphagia

Pulmonary causes of chest pain

Pulmonary causes of chest pain may be related to the pulmonary vessels, lung parenchyma, airways, or pleural tissue. Pulmonary embolus and tension pneumothorax are two pulmonary causes of chest pain that may be imminently life threatening.

The diagnosis of acute pulmonary embolism (PE) often requires a high index of suspicion. It should be considered in any patient who presents with chest pain that is usually but not necessarily pleuritic in nature or dyspnoea that is not fully explained by the clinical evaluation, chest radiograph, or electrocardiogram. It is more commonly seen in the acute setting.

Patients with secondary pulmonary hypertension often have symptoms that reflect the underlying aetiology (eg, COPD, pulmonary embolic disease, collagen vascular disease). Idiopathic pulmonary arterial hypertension is a rare disease. Most patients present with exertional dyspnoea, which is indicative of an inability to increase cardiac output with exercise. Exertional chest pain, syncope, and oedema are indications of more severe pulmonary hypertension and impaired right heart function.

Causes of chest pain related to the lung parenchyma include infection, cancer, or chronic diseases such as sarcoidosis, as well as diseases involving the bronchial airways such as asthma, emphysema, and COPD.

Psychogenic/psychosomatic causes of chest pain

Chest pain may be a presenting symptom of panic disorder, depression, and hypochondriasis, as well as cardiac, cancer or other phobias. Reviews of the literature have estimated that approximately one-third of patients presenting to the ED for chest pain have a psychiatric disorder, while approximately half of patients with non-cardiac chest pain have various psychiatric diagnoses. Formal therapy may be indicated (psychiatric, psychological, CBT etc).

Hyperventilation, which is associated with panic attacks, can also result in non-anginal chest pain and occasionally ECG changes - particularly nonspecific ST and T wave abnormalities in the inferior leads most commonly. More subtle hyperventilation disorders include dysfunctional breathing which can present as chest pain. A Nijmegen questionnaire can help identify these patients who can be helped with respiratory physiotherapy:

http://www.heartofengland.nhs.uk/wp-content/uploads/Nijmegen_Questionnaire.pdf

A sensation of air hunger is common in this cohort of patients and a simple test is to get the patient to hold their breath for as long as possible. Normal is > 30 seconds. Abnormal is < 20 seconds and may reproduce the pain. If this fails, getting the

patient to breathe more deeply than usual for 60 seconds can reproduce the symptoms.

MYOCARDITIS

Myocarditis is most frequently caused by viruses and there may be a clear preceding viral prodrome. The clinical manifestations of myocarditis are highly variable ranging from subclinical disease to fatigue, chest pain, heart failure, cardiogenic shock, arrhythmias, and sudden death. Age at presentation is typically 20-50 years.

Chest pain may reflect associated pericarditis. Myocarditis can mimic myocardial ischaemia and/or infarction both symptomatically and on the electrocardiogram, particularly in younger patients. ***TnI*** may be elevated. It should be suspected in younger patients presenting with apparent STEMI but who have normal coronary arteries. LV function is usually impaired. Dysfunction is usually global but may be regional. CMR can assist in the diagnosis. Endomyocardial biopsy is sometimes diagnostic.

Prognosis is variable but over a third may recover LV function.

Certain infectious causes have specific therapies (mycoplasma, Lyme disease). Generally speaking however, treatment is supportive. Antiviral and immunosuppressive therapy is not usually helpful. Standard heart failure treatment is appropriate (***ACEI***, ***ARBs***, ***diuretics***, ***β-blockers***). Activity should be restricted during the acute phase.

Patients require follow up for review of LV function.

PERICARDITIS

Pericarditis is classified as dry, effusive, effusive-constrictive, and constrictive. The aetiological classification comprises: infectious pericarditis, pericarditis in systemic autoimmune diseases, type 2 (auto) immune processes, post myocardial infarction syndrome, and auto-reactive (chronic) pericarditis. It can also be seen after extensive ablation procedures.

In acute pericarditis a history of fever, malaise, and myalgia is common. Major symptoms are retrosternal or left precordial chest pain (radiates to the trapezius ridge, can be pleuritic or sound ischaemic, varies with posture – worse lying flat) and shortness of breath. Pleural effusion may be present. Heart rate is usually rapid and regular.

Viral pericarditis is the commonest cause of acute pericarditis and can occur with a variety of common viruses (*entero-, echo-, adeno-, cytomegalo-, Ebstein Barr-, herpes simplex-, influenza, parvo B19, hepatitis C, HIV*, etc). Treatment is usually symptomatic but in more severe cases with recurrent episodes, specific anti-viral therapy may be indicated when a specific virus is implicated. Symptomatic therapy comprises the use of ***NSAIDs*** and simple analgesia. ***Colchicine*** (0·5 mg BD) can be used and helps reduce recurrence ([174]). Treatment is usually for 3 months. Without ***colchicine***, recurrence can be anywhere between 15 and 30%. Systemic corticosteroid therapy should be restricted to connective tissue diseases, auto-reactive or uraemic pericarditis. Rarely they can be used if ***NSAIDs*** and ***colchicine*** have failed. Bacterial pericarditis is extremely rare.

An echocardiogram is warranted to exclude effusions and look for myocardial dysfunction. ***TnI*** (around 50% cases) or ***CK-MB*** may be elevated along with a raised ***CRP***. The ECG is abnormal in about 60% with diffuse concave ST elevation and PR depression. The ST and PR segments typically move in opposite directions. It may be difficult to distinguish from ischaemia. Tamponade is rare.

Chronic pericarditis can be due to systemic illness, neoplasia, autoimmune disorder, TB or myxoedema. Chronic recurrent effusions may need treatment with balloon pericardiotomy or surgical pericardiectomy.

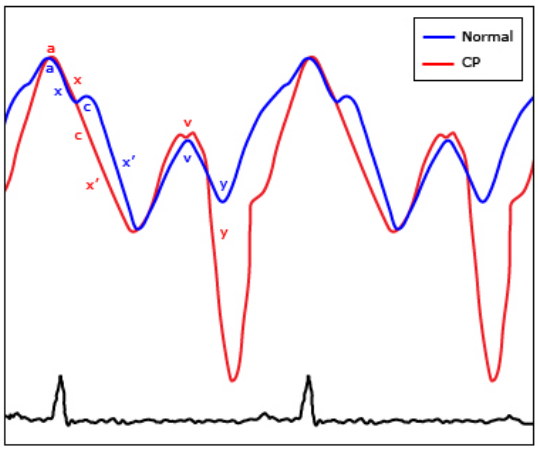
Pericarditis in renal failure is common especially in those just pre-dialysis or those who have just started dialysis. It is more common when patients are fluid overloaded. Typical pericarditis ECG changes are unusual.

Autoreactive pericarditis may be seen in SLE, rheumatoid arthritis, ankylosing spondylitis, systemic sclerosis, dermatomyositis, polyarteritis nodosa and Reiter's syndrome. Pericarditis can occur in the first 2 - 3 weeks after surgery (postcardiotomy syndrome) and post STEMI. Effusions can be due to neoplastic disease (most commonly secondary tumours). Carcinoma lung and breast account for more than half, leukaemia and lymphoma about a quarter.

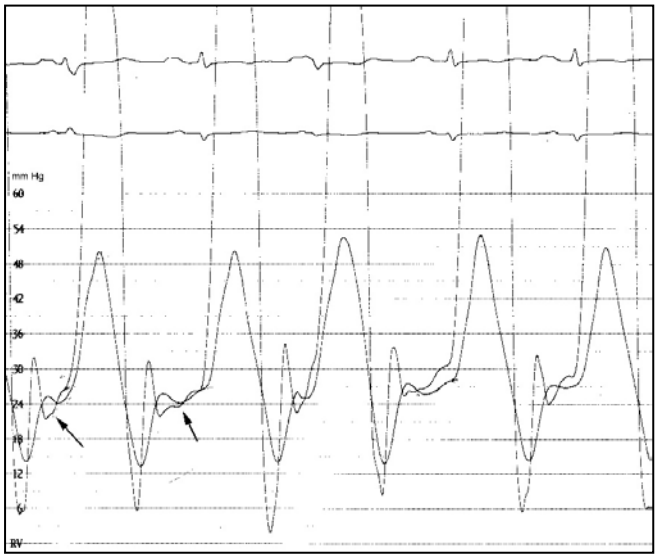
Constrictive pericarditis can occur after virtually any pericardial disease process, but most often follows acute pericarditis (viral or idiopathic) or cardiac surgery. Symptoms include dyspnoea, ascites, cachexia and oedema. Diagnosis can be challenging. A CXR may show pericardial calcification. A TTE may show a thickened pericardium. Other signs may include dilatation of the IVC and hepatic veins with absent or diminished inspiratory collapse. There may be moderate biatrial enlargement. A CT scan can provide valuable additional information as can CMR.

In patients in whom surgical pericardiectomy is being considered, it is common to undertake coronary angiography - this provides an opportunity to perform a right heart catheter. The major haemodynamic findings in patients with constrictive pericarditis include:

- Increased right atrial pressure
- Prominent x and y descents of venous and atrial pressure tracings (see image below)
- Kussmaul's sign (the lack of an inspiratory decline or an inspiratory increase in CVP
- Increased RV EDP, usually to a level one-third or more of RV systolic pressure.
- "Square root" signs in the RV and LV diastolic pressure tracings (an early diastolic dip followed by a plateau of diastasis; the last stage of diastole just before contraction), often with an absent a wave
- A greater inspiratory fall in pulmonary capillary wedge pressure compared to left ventricular diastolic pressure
- Equalization of LV and RV diastolic plateau pressure tracings, with little separation with exercise, since filling, and therefore diastolic pressure, in both ventricles is constrained by the inelastic pericardium. In some patients, this finding is seen only during inspiration (see image below)



The normal JVP waveform is represented in blue. In comparison, the JVP waveform in a patient with constrictive pericarditis (CP) is shown in red.



Simultaneous RV and LV pressure tracings showing diastolic equalisation of pressures in both ventricles in a patient with constrictive pericarditis.

PERICARDIAL EFFUSIONS & TAMPONADE

Pericardiocentesis is life saving in cardiac tamponade and indicated in effusions > 20mm.

The echocardiographic features of cardiac tamponade include the following:

- Collapse of the right atrium at end-diastole and the right ventricle in early diastole.
- Reciprocal changes in left and right ventricular volumes with respiration, which are important in the pathogenesis of pulsus paradoxus.
- Increased respiratory variation of mitral and tricuspid valve inflow velocities (drop in mitral flow by 30%, and tricuspid valve flow by 60% on the first beat of inspiration and expiration, respectively).
- Dilation (plethora) of the inferior vena cava and less than a 50 reduction in its diameter during inspiration, reflecting systemic congestion.

Relative contraindications to pericardiocentesis include uncorrected coagulopathy, ***anticoagulant*** therapy, thrombocytopenia < 50000/mm^3, small, posterior and loculated effusions. If the procedure needs to be delayed, volume depletion (including use of diuretics) should be avoided.

It is prudent to drain the fluid in < 1L steps to avoid acute right heart dilatation. The sub-xiphoid approach has been used most commonly, directed towards the left shoulder at a 30° angle to the skin. If haemorrhagic fluid is freely aspirated a few millilitres of contrast medium may be injected under fluoroscopic observation (sluggish layering inferiorly indicates that the needle is correctly positioned). A soft J-tip guidewire is introduced and after dilatation exchanged for a multi-holed pigtail catheter. If the sub-xiphoid approach is not possible, echocardiography should identify the shortest route where the pericardium can be entered intercostally (usually in the sixth or seventh rib space in the anterior axillary line). The most serious complications of pericardiocentesis are laceration and perforation of the myocardium and the coronary vessels. In addition, patients can experience air embolism, pneumothorax, arrhythmias (usually vasovagal bradycardia), and puncture of the peritoneal cavity or abdominal viscera.

The drain should be left in for 24-48 hours or until drainage is < 25ml/day. A balloon pericardiectomy or surgical pericardiectomy should be considered for recurrent effusions.

Pericardial fluid should be sent for analysis. This should include culture and cytology. If malignant disease is suspected, tumour markers should also be requested (carcinoembryonic antigen (CEA), alpha-feto protein (AFP), carbohydrate antigens CA 125, CA 72-4, CA 15-3, CA 19-9, CD-30, CD-25, etc).

PULMONARY EMBOLISM

Pulmonary thromboembolism (PTE) is occasionally encountered on the CCU either as a primary diagnosis, or alternatively as a complication of myocardial infarction. There are many potential risk factors, some permanent, others temporary.

Strong risk factors (odds ratio >10): fracture of lower limb, hospitalisation for heart failure, atrial fibrillation of flutter (within previous 3 months), hip or knee replacement, major trauma, myocardial infarction (within previous 3 months), previous venous thromboembolism, spinal cord injury.

Moderate risk factors (odds ratio 2–9): arthroscopic knee surgery, auto–immune diseases, blood transfusion, central venous lines, chemotherapy, congestive heart or respiratory failure, erythropoiesis-stimulating agents, hormone replacement therapy (depends on formulation), in vitro fertilization, cancer (highest risk in metastatic disease), oral contraceptive therapy, paralytic stroke, postpartum period, thrombophilia.

Weak risk factors (odds ratio <2): bed rest >3 days, diabetes mellitus, hypertension, immobility due to sitting (e.g. prolonged car or air travel), increasing age, laparoscopic surgery (e.g. cholecystectomy), obesity, pregnancy, varicose veins.

For initial diagnosis, in those with low or intermediate probability of PTE, a negative ***D-dimer*** (< 0·5 µg/ml FEU) means that imaging is unnecessary. There is a different reference range in pregnancy.

Remember false positives are common. In those with a co-existing DVT a leg ultrasound is enough to confirm. A Wells score (see page 90) is useful in determining the likelihood of a PTE. In those with high probability of PTE but no clinical DVT a CTPA is warranted. Isotope scanning is appropriate in patients with significant renal impairment. For massive PTE an echo may be diagnostic.

If the diagnosis is suspected, treatment should be commenced without delay. IV ***UFH*** (5000 IU) should be given followed immediately by therapeutic doses of ***enoxaparin***: 150 IU/kg daily, 100 IU/kg BD for those with a bleeding risk.

For confirmed PTE, ***LMWH*** should be continued until ***warfarin*** levels are therapeutic (INR > 2·0 for 2 consecutive days). An alternative strategy is to immediately initiate a ***DOAC*** and overlap with ***LMWH***.

For the initial treatment of acute pulmonary embolism, the recommended dosage of ***rivaroxaban*** is 15 mg BD for the first 21 days followed by 20 mg OD for continued treatment and prevention of recurrent venous thromboembolism.

The recommended dosage of ***dabigatran*** is 300 mg (150 mg twice daily) following treatment with a parenteral ***anticoagulant*** for at least 5 days. For people aged 80 years or older and for people on ***verapamil***, the recommended dose is 220 mg (110 mg twice daily). In people aged 75 - 80 years, people with moderately reduced kidney function, people with gastritis, esophagitis or gastro-oesophageal reflux, and people at increased risk of bleeding, either dose (300 mg or 220 mg) can be given based on an individual assessment. ***Dabigatran*** is contraindicated in people with severely reduced kidney function.

If ***apixaban*** is employed the recommendation is 10 mg BD for the first 7 days followed by 5 mg BD for at least 3 months (generally 6 months). For prevention of

recurrent DVT and/or PE following completion of 6 months ***anticoagulation***, the dose is 2·5 mg BD.

In patients with massive PTE (hypotension related to the PTE, severe hypoxaemia or acute RV failure), thrombolysis should be seriously considered. Thrombolytic regimes for PTE are not yet universally agreed, but the following is considered acceptable: ***t-PA*** (***Alteplase***): ***Over 65 kg – 10 mg IV bolus followed by 90 mg IV infusion over 2 hours, Under 65 kg – 10 mg IV bolus then max infusion dose should not exceed 1.5 mg/kg.*** If cardiac arrest seems imminent a 50 mg bolus can be given. The usual contraindications to thrombolysis apply. After lysis ***UFH*** (18 IU/kg/hr) once the APTT is less than twice the upper limit of normal. Careful fluid resuscitation may be necessary, but volumes should be limited. Inotropic support may also be necessary.
Very occasionally patients may require surgical embolectomy, although the mortality of the procedure can be very high. Appropriate to consider if within 2 hours of onset and if there is evidence of thrombus in the heart or proximal pulmonary arteries. Mechanical fragmentation is a last ditch procedure.

The standard duration of oral ***anticoagulation*** for the first episode of unprovoked PTE is: 6 months. For those with prior PTE ***anticoagulation*** should be for life.

For patients under the age of 40 and those with a family history, thrombophilia testing is indicated. Testing is recommended in any patient with recurrent thrombosis where there is no clear potential cause. Testing cannot be performed within 6 weeks of a thrombotic event. ***Warfarin*** reduces the levels of Protein C and S and screening is therefore done once ***warfarin*** has been discontinued for at least 6 weeks. Patients aged over 40 years with a first unprovoked DVT or PE who do not have signs or symptoms of cancer based on initial investigations require a CT abdomen and pelvis - this investigation is not required as an inpatient and can be performed on an urgent out-patient basis. In older men, or men with urinary problems, a PSA test should be considered. PV bleeding warrants a gynaecology screen. In women consider mammography.

Certain patients may be suitable for early discharge employing the ambulatory care pathway for PTE. Patients **not** suitable for ambulatory care include the following: associated raised ***TnI***, clinical evidence of right heart strain, hypoxia (< 92% O_2 saturations on air), haemodynamic instability (heart rate > 110, systolic BP < 100 mmHg), potential bleeding risk.

Slow initiation of ***warfarin*** is recommended for those being treated under the ambulatory care pathway employing the Tait and Sefcick regime [175] (see page 203). Or alternatively ***rivaroxaban*** or ***dabigatran*** are used. For patients in whom there is a low bleeding risk and in whom inpatient management has been decided upon, ***anticoagulation*** with ***warfarin*** should be initiated employing the Fennerty algorithm for venous thrombosis ([176]) (see page 203) or ***rivaroxaban*** or ***dabigatran*** are used.

In patients with cancer, long-term ***LMWH*** is often preferred rather than oral ***anticoagulation***.

Deep Vein Thrombosis (DVT)

All patients must be assessed for their risk of DVT on admission and appropriate patients administered prophylactic ***enoxaparin*** (4000 IU OD). In patients in whom DVT is suspected clinically, a Wells pre-test probability score should be calculated [177;178].

Online calculators are available: http://www.mdcalc.com/wells-criteria-for-dvt/

Table 4: Two-level PE Wells score (Wells et al 2000)

Clinical feature	Points
Clinical signs and symptoms of DVT (minimum of leg swelling and pain with palpation of the deep veins)	3
An alternative diagnosis is less likely than PE	3
Heart rate greater than 100 beats per minute	1·5
Immobilisation (for more than 3 days) or surgery in the previous four weeks	1·5
Previous DVT/PE	1.5
Haemoptysis	1
Malignancy (on treatment, treated in the last 6 months, or palliative)	1

Clinical probability revised score:

PE 'likely' = ≥ 5 points

PE 'unlikely' = ≤ 4 points

Table 5: Two-level DVT Wells score (Wells et al 2003)

Clinical Feature	Points
Active cancer (treatment on going, within 6 months, or palliative)	1
Paralysis, paresis or recent plaster immobilisation of the lower extremities	1
Recently bedridden for 3 days or more or major surgery within 12 weeks requiring general or regional anaesthesia	1
Localised tenderness along the distribution of the deep venous system	1
Entire leg swollen	1
Calf swelling at least 3 cm larger than asymptomatic side	1
Pitting oedema confined to the symptomatic leg	1
Collateral superficial veins (non-varicose)	1
Previously documented DVT	1
Alternative diagnosis at least as likely as DVT	-2

Clinical probability revised score:

DVT 'likely' = ≥ 2 points

DVT 'unlikely' = ≤ 1 point

Confirmed DVT requires treatment with ***rivaroxaban***. When ***rivaroxaban*** is contraindicated or the patient declines, ***warfarin*** should be employed after initiation of ***LMWH***. Other ***DOACs*** may be recommended locally in due course. Duration of therapy is variable depending on the circumstances. Post-surgery the guidelines recommend 6 weeks. In other settings, in patients with new DVT without a provoking cause or risk factor, treatment should be for 3 - 6 months ([179]). In a more contemporary study from 2007, there does not appear to be an advantage in treating for 6 months rather than 3 ([180]).

ARRHYTHMIAS

The electrophysiologists offer a consult service for all patients with arrhythmias which are difficult to control or manage. There is a consultant of the week model and referrals can be made either directly with the consultant if immediate assistance is required or via the mailbox: EPconsult@uhl-tr.nhs.uk.

BRADYCARDIA

Heart rates of less than 60 bpm are considered to be bradycardia. However, it is more helpful to classify a bradycardia as absolute (< 40 bpm) or relative when the heart rate is inappropriately slow for the haemodynamic state of the patient. The following signs may indicate instability: Systolic BP < 90 mmHg, HR < 40 bpm, poor perfusion, poor urine output, ventricular arrhythmias requiring suppression or heart failure.

Bradycardias can be classified according to the pacemaker which is at fault: either the sinus node or AV node.

Sinus Node:

Sinus node dysfunction can be sinus bradycardia, sick sinus syndrome (tachy-brady), sinus arrest alone or as part of vasovagal syncope. Obviously not all patients will be symptomatic. In the context of STEMI, moderate sinus bradycardia is common and benign, particularly in the first hour following (especially inferior) myocardial infarction. It is occasionally due to opiates. If the heart rate is persistently less than 45, or there are associated symptoms, treatment with ***atropine*** starting with a dosage of 600 µg repeated every 3 to 5 minutes to a total of 3·0 mg may be required to increase heart rate and prevent symptoms.

At other times, sinus bradycardia may be due to medications. Pacing is rarely required in the acute setting. Hypothyroidism, hypothermia and sleep apnoea should be considered. Less commonly sinus bradycardia can be the result of rheumatic fever, viral myocarditis, amyloidosis, haemochromatosis and pericarditis.

In patients with symptomatic sinus node disease a pacemaker is indicated.

AV Node:

Classified according to the degree of nodal dysfunction:

First degree AV block

Characterised by a PR interval > 0·2 seconds, no specific treatment is indicated. For patients on ***digoxin***, check for toxicity. Care with other rate limiting drugs. If there are symptoms of dizziness or syncope cardiac monitoring should be considered to identify higher degrees of block.

Second degree AV block (Wenckebach, Mobitz Type I)

This is characterised by progressive lengthening of the PR interval, followed by failure of the atrial impulse to conduct to the ventricles. It can occur in young fit patients with high vagal tone so can be seen during the night if monitored. It can occur quite frequently following inferior MI and rarely proceeds to complete heart block. No specific therapy is indicated. Higher degrees of AV block should be looked for if patients present with syncope or dizziness.

Second degree AV block (Mobitz Type II)

Characterised by a constant PR interval followed by sudden failure of a P wave to be conducted to the ventricles, this is less common, but indicates more serious involvement of the conduction system. Many patients will have associated bifascicular or trifascicular block. It can be associated with infarction where infrequently it progresses suddenly to complete heart block. Temporary transvenous pacing should be considered for recurrent symptoms or instability (see above). Recovery of conduction can occur following an MI and, if confirmed with cardiac monitoring, pacing can be avoided. In the absence of a recent acute coronary event, permanent pacing should be arranged (if drugs have been excluded). Various neuromuscular disorders can be associated with Mobitz type II block.

Complete (Third Degree) AV block

This is characterised by no conduction from the atria to the ventricles and therefore AV dissociation. There is no relationship between the P waves and QRS complexes. This block can occur above the AV node at the His region (narrow complex escape and usually well tolerated such as congenital complete heart block) or beneath the AV node with broad complex escape (not well tolerated). In can also be intermittent therefore look for ECGs with trifascicular or bifascicular block (RBBB, left axis deviation with or without prolonged PR interval) and alternating LBBB and RBBB.

Causes include various anti-arrhythmic drugs but more notably ***digoxin*** toxicity. It can occur following inferior STEMI (< 10% of cases) and in this context can resolve in hours to days. It is a more ominous finding following anterior MI (infranodal). However, with the advent of PPCI, complete AV block is rarely seen following recent coronary events. Another important cause is severe hyperkalaemia (can be treated with IV ***calcium chloride*** - 10 ml of 10% solution over 3 - 5 minutes, see page 138). In the haemodynamically unstable patient, ***atropine*** can be administered (600 µg to a maximum of 3 mg). ***Isoprenaline*** administered at a rate of 5 µg/min can be tried. In a peri-arrest situation, use an external pacemaker with sedation before arranging for temporary cardiac pacing. Urgent permanent pacing is indicated, and should be considered within 24 hours, in all patients except those with a reasonable likelihood of recovery of conduction - such as in patients with a recent coronary event.

Temporary Pacing

External (Transcutaneous) Pacing

In an emergency, external pacing can be instituted using percussion pacing or electrical pacing using a defibrillator. External pacing is unpleasant for the patient and should be considered a temporising measure until emergency transvenous temporary pacing / permanent pacing can be achieved. Consider ***isoprenaline*** / ***atropine*** to minimise the need for external pacing and sedation with ***midazolam***.

Percussion pacing protocol:

1. Percussion pacing is performed similarly to a precordial thump but with repeated applications and less force. The force required varies by patient but, as a guide, let the ulnar side of the fist fall from a height of 20-30 cm on to the lower left sternal edge.
2. Aim for a rate of 50-70 / min.
3. The efficacy of percussion pacing is best confirmed by restoration of circulation

and electrical capture on monitoring immediately after the percussion. The defibrillator should immediately be attached and set up as below but percussion pacing can be continued, providing it is effective, to minimise the requirement for electrical external pacing.

4. If there is any doubt as to the efficacy of percussion pacing CPR should be performed.

Electrical external pacing protocol:

1. Not all of UHL's defibrillators are capable of external pacing, check for a "pacer" button on the front. The defibrillators on CCU are able to externally pace and can be brought by the porter in an emergency.
2. Apply the defibrillator pads ideally in an AP position to minimise thoracic impedance but the standard anterolateral position is also acceptable.
3. Apply the defibrillator monitoring electrodes; the defibrillator cannot pace and sense through the pads simultaneously and a common error is to omit this step.
4. Switch the pacer on, it will default to a heart rate of 60 but with 0 mA energy delivery. Increase the energy as needed until electrical capture is achieved, then add a 10% safety margin for consistent capture. A typical threshold range is 40 to 80 mA but will vary with patient habitus e.g. obesity, COPD.
5. Confirm successful pacing with electrical capture of the heart (consistent appearance of QRS complexes immediately post pacing spikes).
6. CPR can be continued during electrical external pacing and should be continued if there is any doubt as to the efficacy of electrical external pacing.

Temporary Transvenous Pacing:

This procedure should be performed following a period of training including certification in the use of the fluoroscopy/X-ray equipment. Consider an externalised permanent pacemaker and discuss with the non-interventionist on call before inserting a temporary transvenous pacemaker.

1. Venous access with a 5F sheath should be either via the internal jugular (reduced risk of infection) or femoral vein (more straightforward) in patients for whom anticoagulant therapy is imminent or recently received because of the risk of haemorrhage.
2. Take a 5F temporary pacing wire with a preformed angle at the tip, if necessary the wire can be curled more to aid placement. Screen up or down following the wire all the way into the heart. Temporary pacing wires are soft and easily bend making further manipulation difficult, avoid this by pushing in repeated small movements holding the wire close to the sheath.
3. A useful technique is to try and place the tip of the electrode within the atrium (particularly the lateral wall), advance the electrode gently until a 'J' is formed, and then apply clockwise rotation. This should allow the electrode to fall across the tricuspid valve and into the right ventricle. Gentle manipulation with backwards and forwards motions with or without rotation should allow positioning of the electrode tip in the apex. Position of the tip should be slightly downward pointing and as lateral as possible.
4. Threshold for pacing should ideally be < 1 Volt. If patients are compliant, stability

should be checked by getting the patient to breathe deeply or cough. This stability should be checked whilst screening.

5. Ensure the electrode is properly secured after placement both by suture placement and adequate dressings to cover both the sheath and the majority of the wire. This is best achieved by making a loop so that if the wire is pulled it pulls on the loop rather than the tip of the wire.
6. Look for LBBB pattern during temporary pacing. Although rarely, RBBB pattern can be seen even with correct positioning in the RV apex, identification of a LBBB pattern with RV pacing should prompt a conscious check to ensure that the RV pacing lead is not inadvertently in the pericardial space, coronary sinus or via a PFO or ASD into the left ventricle.

Permanent Pacing

There are a variety of different indications for pacing. The following is based on ACC/AHA/ESC guidelines [181;182]. It is sensible to check patient's hobbies and occupations before any device therapy as pacemaker function can be affected by external influences (electromagnetic fields, arc welding equipment, industrial magnets).

Inpatient pacemaker and other device requests can be made under 'Service Referrals' on ICE and selecting 'Cath Lab' followed by 'Devices'.

Recommendations for permanent pacing in sinus node dysfunction (SND):

- SND with documented symptomatic bradycardia, including frequent sinus pauses that produce symptoms.
- Symptomatic chronotropic incompetence and in patients with symptomatic sinus bradycardia that results from required drug therapy for medical conditions.
- Not indicated for SND in asymptomatic patients.
- Assess for chronotropic incompetence with a 24 hour ECG looking for heart rate variability during periods of exercise or with an exercise tolerance test.

Recommendations for permanent pacing in acquired atrioventricular block in adults:

- Third-degree and advanced second-degree AV block associated with symptomatic bradycardia.
- Third-degree and advanced second-degree AV block associated with arrhythmias and other medical conditions that require drug therapy that results in symptomatic bradycardia.
- Third-degree and advanced second-degree AV block in awake, symptom-free patients in sinus rhythm, with documented periods of asystole greater than or equal to 3 seconds or any escape rate less than 40 bpm, or with an escape rhythm that is below the AV node (wide QRS).
- Third-degree and advanced second-degree AV block in awake, symptom-free patients with AF and bradycardia with 1 or more pauses of at least 5 seconds or longer.
- Third-degree and advanced second-degree AV block after catheter ablation of the AV junction.

- Third-degree and advanced second-degree AV block with postoperative AV block that is not expected to resolve after cardiac surgery.
- Third-degree and advanced second-degree AV block associated with neuromuscular diseases with AV block, such as myotonic muscular dystrophy, Kearns-Sayre syndrome, Erb dystrophy (limb-girdle muscular dystrophy), and peroneal muscular atrophy, with or without symptoms.
- Second-degree AV block with associated symptomatic bradycardia regardless of type or site of block.
- Asymptomatic persistent third-degree AV block with average awake ventricular rates of 40 bpm or faster if cardiomegaly or LV dysfunction is present or if the site of block is below the AV node.
- Second- or third-degree AV block during exercise in the absence of myocardial ischemia.
- Persistent third-degree AV block with an escape rate greater than 40 bpm in asymptomatic adult patients without cardiomegaly.
- Reasonable for asymptomatic type II second-degree AV block with a narrow QRS. When type II second-degree AV block occurs with a wide QRS, including isolated right bundle-branch block, pacing becomes a Class I recommendation.

Recommendations for permanent pacing in chronic bifascicular block:

- Advanced second-degree AV block or intermittent third-degree AV block.
- Type II second-degree AV block.
- Alternating bundle-branch block.
- Reasonable for syncope not demonstrated to be due to AV block when other likely causes have been excluded, specifically ventricular tachycardia (VT).
- Not indicated for fascicular block without AV block or symptoms.

Recommendations for permanent pacing after the acute phase of myocardial infarction:

- Indicated for persistent second-degree AV block in the His-Purkinje system with alternating bundle-branch block or third-degree AV block within or below the His-Purkinje system after ST-segment elevation MI.
- Transient advanced second- or third-degree infranodal AV block and associated bundle-branch block. If the site of block is uncertain, an electrophysiological study may be necessary.
- Persistent and symptomatic second- or third-degree AV block.

Recommendations for permanent pacing in hypersensitive carotid sinus syndrome and neurocardiogenic syncope:

- Recurrent syncope caused by spontaneously occurring carotid sinus stimulation and carotid sinus pressure that induces ventricular asystole of more than 3 seconds.
- Reasonable for syncope without clear, provocative events and with a hypersensitive cardioinhibitory response of 3 seconds or longer.

- May be considered for significantly symptomatic neurocardiogenic syncope associated with bradycardia documented spontaneously or at the time of tilt-table testing.

Left bundle branch block

LBBB most commonly occurs in patients with underlying heart disease but can also be seen in asymptomatic patients with a structurally normal heart. It increases in incidence with age. Patients should be assessed for hypertension, coronary disease, and other disorders that have been associated with LBBB (myocarditis, valvular heart disease, cardiomyopathies).

An echocardiogram is of value. One should also consider the possibility of underlying ischaemia. MPS scans result in higher false positive cases. Stress echocardiography has better accuracy and specificity.

Right bundle branch block

RBBB can occur in a normal heart in up to about 2% of patients. Incomplete RBBB occurs in up to 13% but reduces in incidence with age. Structural causes include cor pulmonale and pulmonary embolism. It can also be a consequence of myocardial infarction, ischaemia or inflammation. Other less common causes of RBBB include hypertension, cardiomyopathies, and congenital heart disease. RBBB can also result from idiopathic progressive cardiac conduction disease.

TACHYCARDIAS

Sinus tachycardia

Defined as persistent heart rate > 100 bpm. It is commonly due to pain or anxiety in response to increases in circulating catecholamines, but can also be due to dehydration/hypovolaemia, heart failure, hyperthyroidism, sepsis, stimulants, hypoxia and pulmonary embolism. Occurring in the context of myocardial infarction, sinus tachycardia can worsen ischaemia and hence prognosis. Unless there is any contraindication, such as cardiac failure or asthma, ***β-blockade*** should be considered (***bisoprolol*** 1st line then ***metoprolol***, which has a short half-life and requires 3 daily doses or ***atenolol***). Consideration to giving IV ***β-blockers*** in acute MI should be made. Remember that tachycardia may be because of underlying failure or in later stages could suggest the development of a more significant complication such as ruptured chordae or VSD. So until these have been ruled out add in ***β-blockers*** cautiously.

Occasionally an inappropriate sinus tachycardia can be symptomatic and the introduction of ***ivabradine*** can be beneficial, occasionally with the addition of ***β-blockers***.

Postural orthostatic tachycardia syndrome

Postural orthostatic tachycardia syndrome (POTS) occurs predominantly in young women with normal hearts, who have a normal or elevated resting heart rate that further increases with upright posture along with an exaggerated postural sinus tachycardia elicited by upright tilt table testing in the absence of orthostatic hypotension. Optimal therapy is uncertain, but good hydration and increased salt intake is helpful. Rarely ***fludrocortisone*** (0·1 - 0·4 mg per day) or ***midodrine*** (2·5 - 10 mg TDS – non formulary) are used. ***Ivabradine*** which is a preferential drug to slow sinus node function can also be helpful in certain cases (unlicensed). Started at

2·5 mg BD with increments of 2·5 mg to a total dose of 10 mg BD. It may cause flashing lights to be seen but this side effect settles within weeks.

Sinoatrial nodal re-entrant tachycardia

P waves on the ECG appear normal. Most patients are asymptomatic but are noted to have a resting tachycardia between 100 and 150. In patients with persistent high rates there is a risk of tachycardia-induced cardiomyopathy. ***Adenosine*** may slow and then abruptly terminate the tachycardia to aid in diagnosis. In symptomatic patients or those with incessant tachycardia, an EP study is indicated. Ablation is usually the treatment of choice, but ***verapamil***, ***digoxin*** and ***amiodarone*** have all been used with some success.

Supraventricular re-entry tachycardia

Most of the patients who present with paroxysmal supraventricular tachycardia have AVNRT (AV nodal re-entry tachycardia, 60% of SVT) or AVRT (Atrio-Ventricular re-entry tachycardia, 30% of SVT). These arrhythmias depend on AV nodal conduction and therefore can be terminated by transiently blocking AV nodal conduction. AVNRT is probably the commonest form of SVT encountered on the CCU. Rates vary from about 180 - 240 bpm. It is not common in the setting of acute coronary syndromes.

Vagal manoeuvres are the first-line treatment in haemodynamically stable patients. Vagal manoeuvres, such as breath-holding and the Valsalva manoeuvre (i.e. having the patient bear down as though having a bowel movement or blowing hard into a syringe to move the plunger), all slow conduction in the AV node and can potentially interrupt the re-entrant circuit.

Carotid massage is another vagal manoeuvre that can slow AV nodal conduction. Massage the carotid sinus for several seconds on the non-dominant cerebral hemisphere side. This manoeuvre is usually reserved for young patients. Due to the risk of stroke from emboli, auscultate for bruits before attempting this manoeuvre. Do not perform carotid massage on both sides simultaneously. Wait at least 10 seconds before trying the other side.

When SVT is not terminated by vagal manoeuvres, short-term management involves intravenous ***adenosine*** or ***calcium channel blockers***. ***Adenosine*** is a short-acting drug that blocks AV node conduction; it terminates 90% of tachycardias due to AVNRT or AVRT. It is given as a rapid IV bolus followed by a saline flush, best administered via a three-way stopcock (6 mg stat followed by 12 mg if unsuccessful and then a further 12 mg if still unsuccessful), in the antecubital fossa followed by a long flush with 0·9% ***sodium chloride***. ***Adenosine*** has a very short half-life. It may produce chest discomfort (which the patient should be warned about), transient hypotension and flushing. It should be avoided in patients with significant reversible airways disease. The crash trolley should be next to the patient when administering this drug in the unlikely event of significant bradyarrhythmia or more rarely tachyarrhythmia.

If the tachycardia continues despite successful induction of at least some degree of AV blockade, the rhythm is almost certainly atrial tachycardia or flutter; AVRT is excluded, and AVNRT is very unlikely

Synchronised cardioversion following sedation starting at 150J can be used immediately in patients who are hypotensive, have pulmonary oedema, have chest pain with ischaemia, or are otherwise unstable.

Verapamil (5 - 10 mg slowly IV) is an alternative but is dangerous and contraindicated in patients already on ***β-blockers*** or in patients with known significant LV dysfunction. If ***adenosine*** and ***verapamil*** are ineffective or contraindicated (particularly if the patient is symptomatic and hypotensive), electrical cardioversion under general anaesthetic or sedation should be performed.

Intravenous ***flecainide***, ***esmolol***, ***metoprolol*** and ***amiodarone*** may all convert rapid SVT. ***Flecainide*** is probably the best but should be avoided in patients with myocardial infarction (past or present). ***β-blockers***, ***amiodarone*** and ***sotalol*** are all effective in preventing paroxysmal SVT in the setting of myocardial infarction. Contact the on-call electrophysiologist if concerned.

All patients with frequent attacks or drug side effects should be referred to an electrophysiologist for consideration of an electrophysiology study with a view to RF ablation to provide a cure and remove the need for ***antiarrhythmics***. Many individuals with AVNRT respond to ***β-blockers***, ***diltiazem*** or ***verapamil*** (although ***verapamil*** and ***digoxin*** must not be used for WPW / AVRT). Second line drugs to prevent SVT are ***flecainide***, ***sotalol*** or ***amiodarone***.

Asymptomatic adult patients with evidence of pre-excitation on the ECG (delta wave) should be referred for an outpatient EP assessment. An exercise test showing loss of conduction through the accessory pathway at higher heart rates suggests a safe pathway but ultimately an invasive EP assessment of antegrade pathway conduction would still be required due to risk of pre-excited AF and sudden death in those pathways able to conduct fast.

In some patients it may be suspected that they have paroxysmal SVT but it has proved difficult to capture on monitoring. In this situation it is possible to diagnose the presence of an antegradely conducting accessory pathway by means of a bedside ***adenosine challenge*** ([183]).

Management of Wolff-Parkinson-White Syndrome (with Pre-Excited Atrial Fibrillation)

These patients present with SVT in the form of AVRT. The management is the same as that as outlined above. However, pre-excited AF is more worrying. This is the rapid irregular rhythm of AF that conducts antegradely down the bypass tract to the ventricles. Remember that these bypass tracts can allow rates as high as 300 bpm to conduct from the atrium. They are different to the AV node which acts as a ‘gatekeeper’ to the atrial fibrillation where the ventricular rate can never get that fast. Hence the danger of this arrhythmia is that it is associated with sudden cardiac death. It can degenerate into VF quickly and should be diagnosed correctly and with speed. Features on the 12-lead ECG, which would point to this diagnosis, are a broad complex irregular tachycardia with bizarre QRS morphologies, which may vary from beat to beat. AV nodal blocking drugs such as ***digoxin***, ***bisoprolol*** and ***verapamil*** must be ***AVOIDED***. This will block conduction down the AV node and therefore increase conduction preferentially down the bypass tract. Electrical cardioversion is the preferred safest option, but ***flecainide*** or ***amiodarone*** can be helpful. Long term prophylaxis is not really an option as these patients should all be

referred for further in-patient electrophysiological assessment and ablation due to the risk of sudden death.

ATRIAL FIBRILLATION (AF)

AF is the most common sustained cardiac arrhythmia and if left untreated is a significant risk factor for stroke and other co-morbidities. Management has been additionally influenced by the NICE guidance published in 2014 (CG180).

Identification

AF can be a major finding in many patients with co-existent ischaemia, hypertension, heart failure or presenting as an arrhythmia alone.

Symptoms - breathlessness, palpitations, chest pain, fatigue, oedema, syncope/dizziness and stroke/TIA.

Examination - irregular pulse, thyroid disease, valvular heart disease, heart failure.

Investigations - An ECG must be performed in all cases. An irregular pulse can be due to ectopics. Transthoracic echo should be performed in most cases to guide anti-arrhythmic therapy and longer term management of underlying structural heart disease. It can also guide the clinical risk stratification for anti-thrombotic therapy.

Treatment

This will depend on the type of AF (paroxysmal, persistent and permanent) and the timing of symptoms. The main options are rate control or rhythm control.

Acute onset atrial fibrillation

If the patient presents within 48 hours of the onset of symptoms and you can be certain of the timing of the onset, then cardioversion pharmacologically or electrically can be performed. If there are signs of haemodynamic instability, electrical cardioversion with sedation is required immediately.

Correction of electrolytes is mandatory and thyroid dysfunction needs to be excluded. If there is no underlying structural heart disease (confirmed on echo) or coronary disease, then IV ***flecainide*** is probably the most effective. It is given at a dose of 2 mg/kg infusion over at least 10 minutes to a maximum of 150 mg. Otherwise, IV ***amiodarone*** is the next best choice given as 300 mg IV loading over 1 hour followed by a further 900 mg over 23 hours through a large bore cannula/central line (to prevent thrombophlebitis). ***Amiodarone*** administered orally is an option, but the likelihood of achieving sinus rhythm is less. However, approximately 40% of patients will cardiovert with no treatment at all.

In patients who are not on an ***anticoagulant***, ***anticoagulation*** should be commenced in the form of ***LMWH***, in case the patient does not respond to pharmacological cardioversion. This will allow subsequent electrical cardioversion. Other drugs that can be used but are less effective are ***sotalol***, ***esmolol***, ***disopyramide***, ***bisoprolol*** or ***calcium channel blockers***.

If the duration of AF is longer than 48 hours but there is a pressing need to achieve SR, a TOE guided cardioversion can be considered. If there is no left atrial thrombus, the patient can be cardioverted with ***heparin*** cover and then commenced on an ***anticoagulant*** thereafter. This should be considered when the duration of

anticoagulation is ideally to be kept to a minimum as the ***anticoagulant*** can be stopped after 4 weeks.

Vernakalant, a drug currently available only intravenously is likely to be available during the lifetime of this document. It is a class I and III anti-arrhythmic with atrial selectivity which has been shown in trials to be quicker at achieving SR (within minutes) compared to ***amiodarone*** ([184]). Its license is for patients with atrial fibrillation of less than 7 days duration. Dose is 3 mg/kg over 10 minutes. If after 15 minutes sinus has not been restored, a second infusion of 2 mg/kg over 10 minutes is administered.

On-going medical therapy should be started to maintain SR. NICE recommends a standard ***β-blocker*** rather than ***sotalol***. If AF recurs despite first line treatment with beta blockers ***Flecainide*** (initial dosage 50mg BD) can be added to the ***β-blocker*** in patients with normal ventricular function and no history or evidence of ischaemic heart disease. Alternatively the ***bisoprolol*** can be changed to ***sotalol*** (initial dosage 40mg BD).

Amiodarone is useful if there is structural heart disease. In patients in whom cardioversion is planned, consideration should be given to starting ***amiodarone*** 4 weeks before and continuing for 12 months after. Patients starting ***amiodarone*** should be aware of the potential for side effects affecting the thyroid, lung and liver. The incidence is approximately 15% over a three year period and most develop either hyper or hypothyroidism. TFT and LFT should be checked every 6 months and any new cough or increase in breathlessness should be investigated with PFTs and a CXR. Patients taking ***amiodarone*** can develop photosensitivity and the use of sun block on exposed skin is recommended.

Dronedarone [185;186] is a newer antiarrhythmic drug belonging to the benzofuran class of antiarrhythmic compounds. Due to safety concerns this drug is now only used in patients who have failed first line treatment with ***β-blockers***, ***sotalol*** and/or ***Flecainide***. ***Dronedarone*** (400 mg BD) is an option for the treatment of paroxysmal AF only in people who have at least one of the following cardiovascular risk factors: hypertension requiring drugs of at least two different classes, diabetes mellitus, previous TIA, stroke or systemic embolism, left atrial diameter of 50 mm or greater, age 70 years or older, and who do not have current or previous heart failure. Patients treated with ***dronedarone*** must have their liver function checked prior to commencement, monthly for 6 months and then at months 9 and 12 and periodically thereafter. ***Dronedarone*** can cause a worsening of heart failure and patients should be advised to report any deterioration in symptoms. ***Dronedarone*** must be initiated by a consultant and at present is only prescribable by the hospital. Patients in whom ***dronedarone*** is prescribed must be referred to Sue Armstrong, our lead arrhythmia nurse, who runs a ***dronedarone*** clinic to monitor bloods and ECG and to issue prescriptions.

Persistent atrial fibrillation

In patients presenting with AF of several days duration or more, a decision needs to be made over the option of either rate control (slowing the rate if indicated) or rhythm control (with a view to future cardioversion). All patients need to be assessed for ***anticoagulation*** (see page 102).

If a rate control strategy is decided upon, AF should be treated with rate control drugs like ***β-blockers*** (not ***sotalol***) or non-dihydropyridine ***calcium channel***

blockers, with ***digoxin*** used in sedentary patients or as an adjunct to the former for better rate control. Some patients need to be on combinations such as a ***β-blocker*** and ***diltiazem***. ***Amiodarone*** should not be used for long term rate control. Generally speaking, cardioversion is not offered to patients over the age of 75 or in patients in whom the duration of AF is several months. The likelihood of successful cardioversion or maintenance of SR after cardioversion is much lower in these populations, as it is in the presence of significant left atrial dilatation.

If patients remain symptomatic despite good rate control, a rhythm control strategy should be considered after a period of adequate ***anticoagulation*** (minimum three weeks).

In patients in whom cardioversion is planned, consideration should be given to starting ***amiodarone*** 4 weeks before and continuing for 12 months after. In the absence of structural or ischaemic heart disease many patients will maintain SR using ***flecainide***. At the very least, patients undergoing cardioversion must have medication aimed at enhancing the success of the treatment. Without medication, recurrence approaches 100% at one year.

The following medications are most commonly employed: ***β-blockers***, ***dronedarone***, ***amiodarone***, ***flecainide*** and ***propafenone***.

If rate control in the long-term is all that can be achieved, but proves difficult with pharmacological methods, consideration should be given to referring the patient for AV node ablation and permanent pacing.

Paroxysmal atrial fibrillation

Paroxysmal AF can be treated with the same medications outlined previously for maintaining SR after cardioversion (***β-blockers***, ***amiodarone***, ***dronedarone***, ***flecainide***). Although not recommended by NICE, local practice does include the option of employing ***sotalol*** in this situation. ***Flecainide*** should be avoided if there is evidence of structural heart disease or IHD.

Some patients with paroxysmal AF (and no structural heart disease) respond to a ‘pill in the pocket’ approach and take a stat dose of drug as soon as the AF starts and this can be highly successful in terminating an episode (***flecainide*** 200 - 300 mg, ***propafenone*** 450 - 600 mg).

It is important that patients with continuing symptoms despite anti-arrhythmics should be referred to an Electrophysiologist for consideration of AF ablation or pacemaker and AV node ablation.

Anticoagulation

Anti-thrombotic treatment is of great importance in the management of AF. ***Aspirin*** is no longer offered as monotherapy for the prevention of stroke in patients with AF. The decision regarding the need for formal ***anticoagulation*** is decided with reference to the published CHA_2DS_2-VASc criteria (see below). Online calculators are available:

http://www.mdcalc.com/cha2ds2-vasc-score-for-atrial-fibrillation-stroke-risk/

CHA_2DS_2 - VASc criteria:

C= congestive cardiac failure; H= Hypertension; A= Age; D= diabetes; S= stroke/TIA; V= Vascular disease; S= Sex (female).

Scoring is as follows: 2 points if age over 75, 2 points if previous stroke/TIA. 1 point is scored for other risks with the second age category being 65 to 74 years. The risk of thromboembolism is greater the more points are scored.

Low risk is considered 0 - 1 point, although NICE (CG180) recommends ***anticoagulation*** should be seriously considered for all apart from patients under the age of 65 whose only risk factor is their sex (female). For men with a score of 1, ***anticoagulation*** should be considered AND offered.

1 point or more and ***anticoagulation*** is recommended (taking bleeding risk into account and with the exception noted above). The risk is also greater in permanent AF compared to paroxysmal and risk assessed in sinus rhythm. A low threshold to ***anticoagulate*** must be applied in patients with rheumatic mitral stenosis. Another risk factor not included in the CHA_2DS_2 - VASc score are patients with significantly enlarged left atria. In the context of STEMI the risk of stroke with AF is also higher. Patients do not need to be admitted to start ***anticoagulation*** and similarly, inpatients do not need to stay in until their INR is therapeutic when using ***warfarin***. Slow initiation of ***Warfarin*** employing the Tait and Sefcick regime can be used ([187]) (see page 203) or consideration of employing a ***DOAC***. For high risk patients, where there is a significant likelihood of left atrial thrombus, self-administration of ***LMWH*** until the INR is therapeutic should be considered. This is not required with the ***DOACs***.

Before commencing ***anticoagulation***, consideration needs to be made as to the potential bleeding risk. Use of the HAS-Bled score gives an indication of risk and looks at several factors: age over 65, hypertension (> 160 systolic), abnormal renal function (creatinine > 200), significant liver impairment, previous stroke, bleeding tendency, labile INRs (in patients on ***warfarin***), concomitant ***aspirin*** use or alcohol abuse ([188]). One point (maximum 9) is scored for each. A score greater than 3 indicated patients at higher risk ([189]). Online calculators are available:

http://clincalc.com/cardiology/anticoagulation/hasbled.aspx

Anticoagulation can be achieved with ***warfarin*** (vitamin K antagonist), ***dabigatran*** (thrombin inhibitor), ***rivaroxaban*** (factor Xa inhibitor), ***apixaban*** (Factor Xa inhibitor) and ***edoxaban*** (Factor Xa inhibitor). The newer ***anticoagulants*** (***DOACs***) do not require INR monitoring and their onset of action is more rapid than ***warfarin*** (within hours). With both ***dabigatran*** and ***rivaroxaban*** compliance is crucial because they have short half-lives and so the omission of a single dose can result in loss of ***anticoagulation***.

Rivaroxaban is prescribed at a dose of 20 mg OD. Creatinine clearance (CrCl) should be calculated (not eGFR) using the Cockcroft-Gault equation (need age, weight in kg, serum creatinine and sex). There are numerous web based calculators.

http://www.mdcalc.com/creatinine-clearance-cockcroft-gault-equation/

Reduce the dose to 15 mg OD if CrCl is 30 - 49 mL/minute; refer to haematologist if CrCl is 15 - 29; avoid if CrCl less than 15 mL/minute. In patients with hepatic disease associated with coagulopathy and clinically significant bleeding risk, including cirrhotic patients, ***rivaroxaban*** should **not** be prescribed. NICE recommends ***rivaroxaban*** in patients with previous stroke or TIA, heart failure, hypertension, diabetes and those aged over 75.

Apixaban is recommended by NICE in patients with non-valvular AF with one or more risk factors of prior stroke or TIA, age 75 or over, hypertension, diabetes or

heart failure. The dose is 5mg BD (2·5 mg BD if over 80, weighs less than 60 kg, or if CrCl 15 - 29 mL/minute, or if serum-creatinine ≥ 133; avoid if CrCl less than 15 mL/minute). ***Apixaban*** should be considered in preference to ***rivaroxaban*** in patients with a history of previous GI blood loss or current dyspepsia.

Dabigatran is prescribed at 150 mg BD unless there is a higher risk of bleeding when the lower dose of 110 mg BD should be used. It is not frequently used in AF in Leicester. It must be stopped if the eGFR is less than 30. It should be used with caution with other P-glycoprotein substrates e.g. ***verapamil***, ***amiodarone***, ***clarithromycin***) with at least a 2 hour gap between taking ***dabigatran*** and these drugs. NICE recommends its use in patients with previous stroke, TIA or embolism, LVEF less than 40%, NYHA heart failure class 2 or above, aged 75 or older, and aged 65 or older if there are other risks such as diabetes, coronary disease or hypertension.

Edoxaban is recommended by NICE in patients with non-valvular AF with one or more risk factors of prior stroke or TIA, age 75 or over, hypertension, diabetes or heart failure. The recommended dose is 60 mg OD. The recommended dose is 30 mg OD in people with one or more of the following clinical factors: moderate or severe renal impairment (CrCl 15 - 50 mL/minute); body weight of 60 kg or less; concomitant use of the P-glycoprotein inhibitors e.g. ***ciclosporin***, ***dronedarone***, ***erythromycin*** or ***ketoconazole***.

Anticoagulation should be continued for a minimum of 4 weeks (and generally longer) following successful cardioversion to exclude the risk of delayed embolisation. In order to increase the chances of long-term success, ***antiarrhythmic*** therapy needs to be considered, especially in patients with a relapse following previous electrical cardioversion. Many continue long term ***anticoagulation*** in patients even if they are successfully cardioverted, especially if there is a high risk of recurrence.

Unlike ***warfarin***, there are few agents currently available to reverse the action of the ***DOACs***. ***Dabigatran*** however does have a reversal agent (***Idarucizumab***: ***Praxbind***, 5 g in 50 ml IV over 2 minutes) which is available within UHL for use in life-threatening circumstances. For the other ***DOACs*** prothrombin complex concentrate (***Optaplex***) should be considered (contact haematology on call).

If there are uncertainties when considering the use of ***DOACs*** there is excellent guidance available on Insite:

http://insite.xuhl-tr.nhs.uk/homepage/management/clinical-management-groups/emergency-and-specialist-medicine/specialty-medicine/stroke-services/anticoagulation-stroke-prevention

Cardioversion

External cardioversion should be considered in patients with AF if they present within 24 -48 hours of the onset.

If already anticoagulated, then confirm adequate ***anticoagulation*** (INR > 2·0 if on ***warfarin***) for the preceding 4 weeks to proceed. Check electrolytes and correct to normal range to proceed. Sedate with ***midazolam*** (using incremental doses of 1 mg). If there are issues regarding airway, respiratory disease, long term use of anxiolytics or neuromuscular disease, then anaesthetic help is mandatory. The pads should be AP (one on the sternum and one on the back) with high energies started

(200 J Biphasic up to 360 J) to ensure sinus rhythm is obtained on the first synchronised shock. A defibrillator with pacing capabilities is required in case of subsequent bradycardia. It is prudent to discontinue rate limiting medication (especially ***digoxin***) at least 24 hours prior to cardioversion.

Drugs used prior to cardioversion (like ***flecainide***, ***β-blockers*** or ***amiodarone***) should probably be continued for at least 6 months. Risk of relapse in patients not treated with ***antiarrhythmic*** therapy is as high as 80% at 12 months. ***Digoxin*** should generally be avoided in the prevention of AF and is probably no better than placebo for chemical cardioversion.

Maintenance of sinus rhythm can often be achieved with ***flecainide***, ***propafenone***, ***amiodarone***, ***dronedarone*** or ***sotalol***. Class 1C drugs should be avoided in patients with evidence of structural heart disease. If one drug fails, another may succeed. If patients feel symptomatically better with restoration of sinus rhythm but relapse back into AF despite ***antiarrhythmics*** then consider referral to an electrophysiologist for ablation.

Atrial Flutter

This is a different atrial rhythm to atrial fibrillation, with organised p waves (flutter waves) on the ECG but still irregular due to variable block. It is uncommon in a normal heart.

The treatment is very similar to that for AF. Initial management may be directed at controlling the ventricular rate if conduction is 2:1 (rate of ~ 150). A ***β-blocker***, ***calcium channel blocker***, ***digoxin***, or some combination of these drugs may be tried. This may convert the patient to controlled atrial fibrillation. Acute rate control may be achieved by employing IV ***digoxin***, ***diltiazem***, ***verapamil*** or a ***β-blocker*** (such as ***esmolol***, ***atenolol*** or ***metoprolol***). As with atrial fibrillation, if the patient has been in flutter for $\geq$ 48 hours, ***anticoagulation*** should be commenced and cardioversion deferred for at least 3 weeks.

The arrhythmia is more difficult to cardiovert with medications and will require a higher proportion of electrical cardioversions. Caution also if using IV ***flecainide*** with atrial flutter due to the slowing of the flutter circuit with then 1:1 conduction to the ventricle more likely if no AV nodal blocking drugs like ***bisoprolol*** or ***verapamil*** are administered. In this situation it is sensible to administer rate control medication prior to an attempt at chemical cardioversion. Be aware of patients presenting with broad complex tachycardia (rate about 240 bpm) who are taking ***flecainide*** as this can be 1:1 flutter with aberrant conduction. In this situation, vagal manoeuvres or ***adenosine*** can slow the rate and flutter waves can be identified. IV AV nodal blocking drugs can then be administered. If unstable proceed to electrical cardioversion.

Most patients should be considered for catheter ablation due to its low risk and high success rate to prevent recurrence. Therefore refer to an electrophysiologist. The isthmus between the inferior vena cava and the tricuspid annulus (cavotricuspid isthmus) is an obligatory route for typical flutter, and, as such, is the preferred anatomic target for ablation.

Electrical cardioversion is not infrequently required because of the inherent resistance of atrial flutter to therapy. It may require as little as 15 J with a biphasic waveform defibrillator, although 25 J is the recommended starting energy.

Long-term therapy to prevent attacks can be achieved with ***flecainide*** or ***propafenone*** if there is no underlying structural heart disease. ***Amiodarone*** and ***sotalol*** may also be quite effective. ***Anticoagulation*** should be seriously considered (as for AF).

Supraventricular Premature Beats (SBPs)

SPBs are fairly ubiquitous and will be seen frequently on 24 hour monitoring. Patients with very frequent SBPs should be considered for echocardiography. In most patients reassurance is all that is necessary. Occasionally ***β-blockers*** are used for symptomatic relief. ***Non-dihydropyridine calcium antagonists*** are not effective.

Ventricular Premature Beats (VPBs)

Occasional VPBs are very common (40 - 75% of apparently healthy patients on 24 hour monitoring) and are almost always benign. In the context of myocardial infarction, the routine suppression of asymptomatic ectopics does not appear to impact on mortality [190], although the presence of significant numbers of ectopics may identify patients at higher risk of future events [191]. They are more common in hypertensive patients with LVH, in the context of an MI, heart failure, HCM, and congenital heart disease.

In some cases very frequent ectopics (> 20% of complexes) can produce ventricular dilation and dysfunction ([192]), the latter being an indication for treatment even in the absence of symptoms. Unifocal ectopics arising from the RVOT (LBBB, inferior axis pattern) that increase with exercise can be associated with NSVT (see page 110). RF ablation should be considered ([193]).

Outside the context of STEMI they frequently do not need treatment but suppression may be achieved with ***β-blockers***, ***verapamil*** or ***diltiazem***. In severe symptomatic patients RF ablation may be an option. More potent ***antiarrhythmic*** drugs such as ***flecainide***, ***propafenone*** (if no structural disease), ***amiodarone*** or ***sotalol*** can be effective.

Patients with troublesome ectopy should have 24 or 48 hour monitoring to assess frequency and determine if they are monomorphic or polymorphic. An echocardiogram should be considered. An exercise test will determine whether inducible VT is apparent and can detect ischaemia. Exercise-induced ectopy can frequently respond to ***β-blockers***.

VENTRICULAR TACHYCARDIA (VT)

Rapid broad complex tachycardia shortly after STEMI is nearly always VT. Neither non-sustained VT (lasting < 30 s) nor accelerated idioventricular rhythm (usually a consequence of reperfusion with a rate < 120 bpm) occurring in the setting of STEMI serves as a reliably predictive marker of early VF. As such specific therapy is not indicated.

In patients with sustained VT who are haemodynamically compromised cardioversion is indicated (synchronised 150 – 200 joule shock with a biphasic defibrillator). Suppression can be achieved with ***β-blockers*** but care is needed if hypotensive or LV function is significantly impaired. ***Amiodarone*** can be tried (300 mg IV over a few minutes, followed by 900 mg over 24 hours). An alternative is ***lidocaine*** (50 - 100 mg over 3 - 5 minutes), which may be repeated after 5 minutes. No more than 200 - 300 mg should be given in one hour. An infusion may be commenced (4 mg/min for 30 minutes, reducing to 2 mg/min for 2 hours, then 1

mg/min, see page 201). In resistant VT, temporary overdrive pacing may occasionally prove useful. Administration of ***magnesium sulphate*** should be considered (***magnesium sulphate*** 8 mmol, 2 g - in 20 ml of 0·9% ***sodium chloride*** - over 20 minutes followed by an infusion of 65 mmol, 16 g - in 48 ml of 0·9% ***sodium chloride*** - over 24 hours).

Outside the context of STEMI, recognition of VT can be challenging. If ***adenosine*** is given to high enough doses to cause symptoms but has no effect on the rate of a broad complex tachycardia, VT must be the default diagnosis. Supraventricular tachycardia with aberrant conduction (i.e. BBB) may mimic VT. A very irregular broad complex tachycardia is usually AF with BBB and in young patients consider WPW AV re-entry tachycardia.

Features supportive of VT rather than aberrant conduction are:

- Wide QRS (> 140 ms)
- Left axis deviation
- RSR in V_1 with $RV_1 > RV_2$
- AV dissociation (evidence of independent atrial activity)
- Fusion beats (halfway between ventricular and 'normal' beats)

In patients presenting with a broad complex tachycardia but no obvious infarction, and SVT is suspected rather than VT, ***adenosine*** can be given. The vast majority of AV nodal re-entry tachycardias will be terminated and atrial fibrillation or flutter will be slowed. VT will rarely respond at all.

Patients with VT $\geq$ 48 hours following myocardial infarction should be considered for angiographic and electrophysiological referral, as should patients presenting *de novo* with VT, especially in the context of poor LV function. An MRI scan should also be considered to evaluate for viability, ischaemia and scarring. Underlying ischaemia and heart failure must be addressed if present.

Patients unsuitable for revascularisation and/or implantable cardioverter defibrillators (ICDs) are best treated with ***antiarrhythmic*** therapy in the form of ***amiodarone*** and/or ***β-blockers***. ***Mexiletine*** can be helpful but its supply is restricted. It should be remembered that the cause of VT may be underlying ischaemia and treatment directed at ischaemia may be very beneficial, particularly ***β-blockers*** [133]. In addition, the use of ***ACEI*** may also reduce the incidence of arrhythmic deaths following myocardial infarction [194]. The routine use of ***amiodarone*** as a prophylactic against arrhythmias following myocardial infarction should be avoided [195;196]. Response to therapy should be assessed with Holter monitoring.

In patients with documented IHD, even NSVT should be treated. If there is depressed LV function (LVEF < 40%), a VT study should be considered and an ICD implanted if there is inducible VT [197;198]. Essentially anyone with VT and EF < 35% should be considered for ICD. If QRS > 120 ms CRTD should be considered depending on symptoms (see page 126). ICD therapy should be at least considered in all patients presenting with VT (see guidelines page 112).

Electrical Storm

Patients sometimes present with multiple episodes of VT or VF over a short period of time requiring multiple cardioversions or device-related therapies (anti-tachycardia pacing: ATP, defibrillation). The definition is loosely > 3 ICD therapies in < 24 hours, 2 or more unstable episodes in < 24 hours in patients without an ICD or incessant VT lasting for hours. It usually occurs in the context of severe underlying structural heart disease. Occasionally there may be specific underlying triggers:

- Drug toxicity.
- Electrolyte disturbances (i.e. hypokalaemia and hypomagnesaemia).
- New or worsened heart failure.
- Acute myocardial ischaemia.
- QT prolongation (which may be related to drug toxicity, electrolyte imbalance, or an underlying syndrome such as long QT syndrome.

Monomorphic VT related to scar or re-entry accounts for 85 to 90%, primary VF up to 20%, mixed VT/VF 5-15% and polymorphic VT up to 10%.

The management of these patients is challenging but also very individualised.

1. Ensure generous amounts of ***benzodiazepines*** are administered to reduce anxiety. If recurrent shocks consider referral to ITU so that the patient can be anaesthetised with ***propofol*** which itself has anti-arrhythmic properties.
2. Identify and correct any electrolyte imbalance. It is worth giving IV ***magnesium sulphate***, especially if prescribed diuretics. The serum magnesium does not reflect the level of magnesium in the heart (***magnesium sulphate***: 8 mmol, 2 g - in 20 ml of 0·9% ***sodium chloride*** - over 20 minutes followed by an infusion of 65 mmol, 16 g - in 48 ml of 0·9% ***sodium chloride*** - over 24 hours).
3. Keep potassium levels at the high end of normal (4·5-5·0 mmol).
4. Treat any heart failure with IV diuretics and even intra-aortic balloon pump to offload. ***ACEI*** and ***β-blockers*** should also be used or continued if possible.
5. In certain cases, treatment of ischaemia may be helpful. Rarely, coronary angiography may identify a treatable stenosis that is causing the VT. Stabilisation with an intra-aortic balloon pump may also help. If scar related, surgical aneurysmectomy may be beneficial to prevent future episodes.
6. IV anti-arrhythmic drugs should be used. ***Amiodarone*** remains the most efficacious drug but does have side effects related to long term treatment. This is worth the small risk given the life threatening VT storm. It may require a few days of repeated IV loading that should be administered through a centrally placed line rather than a cannula to prevent thrombophlebitis/thrombosis. Think of re-loading patients if they have recently stopped the drug or are maintained on only 100 mg OD. Other common side effects are fever, hypotension, abnormal LFTs and nausea. Oral administration should be continued after IV loading at 200 mg OD. ***β-blockers*** should also be started or up-titrated to maximally tolerated doses and have been shown to be beneficial in combination with ***amiodarone*** to stop VT. IV ***lidocaine*** (loading and maintenance) can be useful in those patients already maintained on ***amiodarone***. When the VT is stopped, start ***mexilitine*** orally whilst weaning the IV ***lidocaine***. In special circumstances when some of these drugs are

not tolerated then oral ***flecainide*** can be used if an ICD is implanted for fear of pro-arrhythmic effects. IV ***steroids*** and latterly oral can be useful in inflammatory cardiomyopathies such as sarcoid if biopsy/CMR proven.

7. If there is an implanted ICD, check that all shocks appropriate and not due to atrial fibrillation, atrial flutter or acceleration of the VT into the shockable zone. Recent evidence suggests that shocks are associated with a poorer outcome. Make sure there is prolonged detection so that non-sustained arrhythmias are not treated. ATP should only be used in slow VT cases and well tolerated VT patients. Ideally, ICD shocks should only be programmed in the VF/very fast VT zone. This will be much individualised depending on the VT rate and patient haemodynamics. Also consider pacing to prevent bradycardias related to anti-arrhythmics/conduction system disease. Atrial pacing would be best if this prevents ventricular pacing but sometimes a short period of higher rate ventricular pacing (90-100 bpm) is required to stabilise the situation. This should be reversed back to normal rates as the treatments take effect. Rarely, VT storm can be initiated after a biventricular pacemaker is implanted. This may relate to pacing near a scar inducing VT. Consider switching off V pacing or trying a different configuration to prevent VT being induced.
8. In patients without an ICD, anti-tachycardia (overdrive) pacing with a temporary pacemaker can be tried. It is usual to pace at a rate that is slightly faster (eg, at a cycle length 10 to 15% shorter) than the rate of the detected tachycardia.
9. Lastly, it would be advisable to inform one of the consultant electrophysiologists to review the patient and consider VT ablation. These patients are very sick with failing hearts and we would rather not perform ablation as it highly risky with poor outcomes such as death. Sometimes we have no choice despite full medical therapy. On-going trials are looking at prophylactic ablation of scar in patients with cardiomyopathy to see if this prevents these episodes and improves longer term outcomes.

‘Torsades de Pointes’ Ventricular Tachycardia

This is a specific form of polymorphic VT arising in association with a prolonged QT interval. The ECG reveals a continually changing axis over a sequence of 5 - 20 complexes and the ventricular rate is usually 200 - 250 bpm. The resting ECG has a QT interval of > 0·47 s.

The QT interval is measured from the onset of the QRS to the end of the T wave and should be corrected for heart rate. The corrected QT interval (QT_c) =

$$\frac{\text{QT interval (ms)}}{\sqrt{\text{RR (secs)}}}$$

The normal QT_c is < 450 ms in men, 470 ms in women.

There may also be prominent U waves. The onset of the tachycardia is usually preceded by a late cycle atrial or ventricular ectopic followed by a compensatory pause. The tachycardia is usually non-sustained and repetitive.

The condition may be congenital (***Romano-Ward*** and ***Jervell-Lange-Nielson*** syndromes) or may be related to drugs or metabolic disturbance. Common secondary causes are hypokalaemia, hypomagnesaemia, class Ia, Ic and III ***antiarrhythmic*** drugs, ***digoxin***, ***ranolazine***, certain antihistamines and

antidepressants, and the tachycardia often occurs in association with a bradycardia (e.g. sick sinus syndrome or AV block).

Management consists of correcting any underlying cause. ***Magnesium sulphate*** should be administered even in the absence of hypomagnesaemia. Hypokalaemia and hypocalcaemia should be corrected. Temporary atrial or ventricular overdrive pacing may be required at a rate of about 100. If this cannot be arranged immediately, an infusion of ***isoprenaline*** can be used (2 µg/min and titrated to get the heart rate up to about 100).

Longer-term management consists of ***β-blockade***, pacing, sympathectomy or ICD implantation. Patients and their first degree relatives should be considered for genetic testing.

RVOT Tachycardia

This arrhythmia belongs to the group of idiopathic or 'normal heart' VT. It is a common cause of VT with onset between the second and fourth decade, being more common in women. VEBs of RVOT origin (LBBB morphology, inferior axis) are seen and can develop into NSVT with exercise or emotional stress.

Arrhythmogenic right ventricular cardiomyopathy (ARVC) is a form of right ventricular cardiomyopathy where there is fibro-fatty infiltration of the RV and subsequent ventricular dilatation. The resting ECG may be normal but there is often the development of T wave inversion in leads V1 to V3. Echocardiography may show RV dysfunction and/or RVOT dilatation. Diagnosis can usually be made with CMR.

VT occurring in ARVC may mimic that of **idiopathic RVOT tachycardia** but prognosis is much less favourable. It is important to distinguish between the two as RVOT tachycardia is now treated with RF ablation, whereas VT in ARVC is best managed with the ICD as long-term results with catheter ablation are disappointing [(199)]. Patients and their first degree relatives should be considered for genetic testing. Avoidance of high intensity activity is advisable. To reduce the incidence of symptomatic arrhythmias, ***sotalol*** or ***amiodarone*** can be tried. Patients and their first degree relatives should be considered for genetic testing.

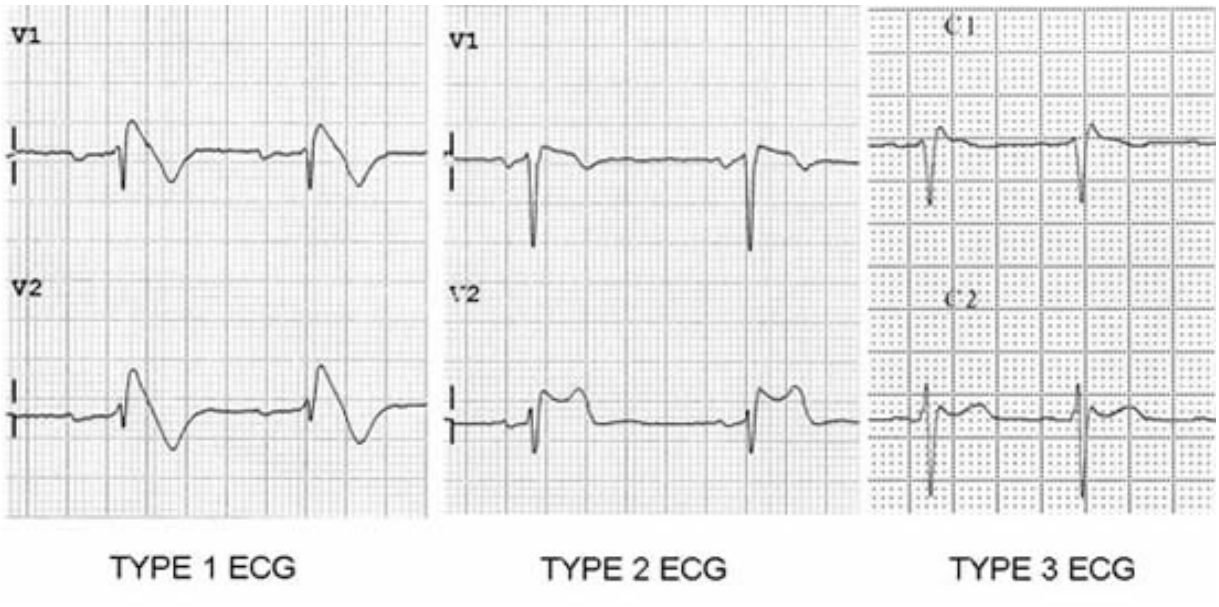
RVOT tachycardia is also known as repetitive monomorphic VT (RMVT). It occurs almost exclusively in young or middle aged patients without structural heart disease. Episodes are frequently associated with stress or exercise. The prognosis is generally good. More aggressive therapy should be directed at patients with a history of syncope, very fast VT (> 230 bpm) and very frequent ectopy.

For prevention, ***verapamil*** and ***β-blockers*** are first line. ***Amiodarone*** and ***sotalol*** can be helpful, as can Class I drugs. To avoid long term use of medication in younger patients, RF ablation should be seriously considered.

Brugada Syndrome

This is an inherited condition (autosomal dominant) which manifests as abnormal repolarisation in the right precordial leads (V1 - V3).

Figure 2: Brugada ECG changes.



- Type 1: Characterised by prominent coved ST-segment elevation displaying J-point amplitude or ST-segment elevation ≥ 2 mm, followed by a negative T wave.
- Type 2: ≥ 2 mm J-point elevation, ≥ 1 mm ST-segment elevation and a saddleback appearance, followed by a positive or biphasic T-wave.
- Type 3: It has either a saddleback or coved appearance, but with ST-segment elevation < 1 mm.

Type 1 is the only ECG diagnostic pattern of BS, while types 2 and 3 should only be considered suggestive of the disease. Types 2 and 3 may require confirmation of diagnosis with exposure to ***flecainide*** (2 mg/kg IV over 10 minutes). Increasingly an ***ajmaline challenge*** is employed (1mg/kg, 5mg/min).

BS is associated with an increased risk of death. Prior syncope, seizures, males, or those with a family history of sudden cardiac death are at higher risk. The risk of cardiac arrest is higher at night during sleep. Atrial fibrillation is more common in BS. When diagnosed, extended family screening is indicated. All patients should be seen by an electrophysiologist as VT studies may be appropriate. Treatment is an ICD.

Ventricular Fibrillation (VF) and Cardiac Arrest

VF may follow complex VEBs and/or VT, but may also occur spontaneously after myocardial infarction. A precordial thump should be applied followed by immediate cardioversion if unsuccessful. In the context of STEMI, ***β-blockers*** reduce the incidence of VF ([200]). Correction of hypomagnesaemia and hypokalaemia is encouraged. Prophylaxis with ***lidocaine*** may reduce the incidence of VF but appears to be associated with increased mortality and has therefore been abandoned. For frequent episodes of VF, ***amiodarone*** should be given in the form of 300 mg IV slow bolus followed by an infusion of 900 mg over the next 24 hours.

In patients who have been successfully resuscitated from an out of hospital VF arrest, consideration should be given to immediate angiography. This is essentially mandatory if the ECG suggests ischaemia and if intervention is likely to affect

outcome. For patients who are intubated, immediate anaesthetic support is needed. Continued ventilatory support and cooling may be necessary.

ICD Therapy

The indications for ICD therapy were relaxed in June 2014 (NICE TA 314).

For **secondary prevention** for patients who present, in the absence of a treatable cause, with one of the following:

- Having survived a cardiac arrest due to either VT or VF (outside context of acute MI).
- Spontaneous sustained VT causing syncope or significant haemodynamic compromise.
- Sustained VT without syncope or cardiac arrest, and who have an associated reduction in ejection fraction (LVEF of less than 35% - no worse than class III of the NYHA functional classification of heart failure).

For **primary prevention** of arrhythmias, for patients who have:

Left ventricular dysfunction with an LVEF of less than 35% (no worse than class III of the NYHA functional classification of heart failure). In patients with LBBB, consideration should be given to resynchronisation therapy (see page 126).

Primary prevention ICDs are only considered at least a month after MI, and in patients on optimal medical therapy, with an anticipated life expectancy of more than a year with a good quality of life. Co-morbidities should be considered when selecting patients for ICD implantation. An ICD is inappropriate in patients with terminal cancer or other illnesses significantly expected to shorten life, including patients with NYHA class IV heart failure.

Ultimately, patient choice is key. The benefit should be balanced against the risks for the patient's complications from ICDs, which can be as high as 9.1% at 16 months, including lead displacement, pneumothorax and haematomas. The psychological burden of having an ICD should also be considered.

In addition, primary prevention is appropriate in patients with a familial cardiac condition with a high risk of sudden death, including long QT syndrome, hypertrophic cardiomyopathy, Brugada syndrome, ARVC, or have undergone surgical repair of congenital heart disease.

ICD therapy should be considered as both primary and secondary prevention in patients with HCM (see page 134).

The choice of what type of ICD is important. ICDs combined with CRT are discussed elsewhere (see page 126). A dual chamber ICD should be considered if the patient has sinus bradycardia or sinus node disease. Leads are either single or dual coil. Single coil leads should be favoured in younger patients (easier to extract).

Subcutaneous ICD (S-ICD) is an alternative approach to the transvenous ICD. It is comprised of a subcutaneous lead that runs parallel to the left sternal edge and along the inferior border of the heart to a generator in the axilla. SICD should **not** be implanted in patients with a pacing indication for bradycardia, anti-tachycardia pacing, or need for cardiac resynchronisation therapy. It should be considered as an option in all patients, particularly the young, to prevent potential long term problems seen with transvenous leads (lead failure, vascular obstruction, infection). S-ICD has

several potential advantages, including the preservation of venous anatomy (or where venous anatomy is unattractive), and is theoretically easier and safer to extract in cases of infection.

ICD and Driving

The advice that must be given to people who drive is complicated and prone to change. See page 172.

Figure 3: Resuscitation Council algorithm for advanced life support.

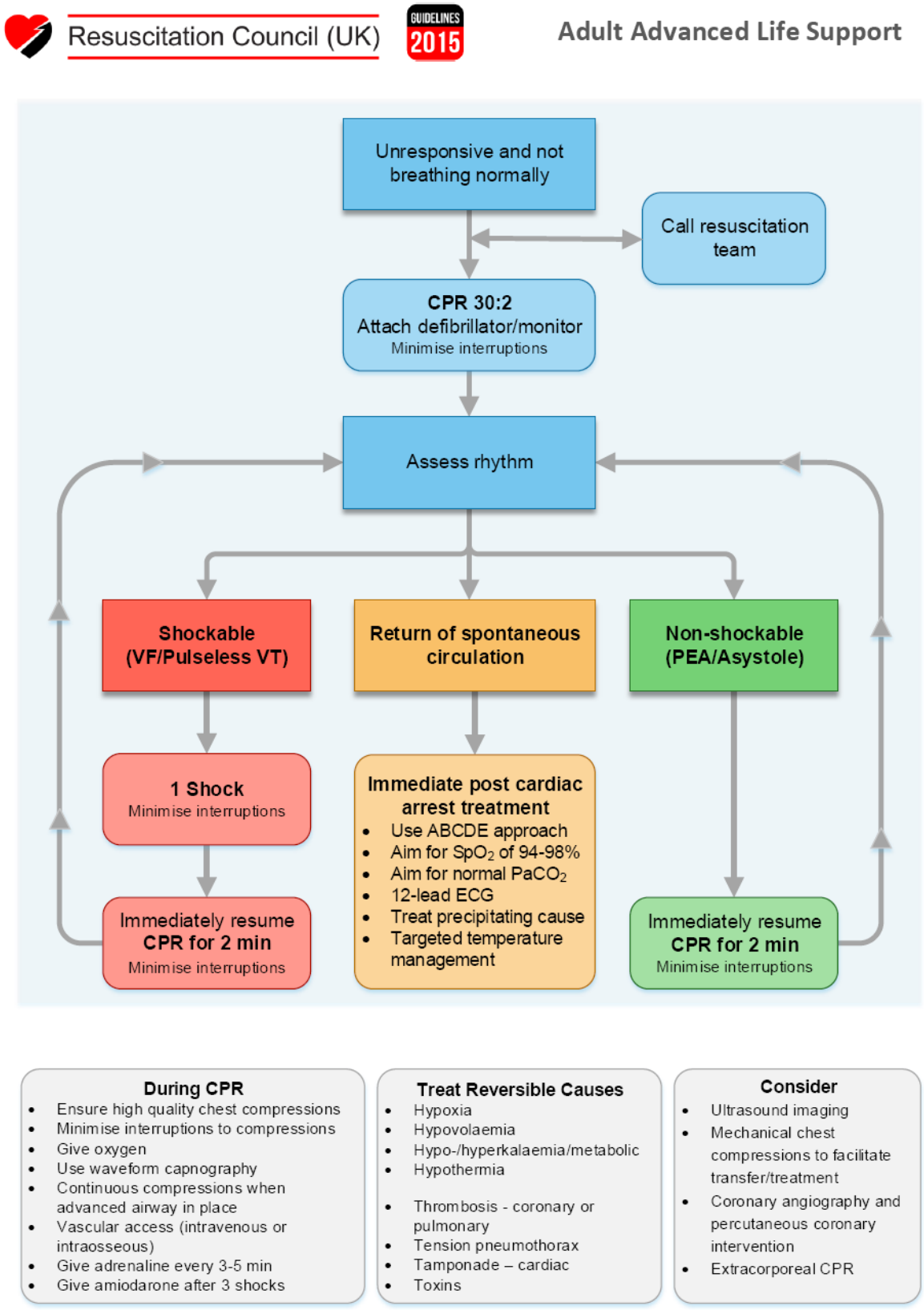


Figure 4: Resuscitation Council algorithm for management of tachycardia.

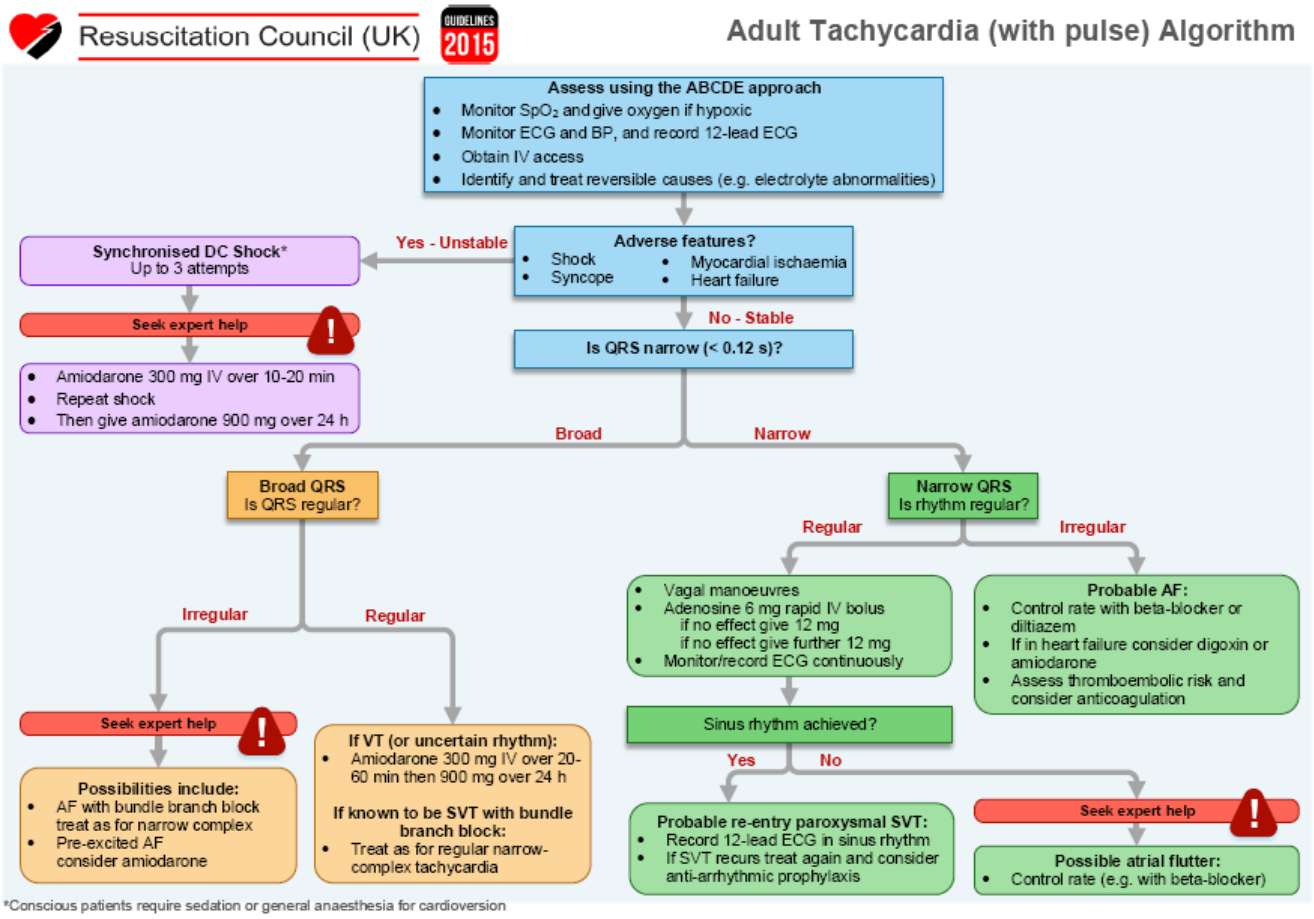
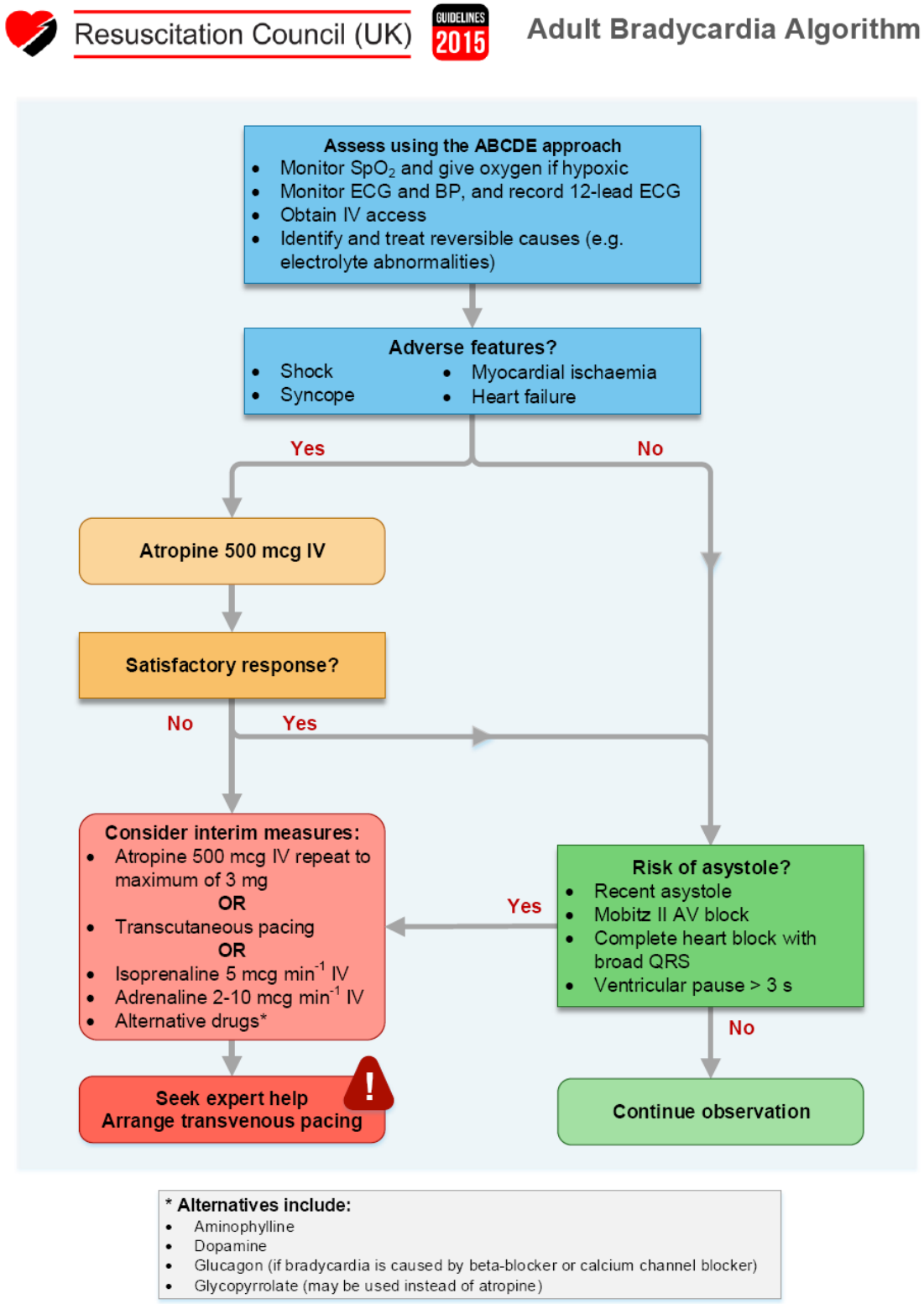


Figure 5: Resuscitation Council algorithm for management of bradycardia.



SYNCOPE

Syncope is an abrupt and transient loss of consciousness, associated with loss of voluntary muscle tone, followed by rapid and usually complete recovery. It is important to distinguish pre-syncope from dizziness (vertigo) as patients may mean different things when they complain of dizziness. It is also important to differentiate syncope from mechanical falls. It is important to establish what happened before, during and after the syncopal episode. There are recent guidelines on the investigation and management of syncope from 2018 ([201]).

There are different types of syncope: reflex or neurally mediated syncope, orthostatic hypotension and cardiac arrhythmia syncope.

Neurally mediated syncope is often associated with prodromal symptoms (feeling hot, sweating, light-headedness, visual changes). It is usually short lived. On regaining consciousness there is usually rapid recovery with no drowsiness, confusion or headache. It may occur sitting or standing but not lying. The most common type of neurally mediated syncope is neurocardiogenic (vasovagal) syncope. Other neurally mediated syncopal conditions include carotid sinus syndrome or syncope after urination, defaecation, swallowing or coughing ('situational' syncope). Getting information from witnesses if possible can be invaluable.

A simple faint can be categorised by the 6 **P**'s: **P**osture (prolonged standing or sitting), **P**rovoking factors (pain, fear), **P**rodromal symptoms, **P**ost-syncope nausea or vomiting, **P**ost recovery recurrence syncope provoked by sitting or standing, **P**revious episodes. Advice needs to include avoidance of triggers, ensuring adequate hydration, limiting alcohol etc.

Orthostatic syncope occurs when there is insufficient vasoconstriction in response to orthostatic stress (standing). Classic orthostatic hypotension is defined as a reduction in systolic BP >20 mmHg and >10 mmHg in diastolic within 3 min of standing.

Cardiac syncope refers to the conditions where syncope is caused by a decrease in cardiac output due to a primary cardiac aetiology. The common causes of cardiac syncope are arrhythmia (tachyarrhythmia and bradycardia) and fixed or dynamic obstruction (HOCM, aortic stenosis, left atrial myxoma, pulmonary hypertension, pulmonary embolism). A family history of sudden death is a concern.

Neurally mediated syncope is more common in the following circumstances:

- Absence of heart disease
- Long history of recurrent syncope
- After sudden unexpected unpleasant sight, sound, smell or pain
- Prolonged standing or crowded, hot places
- Nausea, vomiting or abdominal pain associated with syncope
- During a meal or post-prandial
- With head rotation or pressure on carotid sinus (as in tumours, shaving, tight collars)
- After exertion

Epilepsy more likely if:

- Abnormal movements (brief seizure activity can occur during simple faints)
- Abnormal behaviour
- Unusual posturing
- Head turning to one side
- Post-ictal confusion
- Tongue biting (the side of the tongue) or amnesia

Orthostatic hypotension is more likely:

- After standing up quickly
- Temporal relationship with start or changes of dosage of vaso-depressive drugs leading to hypotension
- Excessive diuresis
- Prolonged standing especially in crowded, hot places
- Presence of autonomic neuropathy (i.e. parkinsonism, diabetes)
- Standing after exertion
- Prolonged immobility or bed rest
- Endocrine disorders such as Addison's disease

Cardiac syncope is more likely:

- Presence of definite structural heart disease
- Family history of unexplained sudden death or channelopathy
- During exertion, or supine
- Abnormal ECG
- Sudden onset palpitation immediately followed by syncope
- ECG findings suggesting arrhythmic syncope:

    - Bifascicular block (defined as either LBBB or RBBB combined with left anterior or left posterior fascicular block)
    - Other intraventricular conduction abnormalities (QRS duration ≥ 120 ms)
    - Mobitz I second degree AV block
    - Asymptomatic inappropriate sinus bradycardia (<50 bpm), sinoatrial block or sinus pause ≥3 s in the absence of negatively chronotropic medications
    - Non-sustained VT
    - Pre-excited QRS complexes
    - Long or short QT intervals
    - Early repolarization
    - RBBB pattern with ST-elevation in leads V1-V3 (Brugada syndrome)
    - Negative T waves in right precordial leads, epsilon waves and ventricular late potentials suggestive of ARVC
    - Q waves suggesting myocardial infarction

Single episodes rarely warrant investigation or admission. Recurrent episodes require further investigation. A careful history is mandatory. Where a cardiac cause is thought to be very likely (see above) admission may be indicated. Initial assessment should include:

- Pulse at rest and on standing
- BP both arms
- BP after lying for 5 minutes
- BP after standing for 3 minutes
- Listen for murmurs or bruits
- Arrange FBC, U&E, Glucose
- ECG

If an arrhythmia is likely, ambulatory ECG should be arranged (inpatients can be monitored and do not need a 24 hour ECG or Looper). The appropriate type of recording and length needed should be gauged by the frequency of events. Infrequent episodes (< every 2 weeks) may benefit from assessment with an implantable cardiac monitor/Looper (ILR). The bulk of arrhythmia-related syncope detected by loop recorders are bradycardias, especially in the elderly. An ILR is extremely useful for patients with recurrent syncope that occur less often than once a week. This is performed under local anaesthesia and enables correlation of clinical events to cardiac rhythm.

An echo (and occasionally CMR) is indicated if known heart disease or suspicion of structural disease.

Electrophysiology studies are underutilised generally in the investigation of syncope but the diagnostic yield is quite high. EP studies are of particular use in older patients with evidence of left ventricular dysfunction or an abnormal ECG.

Admission may also need to be considered in the presence of the following: significant trauma, significant dehydration, significant GI blood loss/anaemia, frail elderly, symptomatic significant orthostatic BP fall (greater than 20 mmHg systolic drop or systolic below 90 mmHg on standing).

The red flags for patients with syncope are: abnormal 12 lead ECG, family history of sudden cardiac death, older patients, syncope with exertion or when supine, structural heart disease and history of heart failure.

An excessive rise in heart rate (≥ 30 beats/min) or to a rate of 120 bpm or more (without significant hypotension) is suggestive of postural orthostatic tachycardia syndrome (POTS). This is readily diagnosed by a tilt study. Tilt studies are generally indicated in patients with frequent episodes of syncope where an arrhythmia is felt to be unlikely.

In patients over the age of 40, carotid sinus hypersensitivity should be considered. Carotid massage should be performed in a controlled environment with ECG recording and resuscitation equipment available. Carotid sinus massage should be avoided in patients with history of transient ischemic attack, stroke or MI within the past three months and in patients with carotid bruits (except if carotid Doppler studies excluded significant stenosis). Carotid sinus massage is diagnostic if

syncope is reproduced together with asystolic longer than 3 seconds and/or a fall in systolic BP > 50 mmHg.

Please refer to the DVLA guidance (page 172) when advising patients whether they can drive.

Management of neurocardiogenic syncope includes patient education, lifestyle changes and physical counterpressure manoeuvres. Avoidance of triggers (prolonged standing, moving from lying/sitting to standing quickly, hot baths/showers, fasting, excessive alcohol intake or drugs with vasodepressor properties) and ensuring adequate salt and fluid intake may reduce syncope frequency.

Common physical counterpressure manoeuvres include leg crossing, limb and/or abdominal contraction, isometric arm contraction, bending forward, squatting, toe raising and knee flexion. The most effective and least cumbersome appears to be leg crossing and whole body muscle tensing in an attempt to mitigate the blood pooling to prevent syncope.

Further interventions such as an increase in salt and water, tilt training, head-up sleeping, abdominal binders, elastic stockings and medical therapy are considered for recurrent neurocardiogenic syncope. It is recommended that patients with recurrent neurocardiogenic syncope drink 2 - 3 litres of fluid per day or enough fluid to avoid dark urine and ingest 10 g of salt per day.

Evidence of benefit utilising ***fludrocortisone*** is lacking. ***β-blockers*** may be of benefit in patients over the age of 42. There is also a suggestion that SSRIs like ***paroxetine*** (20 mg OD) may occasionally be useful. ***Midodrine*** may help as with orthostatic hypotension below.

Management of orthostatic hypotension includes education and the maintenance of adequate fluid and salt intake. In patients without underlying hypertension, 2–3 litres of fluid and 10 g of salt per day is recommended to expand extracellular volume. In patients with drug induced autonomic failure, removal of the offending agent, when possible, is recommended. ***Midodrine*** (2·5 - 10 mg TDS – non formulary and not licensed) and ***fludrocortisone*** (0·1 – 0·2 mg per day) may be helpful. Although trial data is lacking, pacing is indicated in carotid sinus hypersensitivity.

Management of cardiac syncope depends on the specific cause. The recommended treatment is dictated by the risk of syncope recurrence, risk of cardiac arrest and efficacy of the treatment. In general, pacemakers are recommended for symptomatic sinus node dysfunction, significant AV nodal disease (Mobitz II and complete heart block) or in patients with syncope with bundle branch block (BBB) and significant conduction system abnormality at electrophysiology study. Medical therapy (antiarrhythmic medications and AV nodal blockers) may be effective to reduce the risk of syncope due to atrial fibrillation with rapid ventricular response or for supraventricular tachycardia or outflow tract VT that is refractory to ablation. ICDs are recommended in patients with documented VT and structural heart disease, previous myocardial infarction or known channelopathies

HEART FAILURE

A number of patients are admitted every week across UHL with a diagnosis of heart failure. Most will have a prior history of ischaemic heart disease. Other predisposing conditions need to be considered including valvular heart disease, atrial fibrillation, hypertension, diabetes, significant COPD and prior pulmonary thromboembolic disease. A small number will be new presentations as a consequence of cardiomyopathy. Some will be post-viral, but post-partum cardiomyopathy and alcohol abuse also need to be considered. A family history should include questions of premature or sudden death. Endocarditis needs to be considered. Treatment, whenever possible, should also be aimed at the underlying disease (if identifiable).

About 50% of patients will have systolic heart failure or heart failure with reduced ejection fraction (HFREF). Many patients with clinical features of heart failure however have echocardiograms that suggest just mild impairment or even normal systolic function. There is increasing recognition that such patients, called HFNEF (heart failure normal ejection fraction), have a very similar clinical course and outcome as patients with LV systolic dysfunction. Patients with HFNEF are often more elderly, overweight and have hypertension and atrial fibrillation. It is important to consider and exclude other causes such as coronary artery disease, pulmonary disease, anaemia etc. It is hypothesised that the physiology behind HFNEF relates to impaired filling or diastolic dysfunction. Treatment is very similar to standard heart failure patients, with diuretics etc but there is little evidence for the use of ***ACEI*** and ***β-blockers*** although one recent study suggests ***aldosterone antagonists*** may have some benefit. Nonetheless these patients have mortality similar to patients with left ventricular dysfunction and are equally disabled.

Most patients with systolic heart failure will have underlying coronary artery disease, but a fair proportion will have a non-ischaemic cardiomyopathy.

Patients who are admitted with a diagnosis of heart failure have a high mortality, both as inpatients (up to 10%) and following discharge (up to 50% in the following 12 months). Patients who have severe fluid overload, very high NT-proBNP levels, severe renal impairment, advanced age, multi-morbidity and frequent admissions with heart failure have an especially grave prognosis.

Comprehensive updated guidelines are available from the ACCF/AHA 2013 ([202]) and ESC 2012 ([203]).

INVESTIGATIONS

ECG

Q waves may suggest previous MI; LVH may suggest aortic stenosis, hypertension or diastolic overload; RV dominance and RAD may suggest chronic lung disease.

Routine blood tests

Renal function should be assessed to give clues as to previous hypertension, effect of medication and baseline. Allows exclusion of renal failure as a cause for oedema. Liver function tests may suggest hepatic congestion. A blood count excludes anaemia. Glucose may unmask undiagnosed diabetes. Thyroid function excludes thyroid dysfunction as the primary diagnosis. Check if on ***amiodarone*** therapy, or therapy planned. Uric acid will assess possible susceptibility to gout from diuretic use.

Serum ferritin and transferrin should be taken in younger patients to exclude haemochromatosis. A careful family history (see later) is important to identify familial disease and genetic testing should be seriously considered.

Brain natriuretic peptide (NT-proBNP) has an increasingly important role to play in the identification of patients with LV dysfunction [204;205]. Levels less than 100 ng/L essentially rule out acute heart failure. Generally speaking however, NTproBNP should be measured only where there is doubt about the diagnosis. A level above the normal range does not equate to a diagnosis of "heart failure" as any stimulus which causes increased cardiac chamber stress can elevate these peptides. Thus NTproBNP may be elevated in atrial fibrillation, or RV strain (such as acute PE or cor pulmonale).

Renal impairment is very common in patients with CCF and it is important to react to results in a measured fashion. It is crucial to look at trends and whether renal function has changed as a consequence of alterations in medication. Drugs like ***spironolactone*** can cause deterioration and drugs like ***amiloride*** should be used with caution (and be aware of the ***amiloride*** content in ***co-amilofruse*** – ***Frumil***).

Stopping ***ACEI*** because of renal impairment is a common reaction and should be done with caution in patients who have been established on them for a long time. Temporary discontinuation is reasonable in the acute phase but they should be reintroduced as soon as possible if renovascular disease is not suspected. In patients admitted with exacerbations of heart failure, diuretic doses are often reduced because of renal impairment and patients are subsequently discharged on lower doses than on admission. This is likely to result in readmission and careful comparison of admission and discharge doses is necessary.

The Chest X-Ray

Usually cardiomegaly; May have pleural effusions; may be interstitial fluid, upper lobe blood diversion and Kerley b lines. May show enlarged left atrium in mitral stenosis. If heart size normal, consider diastolic dysfunction or pericardial disease. May reveal pericardial calcification.

Echocardiography

THE KEY INVESTIGATION. It will confirm whether the diagnosis is correct. Possible findings: dilated poorly contracting left ventricle (systolic dysfunction); stiff, poorly relaxing, often small diameter left ventricle (diastolic dysfunction); valvular heart disease; atrial myxoma; pericardial disease. **DO NOT** request if performed in the previous 12 months and where there is no clinical suggestion of change, or if the result will not result in a change of management.

CMR

Not mandatory in all patients but is a valuable non-invasive method of imaging that can elaborate on the cause of heart failure. Expensive and time consuming, this investigation can only be requested by consultants. Useful in patients with coronary disease for viability assessment as revascularisation may improve systolic function.

Coronary Angiography

A proportion of patients, especially those with systolic failure, will have heart failure as a consequence of coronary artery disease. Combined with viability studies (CMR,

stress echo) this investigation will identify whether patients may have the option of revascularisation therapy.

MANAGEMENT

Lifestyle modification Smoking cessation and restriction of alcohol consumption is recommended. Salt restriction is advisable. Fluid restriction may be indicated especially in the presence of hyponatraemia. Daily weight monitoring can help identify fluid accumulation earlier.

Diuretics First line. The most effective symptomatic treatment. Loop diuretics are the most effective. ***Furosemide*** 40 - 500 mg daily in divided doses. May be given IV, especially when patients are very fluid overloaded (remember ampoules of ***furosemide*** are 50 mg so give 50 mg or multiples thereof rather than 40 mg as per oral dosing). Big doses may be needed in renal impairment. Better effect is occasionally seen with prolonged infusions (i.e. 250 mg over several hours). ***Bumetanide*** may be better absorbed orally, and may have advantages when patients are markedly oedematous. ***Torasemide*** (20 - 60 mg daily in divided doses) is also better absorbed.

The initial dose of diuretics given to a patient who is fluid overloaded depends on whether they are already on diuretic therapy and what their baseline renal function is. It is customary to give a larger dose than what the patient is currently taking – a suggested regime is 1·5 to 2·5 times the prescribed dose administered intravenously (for example if patient is on ***Furosemide*** 40mg PO, start with ***Furosemide*** 100mg IV), The patient should be carefully monitored for the response to treatment and doses should be adjusted accordingly. Patients should have urine input and output monitoring as well as daily weighing to assess response to treatment. A pragmatic approach should be adopted with respect to the impact on renal function (both in the acute and chronic situation). A trade-off is reasonable in terms of achieving appropriate fluid offloading and accepting a reduction in renal function – as long as renal function does not continue to decline or when function is so severely impaired that the need for dialysis is a possibility.

Thiazide diuretics are often useful when added to a loop. Only small doses may produce a profound diuresis. ***Bendroflumethiazide*** (2·5 mg OD) may be employed. More dramatic diuresis may be seen with ***metolazone*** (2·5 - 5 mg daily). Very careful monitoring of renal function is required in this situation, and extra special caution should be applied in outpatients. Potassium depletion may occur with long-term diuretic use, although this may be counterbalanced by ***ACEI***. If hypokalaemia persists consider the introduction of ***amiloride*** 5 mg OD orally with careful monitoring of the U&Es. For the most part, ***spironolactone*** 25 mg OD should be considered in preference to ***amiloride*** in all patients with class III or IV heart failure if they are already established on an ***ACEI*** [206]. Care should be taken if the creatinine is greater than 200 µmol/l. Careful monitoring of the U&Es after introduction is essential. Monitoring of the patient's weight and urine output is mandatory.

Angiotensin Converting Enzyme Inhibitors are particularly useful if the patient is also hypertensive [77]. ***ACEI*** improve the symptoms and signs of all grades of heart failure (even if the patient is asymptomatic). They improve exercise tolerance, slow disease progression and improve survival [194;207;208]. If an ***ACEI*** is given to 1000 CHF patients for 1 year it would save 17 premature deaths, save 67 hospitalisations for CHF, prevent 13 episodes of unstable angina or myocardial infarction (compare with

β-blocker use after acute MI which would save 17 lives only per 1000 patients treated). Patients with diabetes are particularly likely to benefit [78].

Only larger doses have shown to be effective in the clinical trials, and there is evidence to suggest that patients should be maintained on the highest dose of ***ACEI*** they can tolerate [209].

Patients should have careful monitoring of renal function after starting an ***ACEI*** and shortly after each dose titration - it is good practice to give patients a U&Es request form with instructions to arrange a blood test via their GP within a week of discharge. A rise in creatinine of up to 25% above baseline, or up to 200 mmol/l, whichever is the smaller, is usually acceptable. Seek senior advice regarding greater rises in creatinine, which may require discontinuation of the ***ACEI*** and further renal investigation as appropriate.

Angiotensin 2 Receptor Antagonists (ARBs) There is good evidence for ***valsartan*** and ***candesartan*** in this setting ([80;81]). Evidence for ***losartan*** was disappointing, but may have been due to lower doses than required being employed in the trials [79]. The dose should be increased to the maximum recommended by titrating up over a few weeks according to tolerability.

Angiotensin Receptor-Neprilysin Inhibitor (ARNI) A recent trial, PARADIGM HF, compared the ***ACEI enalapril*** 10mg BD to the first-in-class ***ARNI*** LCZ696 in patients with stable chronic heart failure ([210]). The trial was terminated prematurely on the advice of the data safety monitoring committee, in light of overwhelming evidence of superiority of LCZ696; this agent was associated with a 20% relative risk reduction compared to ***enalapril*** in the primary endpoint of the combination of cardiovascular death or heart failure hospitalisation. Each component of the primary endpoint was reduced to a similar extent, and all-cause mortality was reduced by 16%. LCZ696 was also better tolerated than ***enalapril*** and in spite of lowering BP slightly more than ***enalapril***, LCZ696 did not show any greater risk of adverse effects on renal function. In 2016 LCZ696 became available under the name of ***sacubitril/valsartan***.

NICE guidance (TA388) states ***sacubitril/valsartan*** is recommended as an option for treating symptomatic chronic heart failure with reduced ejection fraction, only in people:

- With New York Heart Association (NYHA) class II to IV symptoms and
- With a left ventricular ejection fraction of 35% or less and
- Who are already taking a stable dose of ***ACEI*** or ***ARBs***.

It should not be prescribed with any other ***ACEI*** or ***ARB*** or in patients with a history of angioedema associated with previous use of these drugs. ***ACEI*** should be discontinued 2 days prior to initiation.

Sacubitril/valsartan is available at doses of 24mg/26mg, 49 mg / 51 mg, and 97 mg / 103 mg, each administered BD. The choice of initiation dose will be guided by clinical variables such as blood pressure, renal function and the patient's dose of ACEI or ARB prior to switching. In keeping with NICE guidelines and local recommendations, the switch to ***sacubitril/valsartan*** should be made under the supervision of the UHL heart failure team.

Beta Blockers These improve survival after myocardial infarction, especially in patients with evidence of left ventricular dysfunction [211]. In patients with dilated

cardiomyopathy, cautious administration of ***bisoprolol*** improved QOL and survival [211]. ***Carvedilol*** can also be used in this setting [212;213]. There is a 5 - 20% risk of worsening heart failure. ***β-blockers*** can also be extremely useful in diastolic dysfunction. They may help if used cautiously in patients with co-existing angina.

The introduction of ***β-blockers*** should be cautious and avoided in the context of heart block and shock. In particular, the subsequent dose titration must be performed slowly - in other words: **START LOW AND GO SLOW**. It is usually safe to initiate ***β-blockers*** if the patient's systolic BP is > 100 mmHg with a resting heart rate > 60 bpm (and no AV block) and no significant postural drop (and they are not dizzy). It is usually safe to titrate the dose subsequently if the systolic BP is > 90 mmHg with a resting heart rate > 50 bpm and no significant postural drop (and they are not dizzy). As with ***ACEI***, it is important to aim for the optimal dose of ***β-blocker*** in order to maximise the mortality benefits. The titration steps are:

Carvedilol: Start with 3·125 mg BD orally (with food) for 2 weeks, increase to 6·25 mg BD for 2 weeks, increase to 12·5 mg BD for 2 weeks, increase to 25 mg BD thereafter*

*A further increase in ***carvedilol*** dose to 50 mg BD after a further 2 weeks is indicated if the patient weighs more than 85kg.

Bisoprolol: Start with 1·25 mg OD orally for 1 week, increase to 2·5 mg OD for 1 week, increase to 3·75 mg OD for 1 week, increase to 5 mg OD for 4 weeks, increase to 7·5 mg OD for 4 weeks, increase to 10 mg OD thereafter.

Other Vasodilators ***Hydralazine*** and ***isosorbide mononitrate*** in combination appears to have a beneficial effect on survival [194], this is particularly true in patients of African or Caribbean origin. They should generally be used if patients cannot take ***ACEI*** or ***ARBs***. Occasionally the addition of these drugs to ***ACEI*** or ***ARBs*** in patients with resistant CCF may be helpful.

Ivabradine ***Ivabradine*** is beneficial in heart failure in patients who either cannot tolerate ***β-blockers***, or in whom the resting heart rate is higher than 75 despite ***β-blockers*** ([214]). Patients must be in sinus rhythm to benefit. Should be avoided with ***diltiazem*** or ***verapamil***. ***Ivabradine*** is particularly useful when blood pressure is low because it has no impact on the blood pressure.

Nitrates ***Nitrates*** reduce preload; reduce pulmonary oedema and reduce ventricular size. There is a beneficial effect of using IV ***nitrates*** in acute heart failure if there is underlying ischaemia, hypertension or regurgitant aortic and mitral valve disease. In chronic heart failure they can be especially useful for relief of orthopnoea and exertional dyspnoea. Caution should be applied with aortic and mitral stenosis, HOCM and pericardial constriction.

Digoxin ***Digoxin*** may be beneficial in heart failure, even in the context of sinus rhythm [215;216]. It can be used as an adjunct to diuretics and ***ACEI*** [217]. It is a weak inotrope and arterial vasodilator. It has electrophysiological effects, and is especially useful if patient in atrial fibrillation). There is some evidence that using lower dose ***digoxin*** (maintaining serum levels between 0·5 - 1·0 µg/L) not only reduces hospitalisations but mortality too in heart failure and sinus rhythm ([218]). ***Digoxin*** levels should be carefully monitored in patients with CKD and in particular with hyperkalaemia.

Calcium channel blockers ***Amlodipine*** should be considered for the treatment of co-morbid hypertension and/or angina in patients with heart failure, but ***verapamil***, ***diltiazem*** or ***short-acting dihydropyridine agents*** should be avoided.

Anticoagulation

Warfarin or one of the ***DOACs*** should be employed in atrial fibrillation (established and paroxysmal). It should also be considered if there is severe CHF or marked cardiomegaly, and if there is a known ventricular aneurysm. Consider if there is a suspicion of pulmonary thromboembolic disease.

Patients with severe peripheral oedema often have poor mobility and are at risk of DVT and PE. In the absence of contraindications, it is advisable to use a prophylactic dose of ***LMWH*** until the patient is ambulant.

Aspirin 75 mg OD should be used in patients with vascular disease and heart failure.

Amiodarone This should be considered in patients with evidence of symptomatic ventricular or supraventricular arrhythmias.

Opiates Very useful in terminal CHF for control of pain and distress, but care should be taken to avoid excessive sedation or respiratory depression.

Inotropes ***Dobutamine***: brief infusions may confer symptomatic benefit for some time. Drawback is the risk of arrhythmias, increased myocardial oxygen consumption and 'tolerance'. ***Dopamine***: in renal dose (2·5 µg/kg/min) can speed up diuresis and reduce length of in-patient stay.

COMPLEX DEVICE THERAPY

Inpatient device requests can be made under 'Service Referrals' on ICE and selecting 'Cath Lab' followed by 'Devices'.

Patients with impaired left ventricular function may benefit from either cardiac resynchronisation therapy (***CRT-biventricular pacing***) or an implantable cardioverter defibrillator (***ICD***). Cardiac resynchronisation therapy aims to improve the efficacy of cardiac contraction by pacing both the left and right ventricles. Around 70% of appropriately selected patients respond to ***CRT*** and it improves symptoms, reduces heart failure hospitalisation and reduces mortality. Those most likely to benefit are patients with very poor LV function (LVEF < 35%), sinus rhythm and prolongation of the QRS on ECG with left bundle branch block (especially if QRS > 130 ms). Echocardiography criteria are no longer required for ***CRT*** but may be helpful where the ECG suggests uncertain benefit: Aortic pre-ejection delay > 140 ms, interventricular mechanical delay > 40 ms, Delayed activation of posterolateral wall (d1 > d2), rocking of the apex.

CRT can simply have a pacing function (***CRT-P***) or be combined with a defibrillator (***CRT-D***). NICE have recently updated their recommendations for ***CRT*** (TA 314) see ***Table 6***.

ICDs do not improve symptoms, their purpose is purely to prevent sudden cardiac death by detecting and cardioverting VT/VF. ***ICDs*** achieve this either using anti-tachycardia pacing (asymptomatic) or by delivering an electric shock (unpleasant for the patient if conscious during the arrhythmia). ***ICDs*** are used either for secondary prevention in survivors of sudden cardiac arrest or for primary prevention. Primary prevention ***ICD*** risk stratification in most conditions revolves around left ventricular

ejection fraction (LVEF). LVEF is limited in that most patients dying of sudden cardiac death have relatively preserved LVEF but it is the least worst marker of sudden cardiac death risk that we have at present. NICE have recently updated their recommendations for ***ICDs*** (TA 314) to include patients with non-ischaemic cardiomyopathy. ***Table 6*** (page 127) is self-explanatory in the main, and patients meeting the specified criteria should be considered for an ***ICD***. NICE states that patients with LVEF <35% and QRS interval <120ms are considered for ***ICD*** 'if there is a high risk of sudden cardiac death'. NICE does not further define 'high risk of sudden cardiac death' and such patients need assessment by a device specialist. ***ICD*** prescription is a balance between risk and benefit; not all patients meeting the NICE criteria are appropriate for ***ICD*** implant. The criteria are simple to follow but hide nuances in device benefit. It is helpful, when referring to a device specialist, to make clear that the referral is for assessment and consideration of device implant.

Table 6: Treatment options with ICD or CRT for people with heart failure who have LVEF of 35% or less (according to NYHA class, QRS duration and presence of LBBB (from NICE TA 314).

	NYHA class			
QRS interval	**I**	**II**	**III**	**IV**
<120 milliseconds	**ICD if there is a high risk of sudden cardiac death**			**ICD and CRT not clinically indicated**
120–149 milliseconds without LBBB	ICD	ICD	ICD	CRT-P
120–149 milliseconds with LBBB	ICD	CRT-D	CRT-P or CRT-D	CRT-P
≥150 milliseconds with or without LBBB	CRT-D	CRT-D	CRT-P or CRT-D	CRT-P
LBBB, left bundle branch block; NYHA, New York Heart Association				

Audit of the UHL ***ICD*** service has found that our patients have around a 10% annual rate of appropriate ***ICD*** therapy. ***ICD*** have the potential for significant psychological and physical morbidity. In particular there is a risk of inappropriate shocks. Patients can present with ventricular tachycardia storm (3 or more episodes of ventricular tachycardia within 24 hours) which leads to multiple unpleasant shocks (see page 108). Patients can also have lead fractures or fast atrial fibrillation causing multiple (occasionally 100s) of inappropriate shocks. If a patient presents with multiple / on-going ***ICD*** therapies not associated with loss of consciousness, contact the on call cardiac technician for immediate ***ICD*** interrogation and reprogramming. As a temporising measure, consider placing a magnet over the ***ICD*** (found on defibrillator

trolleys) - this will inactivate the device and provide relief from multiple ***ICD*** therapies. Placing a magnet over the ***ICD*** deactivates therapies and leaves the patient at risk of sudden cardiac death. It should only be done with cardiac monitoring in a high dependency setting such as CCU. There are important implications for driving with an ***ICD***, the DVLA rules change frequently; this is covered in the section on cardiovascular disease and driving on page 172.

CARDIAC TRANSPLANTATION

Patients with severe functional impairment should be considered for **transplantation**. Cardiac transplantation is now a highly successful procedure with a one-year survival of 86%. It should be considered in patients up to the age of 65 years with advanced heart failure whose symptoms remain limiting despite optimal medical treatment. Contraindications (some relative) to cardiac transplantation include:

- Irreversible pulmonary hypertension (pulmonary vascular resistance > 5 Wood units, a transpulmonary gradient > 15 mm Hg and a pulmonary artery systolic pressure > 60 mmHg
- Active infection
- Pulmonary infarction within last 6 - 8 weeks
- Significant chronic renal impairment (e.g. Creatinine clearance < 40 ml/min)
- Significant chronic hepatic impairment (e.g. persistent ALT/AST > 2 x upper limit of normal)
- Active or recent malignancy
- Systemic diseases such as amyloidosis
- Significant chronic lung disease
- Significant symptomatic carotid or peripheral vascular disease
- Significant coagulopathies
- Recent peptic ulcer disease
- Major chronic disabling disease
- Diabetes with end organ damage and/or brittle diabetes
- Excessive obesity (e.g. > 30% over normal)
- Active mental illness
- Evidence of drug, tobacco or alcohol abuse within the last 6 months refractory to expert intervention
- Psychosocial instability refractory to expert intervention
- Age > 65 years

Some patients may be considered for other forms of surgery including mitral and tricuspid valve repair and LV reduction.

Dietary advice should be given. Weight loss and reduced salt intake may help. Fluid intake should be limited to 2 litres per day for most patients. Avoid alcohol. Smoking

cessation is obvious. Encourage influenza & pneumococcal vaccination. Exercise should be encouraged between exacerbations. Daily weighing at home may allow titration of the patients' own diuretics.

Patients who are admitted with heart failure should be reviewed by the cardiac rehabilitation team. Some patients benefit greatly from a focussed heart failure rehabilitation programme consisting of graded exercises as well as patient education. You should ALWAYS discuss the diagnosis of heart failure with your patient as well as their families. This is a serious diagnosis with a high mortality and morbidity. Many patients have a poor understanding of their disease process.

Heart Failure Nurse Specialists

There are specialist heart failure nurses on both the wards and in the community. They should be referred ALL relevant patients. If patients are already under the care of a heart failure nurse, the nurse must be informed of their impending discharge. There is also an inpatient heart failure team led by Dr Ian Loke, Dr Will Nicolson and Sister Louise Clayton (07961729241) to whom patients with more difficult heart failure can be referred. There is a contact email: heartfailure@uhl-tr.nhs.uk. Patients who require specialist heart failure management are cared for on the specialist heart failure ward.

Sometimes patients with heart failure are very sick and do not respond to conventional medial therapy. It may be that a palliative care focus is more appropriate. These patients should be referred urgently to the heart failure team or to the palliative care team. Familiarise yourself with the AMBER Care Bundle for patients who are not expected to survive for more than 1 - 2 months.

INFILTRATIVE CARDIOMYOPATHIES

Sarcoidosis About a third of patients with sarcoidosis have cardiac involvement ([219]). Supraventricular and ventricular arrhythmias are common and bundle branch block occurs in two thirds. A quarter will develop complete heart block and a similar number heart failure. It should be seriously considered in younger patients (< 55 years) presenting with heart block or heart failure. Similarly cardiac involvement should be looked for in those with known extracardiac sarcoidosis.

A 12 lead ECG and Holter monitoring is mandatory. An echocardiogram is also essential when suspecting cardiac involvement. CMR is extremely helpful as is PET scanning to assess disease activity. PET appears to be more sensitive than CMR, but CMR may have higher specificity.

Treatment is with ***prednisolone***, starting with a dose of 60 mg/day and gradually reducing this dose to a maintenance level of 10 to 15 mg/day over one year. Glucocorticoid treatment should be continued for at least one to two years.

AmyloidosisCardiac involvement in amyloidosis ([220]) carries a poor prognosis, especially with light-chain (primary) amyloid, with average life expectancy of 6 months and only 6% surviving to three years. . Rapidly progressive heart failure is a feature, with arrhythmias being common. In senile amyloid heart block is not uncommon. There is a high incidence of thromboembolism, especially but not only in the context of atrial fibrillation. Neuropathy is common in primary amyloid and can be manifested by hypotension. The echocardiogram can show subtle changes such as dilated atria, thickened heart valves or an appearance of myocardial speckling. CMR can be diagnostic. Serum or urine monoclonal paraprotein is suggestive of primary

amyloid but not diagnostic. Endomyocardial biopsy can be helpful. Consider referral to the National Amyloidosis Unit at the Royal Free Hospital who will assess and recommend appropriate chemotherapy regimens. Patients with a restrictive cardiomyopathy have a very high NT-proBNP level (often over 1000 ng/L) despite an echocardiogram showing mild systolic dysfunction or normal function.

While loop diuretics are a mainstay of treatment of cardiac amyloidosis, ***β-blockers*** and ***ACEI*** may be harmful despite their efficacy in other types of systolic heart failure. Similarly, ***calcium channel blockers*** that may be useful in treatment of diastolic heart failure are contraindicated in amyloid cardiomyopathy.

Fabry disease An X-linked recessive lysosomal storage disorder characterised by deficiency of alpha-galactosidase A. Fabry cardiomyopathy has an incidence of 3 - 6% of males with unexplained LVH ([221]).

If suspected an assay for α-galactosidase is available. In women however, genetic testing is required.

Enzyme replacement therapy is beneficial.

Haemochromatosis One third of homozygotes have cardiac involvement. Untreated there is the development of progressive heart failure.

Diagnosis is confirmed with the finding of increased transferrin saturation (ratio of iron to transferrin) and increased levels of plasma transferrin. CMR and genetic testing should be considered.

Therapeutic phlebotomy is the first line of treatment in non-anaemic patients.

ISOLATED RIGHT HEART FAILURE

Causes of isolated right heart failure include severe lung disease (resulting in severe pulmonary hypertension), pulmonary/tricuspid valve disease, primary pulmonary hypertension, chronic pulmonary embolism, sleep related breathing disorders (obstructive sleep apnoea) or right ventricular infarction.

COPD is the commonest cause and will usually be clinically apparent. Interstitial lung disease also results in right heart failure in a sizeable proportion of patients. Sleep apnoea may not necessarily be apparent unless specifically considered.

Tricuspid regurgitation is most commonly functional as a consequence of right heart dilatation. Other causes are discussed in the section on valvular heart disease (page 146).

In right heart failure due to lung disease, supplementary ***oxygen*** in patients with hypoxaemia is beneficial. In patients with sleep apnoea, CPAP therapy is helpful. Patients with pulmonary hypertension associated with chronic thromboembolic disease may benefit from surgical thromboendarterectomy (contact the pulmonary vascular diseases unit (PVDU) at Papworth).

Diuretic therapy is helpful but needs to be used with caution as these patients are pre-load dependent so over diuresis is harmful.

PERIPARTUM CARDIOMYOPATHY

This condition manifests in the latter part of pregnancy or in the first few months postpartum. Mothers tend to be over the age of 30 and it is more common in women of African descent and in those who have had multiple births. Treatment is similar to

that for other forms of systolic heart failure. The exception is that there may also be a role for ***bromocriptine*** ([222]). The recommended dose is 2·5 mg BD for 2 weeks and then 2·5 mg OD for a further 6 weeks. A full SCA is needed. If ***bromocriptine*** is employed, lactation will cease. Generally women should be counselled against breast feeding regardless mainly because of the medications employed.

ACEI and ***ARBs*** are contraindicated during pregnancy and so ***hydralazine*** and ***nitrates*** are usually employed prior to delivery.

Approximately half will recover within 6 months, particularly if the baseline ejection fraction is > 30%. There is a risk of recurrence in subsequent pregnancies and future pregnancy should be avoided if ejection fractions remain below 30%.

TAKOTSUBO CARDIOMYOPATHY

Takotsubo cardiomyopathy, also called apical-ballooning syndrome, broken heart syndrome, stress cardiomyopathy, and stress-induced cardiomyopathy, is an increasingly reported syndrome generally characterised by transient systolic dysfunction of the apical and/or mid segments of the left ventricle that mimics myocardial infarction, but in the absence of obstructive coronary artery disease. Cardiac enzymes are usually elevated and the ECG may show features of either STEMI or NSTEMI. If suspected, LV angiography should be undertaken after demonstrating the absence of coronary disease. In patients awaiting angiography, early echocardiography is crucial as the abnormality may only be present for a few days. It is much more common in women, predominantly in the fifth decade of life onwards. Not infrequently presentation follows an episode of emotional trauma such as bereavement or an argument, and can occur in the context of severe sepsis.

The degree of LV dysfunction varies but can result in severe heart failure. In patients with significant LVSD standard treatment with ***ACEI***, ***β-blockers and diuretics*** is justified. There is an increased risk of LV thrombus and this should be looked for and treated if present with ***anticoagulation*** (typically three months or until thrombus has resolved). In patients without thrombus but severe LV dysfunction some advocate ***anticoagulation*** until there is recovery. In a third of patients there is also RV dysfunction.

Generally heart failure medication is only necessary for the first few weeks as most recover within 4 weeks. There is an argument that ***β-blockers*** should be maintained longer term to reduce the risk of recurrence (which can occur in 5-10%).

SCREENING IN CARDIOMYOPATHY

All patients with cardiomyopathy should have a careful family history taken going back three generations if possible. This recommendation applies to patients with hypertrophic cardiomyopathy, dilated cardiomyopathy, arrhythmogenic right ventricular cardiomyopathy (ARVC), left ventricular non-compaction (LVNC), restrictive cardiomyopathy (RCM), and cardiomyopathies associated with extra-cardiac manifestations (eg, muscular dystrophy, Fabry disease, amyloidosis, or sarcoidosis).

The initial evaluation of the index patient should include family history and pedigree analysis for unexplained heart failure before age 60 or sudden cardiac death in the absence of ischaemic symptoms. First-degree relatives should be screened.

The frequency of recommended re-screening varies with cardiomyopathy type:

- DCM - Every three to five years beginning in childhood
- ARVC - Every three to five years after age 10
- LVNC - Every three years beginning in childhood
- RCM - Every three to five years beginning in adulthood

Genetic and family counselling is recommended for all patients and families with cardiomyopathy. Genetic testing should be considered for the one most clearly affected person in a family to facilitate family screening and management. Screening the most affected individual increases the likelihood of detecting a relevant mutation.

HYPERTROPHIC CARDIOMYOPATHY

Hypertrophic cardiomyopathy is one of the commonest inherited cardiac conditions encountered in clinical practice with an estimated prevalence if 1 in 500.

Hypertrophic cardiomyopathy (HCM) is defined by the presence of increased left ventricular (LV) wall thickness that is not solely explained by abnormal loading conditions. In an adult, this represents a wall thickness ≥ 15 mm in one or more LV myocardial segments (or ≥ 13 mm in a first degree relative of someone with HCM) measured by any imaging technique.

Patients with outflow tract obstruction are referred to as hypertrophic obstructive cardiomyopathy (HOCM), those without obstruction as HCM. Symptoms occur earlier and are more severe in patients with obstruction. HOCM is easier to diagnose from echo but HCM can be more challenging. It should be considered in patients with LVH and no clear cause (hypertension, aortic stenosis). CMR can help in borderline cases.

In patients with a resting LVOT gradient < 50 mmHg bedside physiological provocation with Valsalva manoeuvre and standing should be routinely performed during echocardiography to determine if LV outflow obstruction can be provoked. Exercise stress echocardiography is recommended in symptomatic patients with an LVOT gradient < 50 mmHg at rest or during physiological provocation.

The distribution of hypertrophy is variable; the most common is asymmetrical septal hypertrophy, but other types including concentric hypertrophy, apical hypertrophy, and hypertrophy of the LV free wall are seen. About one quarter of patients have obstruction of the left ventricular outflow tract (LVOT); less commonly, dynamic obstruction may occur in the mid LV cavity or at the right ventricular (RV) outflow tract. Patients may be diagnosed incidentally during investigations for other conditions, some present with symptoms such as chest pain, dyspnoea, impaired exercise tolerance and syncope (the latter especially with HOCM).

Patients should be seriously considered for referral for genetic testing and first-degree family members screened and probably genetically tested too. Inheritance is autosomal dominant and, even if the patient appears to be a ‘spontaneous mutation’, their offspring will still have a 50:50 chance of developing the condition. Longer term follow up is indicated in those family members with an abnormal gene. In those under 12 years of age, screening (ECG, echo) is not indicated unless they are a competitive athlete. From age 12 to 22, screening should be every 2 years or so. Over the age of 23, screening should be every 5 years. The condition does not skip generations.

Medical therapy is somewhat limited but traditionally first-line therapy is with either ***β-blockers*** or non-dihydropyridine ***calcium antagonists*** (***verapamil*** or ***diltiazem***). Some patients will deteriorate (especially those with HCM) and so need to be reviewed. In patients with obstruction, ***disopyramide*** (300 – 600 mg daily) may reduce the gradient. Vasodilators and ***digoxin*** should be avoided (especially in HOCM).

In patients with significant obstruction (> 50 mmHg at rest, > 100 mmHg with provocation) should be considered for alcohol septal ablation (ASA) or surgical myectomy. ASA carries a risk of 5 - 10% or heart block requiring permanent pacing. The anatomical requirement for ASA is for a first septal perforator of sufficiently large calibre to allow an over-the-wire balloon to be inflated to occlude the vessel (usually

≥ 1.5 mm). This vessel must supply an appropriate area of the basal septum assessed by contrast echocardiography. ASA is not performed in UHL and referral to a centre with experience is appropriate: Professor Charles Knight at Barts Heart Centre is the UK's leading expert in this field.

Sudden cardiac death (SCD) is a concern, especially in younger patients with HOCM. Those at higher risk are:

- Patients with a family history of SCD
- Previous cardiac arrest
- Patients with a malignant genotype
- Patients with syncope, especially with exercise
- Patients with an abnormal BP response to exercise (< 20 mmHg rise)
- Excessive VEBs or NSVT on monitoring
- Patients with severe LVH (> 30 mm)

Patients in the above categories should be seriously considered for an ICD. The use of a new risk calculator (HCMRisk-SCD): http://www.doc2do.com/hcm/webHCM.html is recommended to guide the use of implantable cardioverter defibrillators (ICD).

If an ICD is not appropriate, or the patient declines, ***sotalol*** or ***amiodarone*** can be considered. In the absence of any of these factors, the risk of SCD is low. The role of dual chamber pacing is less clear and is no longer recommended as a first line option. It should be considered in HOCM patients with severe symptoms, not responding to medical therapy, in whom myectomy or alcohol ablation are not an option. Atrial fibrillation is quite common in HCM and should be managed in the usual manner. It should be treated quite aggressively and the threshold to anticoagulate should be lower.

Follow up of stable HOCM patients should be every 1 - 2 years with repeat echo and ECG. A 48 hour ECG is recommended every 1 - 2 years in stable patients but consider more often in patients with LA enlargement or new palpitations.

PULMONARY HYPERTENSION

Pulmonary hypertension (PH) has been defined as a mean pulmonary arterial pressure (mPAP) ≥ 25 mmHg at rest, measured by right heart catheterisation. PH leads to right ventricular (RV) overload and finally RV failure and death.

Patients with PH often present with non-specific complaints of dyspnoea, fatigue, chest pain, syncope, peripheral oedema, and palpitations.

PH is characterised by different pathological lesions in the pulmonary vasculature, depending on the underlying cause:

- Pulmonary arterial hypertension (PAH)
- PH due to left sided disease
- PH due to lung disease
- Chronic thromboembolic PH (CTEPH)
- PH with unclear or multifactorial mechanisms

Pulmonary arterial hypertension is characterised by abnormalities in the pulmonary vasculature. Idiopathic PAH is rare and there is no associated family history or associated risk factors. Inheritable PAH will usually have a positive family history for the condition. There is also drug and toxin related PAH, most recently seen with weight reducing agents (***fenfluramine***). PAH is also seen in some systemic diseases particularly the connective tissue disorders.

PH due to left sided disease comprises patients with PH caused by left sided heart failure, usually valvular disease or left ventricular (LV) failure (either diastolic or systolic). A new proposed definition for PH due to left heart disease is isolated post-capillary PH (PCWP >15 mmHg and diastolic PAP – PCWP <7 mmHg) and combined post-capillary and pre-capillary PH (PCWP >15 mmHg and diastolic PAP − PCWP ≥7 mmHg).

PH due to lung disease (COPD, ILD) is one of the most common causes of PH.

Chronic thromboembolic PH is caused by a substantial loss of pulmonary arterial vascular lumen because of non-resolving pulmonary thromboembolism. From a therapeutic viewpoint there is a difference between macro- and microvascular CTEPH, since macrovascular CTEPH can be cured surgically by pulmonary endarterectomy. Importantly, a large proportion (~ 40%) of CTEPH patients had no evident episodes of acute pulmonary embolism before diagnosis.

PH with unclear or multifactorial PH comprises patients with disorders that lead to PH by compression, destruction of lung tissue or other extravascular destruction. This group includes haematological, systemic (sarcoidosis) and metabolic disorders.

Diagnosis

A 6 minute walk test or cardio-pulmonary exercise test can be used to assess functional capacity. In PH, a reduction in peak VO2, arterial blood oxygen saturation and anaerobic threshold may be observed. Blood gases may show hypoxia.

A chest x-ray provides information about the lungs, heart size, the size of the proximal pulmonary arteries, and congestion. Also, blood tests (biochemistry, haematology, and thyroid function) should be performed. BNP may be useful for RV

and LV dysfunction. Pulmonary function studies to assess for respiratory disease should be considered.

The ECG may suggest left sided heart disease or an RV strain pattern or right axis deviation.

CMR is the gold standard for assessing RV function and volumes. CT angiography can demonstrate the pulmonary vasculature and HRCT the lung tissue. Although CT angiography is more commonly used, ventilation perfusion scanning is more sensitive in the diagnosis of CTEPH.

Echo can be helpful in establishing the diagnosis as a good estimation of the pulmonary artery pressure can be made from the peak velocity of the TR jet and adding RA pressure. RV function is not always reliably assessed on echo. Left sided disease can also be evaluated.

Right heart catheterisation is the gold standard.

For patients with sarcoidosis there is an online risk calculator to determine whether PH should be considered: http://www.detect-pah.com/

Treatment

Patients with PH require general lifestyle advice. Depending on the severity of the disease, patients should be instructed to reduce salt and fluid intake. Furthermore, physical activity should be encouraged within symptom limits. Pregnancy carries a high mortality.

In PAH there is evidence of coagulopathies with increased risk of thrombosis. Therefore the use of oral ***anticoagulation***, in the absence of contraindications, should be considered in PAH. CTEPH patients should receive lifelong anticoagulation therapy. ***Diuretics*** are recommended in the case of right sided decompensation. ***Digoxin*** may be helpful for inotropic support.

Maintenance of sinus is important and ant-arrhythmic drugs may be needed. The use of long term oxygen therapy should be encouraged in patients with hypoxia, because the hypoxic mediated vasoconstriction may be reduced.

Currently available drug therapies that target the pathologic pathways in PH do not cure the disease but are meant to reduce the PVR, pulmonary pressures, and symptoms. Several classes of PH specific drugs are available. ***Prostacyclin analogues*** are potent pulmonary vasodilators.

Epoprostenol was the first available short acting pulmonary vasodilator. It was shown to improve exercise capacity, quality of life and survival in patients with idiopathic PAH and other forms of PAH. ***Epoprostenol*** has to be administered by continuous IV infusion and has serious dose dependent adverse effects. Other prostacyclin analogues are ***treprostinil***, which has a longer half-life compared to ***epoprostenol***, and ***iloprost***, which can be inhaled.

The use of ***endothelin receptor antagonists*** (***ERAs***) followed the successful introduction of the ***prostacyclin analogues***. An important advantage of ***ERAs*** is that they can be administered orally. ***Bosentan*** improves functional class, and haemodynamics. A disadvantage of ***bosentan*** is the risk of an increase in hepatic aminotransferases in about 10% of patients, requiring monthly assessment of liver enzymes. This risk can occur any time during the use of ***bosentan***. ***Ambrisentan*** reduces the risk of elevation in hepatic enzymes. However, monthly testing of liver

enzymes is required in patients taking ***ambrisentan***. The new ERA ***macitentan*** probably has no effect on liver enzymes. In addition, it has been shown to reduce morbidity and mortality in PAH. ERAs are recommended in PAH patients in NYHA functional class II and III.

Another group of PH specific drugs are the ***phosphodiesterase-5 inhibitors*** (***sildenafil*** and ***tadalafil***), which inhibit the cyclic guanosine monophosphate (cGMP) degrading enzyme phosphodiesterase type 5 and cause vasodilatation through the NO/cGMP pathway. ***Phosphodiesterase- 5 inhibitors*** are recommended in patients in NYHA class II and III.

There have been no large randomised clinical trials performed in non-PAH groups addressing the effects of PAH specific treatment. Therefore, the underlying disease should be treated.

In appropriate selected CTEPH patients pulmonary endarterectomy can be curative. However, not all CTEPH patients are candidates for this surgical therapy, and in a subgroup (10–15%) of CTEPH patients receiving pulmonary endarterectomy PH persists or recurs. In these patients PH specific treatment can be beneficial, and there are several studies indicating improvement in haemodynamics and clinical condition. PH patients in NYHA functional class IV with right heart failure who do not respond to PH specific drug therapy should be considered for balloon atrial septostomy or heart/lung transplantation. By creating an intra-atrial right–left shunt, the RV will be decompressed and the cardiac output will be increased. This intervention should only be considered in patients with arterial oxygen saturation >80%. Patients with indicators of poor prognosis despite maximal medical therapy should be referred for transplantation.

Most patients with PH not related to left sided heart disease or lung disease are referred to other centres where there is an expertise in managing these complex patients. The centres used most frequently locally are in Cambridge and Sheffield.

The pulmonary vascular diseases unit (PVDU) at Papworth Hospital:

Referrals should be made to Dr Joanna Pepke-Zaba, Dr Karen Sheares, Dr John Cannon or Dr Mark Toshner.

Pulmonary Vascular Disease Unit
Papworth Hospital NHS Foundation Trust
Papworth Everard
Cambridgeshire
CB23 8RE Phone: 01480 830541

The PVDU at the Royal Hallamshire Hospital in Sheffield:

Referrals should be made to Prof David Kiely, Dr Charlie Elliot or Dr Robin Condliffe.

Pulmonary Vascular Disease Unit, RHH
M floor
Royal Hallamshire Hospital
Glossop Rd
Sheffield S10 2JF Phone: 0114 2712132 or 2712187

ELECTROLYTE DISTURBANCE

Arrhythmias, especially ventricular arrhythmias, may be exacerbated or caused by hypokalaemia. If K^+ is < 4·0 mmol/L, K^+ replacement should be given. Similarly if the K^+ is > 6·0 mmol/L and associated with arrhythmias treatment should be commenced. Treatment should also be commenced regardless if K^+ is > 7·0 mmol/L.

Hypokalaemia can usually be corrected with oral supplements (***Slow K*** tablets, ***Sando K*** effervescent tablets, 2 tablets TDS). If IV replacement is required, 40 mmol ***KCl*** in 500 ml 5% ***glucose*** can be infused 4 - 6 hourly. Alternatively, high dose ***KCl*** may be given centrally (40 mmol ***KCl*** in 100 ml slow infusion). The serum K^+ level should be monitored frequently according to the initial level and the treatment given (i.e. more frequently with IV replacement). Consideration should be given to the use of potassium sparing diuretics such as ***spironolactone*** or ***amiloride***.

Hyperkalaemia is defined as a potassium > 5·5 mmol/L. It is seen with patients in acute renal failure but can also be seen in Addison's disease and can be drug-induced. For those with end stage renal failure it is best treated by the renal team.

Severe hyperkalaemia (> 6·4 mmol/L), or a level > 5·9 with ECG changes (tall T waves, flattened or absent p waves, QRS > 120 ms, ST changes) should be treated. ***Calcium chloride*** 10%, should be given IV over 2 – 5 minutes (10 ml of 10% in 90 ml of 0·9% ***sodium chloride*** over 30 minutes if the patient is on ***digoxin***).

Administering nebulised ***salbutamol*** (usually 20 mg, 10 mg if patient has coronary disease) can be helpful. Omit if patient is on a ***β-blocker***.

The next step is to give ***glucose*** and ***insulin***. Regimes of ***glucose*** and ***insulin*** differ widely but the following is recommended: Add 10 U of soluble ***insulin*** (i.e. ***actrapid*** or ***humulin S***) to 500 ml of 10% ***glucose***. These can be given peripherally, ideally into a large vein. Administer this infusion over a minimum of 30 minutes (if the patient has a history of heart failure or they are elderly then give over 60 minutes). Blood glucose should be checked at 15 and 30 minutes and hourly for 6 hours to avoid hypoglycaemia. If the initial BM is > 14, give ***actrapid*** 10 U WITHOUT ***glucose***. Electrolytes should also be checked 6 hourly. If hypovolaemia is suspected consider volume resuscitation with 0·9% ***sodium chloride***.

For less severe hyperkalaemia, consider ***calcium resonium*** orally (15 g, 6 hourly). Obviously discontinuing any K^+ sparing or containing drugs and ***ACEI*** is essential.

If acidotic (pH < 7·25 or HCO_3 > 15), patients should be given 50 mmol ***sodium bicarbonate*** (50 ml of 8·4% $NaHCO_3$) over 5 minutes. Dialysis should be considered if severe renal failure is present, but carries risks in the setting of myocardial infarction and haemodynamic instability.

Occasionally recurrent unresponsive ventricular arrhythmias are associated with magnesium depletion (often associated with diuretic therapy) and these patients may respond to ***magnesium sulphate*** 8 mmol, 2 g (in 20ml of 0·9% ***sodium chloride***) over 20 minutes followed by an infusion of 65 mmol, 16 g (in 48 ml of 0·9% ***sodium chloride***) over 24 hours.

HYPERTENSION

This chapter is based on latest NICE guidance issued in 2011 (CG127), the BHS guideline from 2004 ([93]), and the latest ESC guidance published in 2013 ([223]).

DIAGNOSIS

Hypertension is defined as being stage 1, stage 2 or severe (Grades 1 to 3 in the ESC guidance).

Stage 1 hypertension: Clinic blood pressure (BP) is 140/90 mmHg or higher and subsequent ambulatory BP monitoring (ABPM) daytime average or home BP monitoring (HBPM) average BP is 135/85 mmHg or higher.

Stage 2 hypertension: Clinic BP is 160/100 mmHg or higher and subsequent ABPM daytime average or HBPM average BP is 150/95 mmHg or higher.

Severe hypertension: Clinic systolic BP is 180 mmHg or higher or clinic diastolic BP is 110 mmHg or higher.

In diagnosing hypertension, BP should be measured in both arms, taking the highest reading. Ambulatory monitoring should be offered if the BP is > 140/90. Home BP monitoring is an alternative. If the patient has severe hypertension, treatment should be considered immediately without the need for ABPM or HBPM.

History & Assessment

A full medical history is mandatory with particular attention to presence of cardiovascular disease such as angina, heart failure, palpitations, syncope and valvular heart disease. A history of previous TIA or stroke, diabetes, previous renal disease, smoking history, dyslipidaemia, NSAIDs excess. Sweating, headache, palpitations and anxiety may point to phaeochromocytoma. Muscle weakness or tetany may point to hyperaldosteronism. Family history should look for hypertension, premature coronary disease, polycystic kidney disease etc. A full drug history should be taken including any prior anti-hypertensive therapy and details of previous drug intolerances. It is very useful to assess for medicine adherence: in patients presenting with 'resistant hypertension', over 50% of individuals taking 4 or more anti-hypertensive drugs will be fully or partially non-compliant.

Physical assessment should look for secondary causes: Cushing's syndrome, enlarged kidneys (PCK disease), renal bruits, radio-femoral delay (coarctation). Bloods may suggest a secondary cause (low potassium, high sodium: hyperaldosteronism).

Whilst awaiting confirmation of hypertension, evidence for target-organ involvement should be sought and a cardiovascular risk assessment made. Calculators are available:

https://qrisk.org/2017/ or http://www.jbs3risk.com/pages/risk_calculator.htm.

The QRISK2 score is not to be used in patients with type 1 diabetes or those with documented cardiovascular disease.

Patients with confirmed hypertension should have the following:

- Test for the presence of protein in the urine by sending a urine sample for estimation of the albumin:creatinine ratio and test for haematuria using a reagent strip.

- Blood sample to measure plasma glucose, electrolytes, creatinine, estimated glomerular filtration rate, serum total cholesterol and HDL cholesterol.
- Examine the fundi for the presence of hypertensive retinopathy.
- Arrange for a 12-lead electrocardiograph to be performed.
- Consider echocardiography if suggestion of LVH, valve disease or LVSD or diastolic dysfunction.

CKD 1 is defined as a normal GFR (> 90 ml/min/1·73 m^2) but suggestion of renal disease from urinalysis or structural abnormalities. CKD 2 is defined as a GFR 60 - 89 ml/min/1·73 m^2. When eGFR is below 60 ml/min/1·73 m^2, three different stages of CKD are recognized: CKD 3 with values between 30-60 ml/min/1·73 m^2; and stages 4 and 5 with values below 30 and 15 ml/min/1·73 m^2, respectively. Patients with CKD are at significantly increased risk of CV morbidity and mortality.

In those with stage 1 hypertension under the age of 80, treatment should be offered in those with evidence of target organ damage, those with established cardiovascular disease, patients with renal impairment, diabetes and patients with a 10-year risk ≥ 20%. In those with stage 2 hypertension, of any age, treatment should be offered.

Target blood pressure is < 140 mmHg systolic in patients at low-moderate risk. In diabetes, previous stroke/TIA, IHD and in patients with CKD, target blood pressure is ideally < 130/80. In elderly hypertensives less than 80 years old with systolic readings > 160 mmHg, target is 140-150 mmHg although < 140 mmHg is reasonable if tolerated. In those over 80 years, systolic target is 140-150 mmHg. For all patients the diastolic target is < 90 mmHg except in diabetes where the target is < 85 mmHg. In patients with CKD and overt proteinuria, systolic readings < 130 mmHg should be considered.

Treatment

Initial (Step 1) treatment

Non-pharmacological:

Weight reduction if body mass index > 25 kg/m^2. Each kg weight loss yields a BP reduction of 3/2 mmHg. Moderate salt intake (can reduce BP by 8/5 mmHg). Minimise alcohol intake. Aerobic exercise. Smoking cessation (to reduce cardiovascular risk).

Pharmacological:

Under the age of 55 offer ***ACEI*** or low cost ***ARB***. Do not combine an ***ACEI*** and ***ARB***. For patients over 55 or those of African or Caribbean origin of any age, offer a ***calcium channel blocker***. If the latter aren't tolerated, consider a ***thiazide-like diuretic*** such as ***indapamide*** 2.5 mg OD. ***Bendroflumethiazide*** and ***hydrochlorothiazide*** are no longer recommended as first-line but may be continued if already established.

β-blockers are no longer recommended first-line but may be considered in younger patients who are intolerant of ***ACEI*** or ***ARBs***, women of child-bearing age and those with evidence of increased sympathetic drive. If ***β-blockers*** are used first-line, and a second drug is required, diuretics should be avoided to reduce the risk of diabetes developing.

Step 2 treatment

If BP is not controlled with by step 1 treatment, offer a ***calcium channel blocker*** in combination with an ***ACEI*** or ***ARB***. If a ***calcium channel blocker*** is not suitable, or if there is evidence of or a high risk of heart failure, offer a ***thiazide-like diuretic***. For people of African or Caribbean origin, consider an ***ARB***, in preference to an ***ACEI***, in combination with a ***calcium channel blocker***.

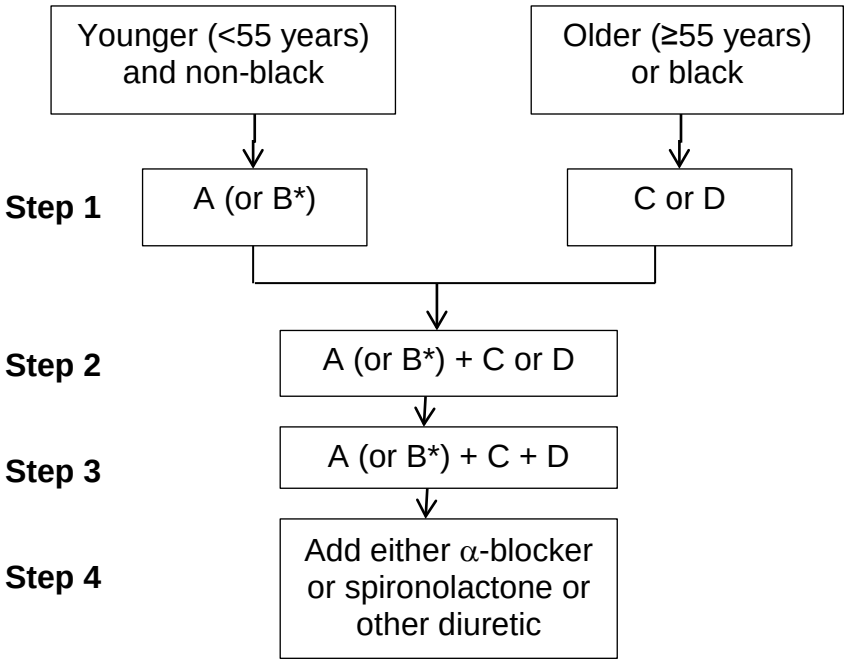
Step 3 treatment

First ensure step 2 treatment is with optimal doses. If further treatment is required, combine an ***ACEI*** or ARB with a ***calcium channel blocker*** and ***thiazide-like diuretic***.

Step 4 treatment

Regard clinic blood pressure that remains higher than 140/90 mmHg after treatment (with the optimal or best tolerated doses of an ***ACEI*** or an ***ARB*** plus a ***calcium channel blocker*** plus a ***diuretic***) as resistant hypertension, and consider adding a fourth antihypertensive drug. Consider further ***diuretic*** therapy with low-dose ***spironolactone*** (25 mg OD) if the blood potassium level is 4·5 mmol/l or lower. Use particular caution in people with a reduced estimated glomerular filtration rate because they have an increased risk of hyperkalaemia. Consider higher-dose ***thiazide-like diuretic*** treatment if the blood potassium level is higher than 4·5 mmol/l. The next step is to consider a ***β-blocker*** of ***alpha-blocker***.

There is an algorithm recommended when combining hypertensive drugs based on the AB/CD rule ([224]):



A: ACEI or ARB **B: β-blocker**

C: Calcium channel blocker **D: Diuretic**

The combinations used should also consider associated co-morbidities such as heart failure (***ACEI*** or ***ARBS***, ***β-blockers***, ***diuretics*** including ***spironolactone***), angina (***ACEI***, ***ARBS***, ***β-blockers***, and ***calcium channel blockers***), diabetes (all classes

but care with ***diuretics***), nephropathy (***ACEI***, ***ARBS***, possibly ***blockers***, ***calcium channel blockers*** but not ***spironolactone***. In ESRF ***diuretics*** are ineffective).

Aspirin is indicated for hypertensive patients ≥ 50 years of age with BP controlled to < 150/90 and with at least one of the following:

- Cardiovascular complications
- Target organ damage
- Diabetes
- Ten year coronary event risk ≥ 10%

Statins are recommended as primary prevention in patients under the age of 85 with a ten year coronary event risk ≥ 10% (using QRISK2 tool or JBS3 tool) and where total cholesterol is ≥ 3·5 mmol/l. They are recommended in all patients, regardless of baseline cholesterol, in secondary prevention.

HYPERTENSIVE EMERGENCIES

A hypertensive crisis is an increase in blood pressure, which if sustained over the next few hours, will lead to irreversible end-organ damage (encephalopathy, LV failure, aortic dissection, unstable angina, renal failure). Patients can present with an **emergency** (high BP associated with a critical event: encephalopathy, pulmonary oedema, acute kidney injury, myocardial ischaemia) or an **urgency** (high BP without a critical illness, but may include 'malignant hypertension': associated with grade 3/4 hypertensive retinopathy). The aim of therapy is to reduce the diastolic BP to 110 mmHg in 3 - 12 hours (emergency) or 24 hours (urgency). As a rule of thumb, IV treatment is given in hypertensive emergencies, whereas oral usually suffices in hypertensive urgencies.

Sodium nitroprusside (0·25 - 10 µg/kg/min) IV is particularly useful in patients with additional heart failure (see page 199), but should be avoided early after myocardial infarction ([225]). ***Labetalol*** (see page 197) can be used if LV function is preserved and there are no other contraindications to ***β-blockade***. ***GTN*** (1 - 10 mg/hr) is useful in the presence of ischaemia. ***Esmolol*** acts within 60 seconds, with a duration of action of 10 - 20 minutes. Typically, the drug is given as a 0·5 - 1 mg/kg loading dose over 1 minute, followed by an infusion starting at 50 µg/kg/min and increasing up to 300 µg/kg/min as necessary.

Hypertensive urgency is severe blood pressure elevation that will cause damage within days. Diastolic is usually > 130 mmHg and retinal changes will be apparent. The aim should be to reduce BP gradually to a diastolic of 100 mmHg over 48 - 72 hours using an oral regime. For oral treatment, any of the following drugs may be used: ***atenolol*** 50 - 100 mg OD, ***amlodipine*** 5 - 10 mg OD, ***diltiazem*** 120 - 300 mg daily, ***lisinopril*** 5 mg OD, etc. A combination of a ***β-blocker*** and ***calcium antagonist*** or ***ACEI*** and ***calcium antagonist*** is effective and well tolerated. Local expertise advises that the safest and most effective treatment regimen for the majority of patients is ***nifedipine*** 20mg MR BD plus ***amlodipine*** 10 mg OD for three days, continuing with ***Amlodipine*** 10 mg OD thereafter (***Amlodipine*** has a large volume of distribution and takes 3 days to become effective).

Phaeochromocytoma

The classic triad of symptoms in patients with a phaeochromocytoma consists of episodic headache, sweating, and tachycardia although most patients will not have

all three. Sustained or paroxysmal hypertension is the most common sign of phaeochromocytoma.

The diagnosis is typically confirmed by measurements of urinary and plasma fractionated metanephrines and catecholamines. A 24 hour urine collection is the main test. A CT or MRI scan of the abdomen and pelvis may detect tumours. A MIBG scan can detect tumours not detected by CT or MRI but the diagnosis is still considered likely.

Once a phaeochromocytoma is diagnosed, all patients should undergo a resection. Pending surgery, control of hypertension is combined ***alpha***- and ***beta-adrenergic blockade***. ***Phenoxybenzamine*** is most commonly used. The initial dose is 10 mg once or twice daily, and the dose is increased by 10 to 20 mg in divided doses every two to three days as needed to control blood pressure and spells. The final dose of ***phenoxybenzamine*** is typically between 20 and 100 mg daily. If not tolerated, the ***calcium channel blocker nicardipine*** can be used.

After adequate ***alpha-adrenergic blockade*** has been achieved, ***beta-adrenergic blockade*** is initiated, which typically occurs two to three days preoperatively. The ***beta-adrenergic blocker*** should **never** be started first.

Cushing's Syndrome

Usually apparent from the typical physical appearance. Bloods may reveal hyperglycaemia. A 24 hour urine cortisol excretion will be elevated (three times normal). Confirmation can be made with a low-dose dexamethasone suppression test. Adrenal CT is indicated.

Primary Aldosteronism

Suspect if low serum potassium and high/normal sodium. In up to 50% however the potassium is normal. It should certainly be considered in patients with hypokalaemia and in patients with resistant hypertension or in those with a family history of premature hypertension.

An aldosterone:renin ratio should be measured in the morning. Plasma renin activity is typically very low or undetectable in patients with primary aldosteronism, and the plasma aldosterone concentration high. The ratio is typically > 20-30 but the laboratory will define that. Generally speaking patients with suspected primary aldosteronism should be investigated by hypertension specialists or endocrinologists as confirmatory testing will be required. Adrenal CT is indicated.

DISEASES OF THE AORTA

Aortic Dissection

An aortic dissection is classified as type A or B depending on where it begins and ends. Type A begins in the first (ascending) part of the aorta. Type B begins in the descending part of the aorta. Type A is almost twice as common as type B.

Consider if very sudden and severe 'tearing' pain radiating to back, particularly in a known hypertensive. Diagnosis is supported by hypertension, loss of pulses and aortic regurgitation and may be complicated by myocardial infarction. Echocardiography may demonstrate a dissection, but the investigation of choice is CT or MRI. TOE is an alternative if CT or MRI are not readily available.

Management consists of analgesia (large doses of opiate may be required). Blood pressure should be controlled with ***labetalol*** (0·1 - 2·0 mg/min) or ***sodium nitroprusside*** (0·25 - 10·0 µg/kg/min) aiming for BP between 100 - 120 mmHg systolic. ***Thrombolytics***, ***anticoagulants*** and ***aspirin*** should be avoided.

A surgical opinion should be sought if there is severe aortic regurgitation, loss of pulses, or evidence of extension. Before referral the clinical appropriateness of surgical intervention needs to be considered. Proximal type A dissections are those most likely to need surgery, uncomplicated Type B distal dissections can often be managed medically.

Aortic dissection occurring during coronary angiography is rare and the management is not clearly defined. It seems to be more common during right coronary angiography, especially when left Amplatz catheters are employed. Immediate stenting of the right coronary ostium can be beneficial but mortality is still high at up to 30%. From the technical viewpoint, soft-tip wires should be used when attempting to access the true lumen, and if the initial wire enters the false lumen, another soft-tip wire should be carefully manipulated into the true lumen (double-wire technique). If conventional methods have resulted in dissection, the use of a ball-tipped guidewire, such as the Magnum wire, proves very useful to localise the true lumen in cases of spiral dissection. Stenting should be performed as soon as possible, as saving time is mandatory in this setting, and implantation should be started distally and finally to the RCA ostium.

Thoracic aortic aneurysm

Most thoracic aortic aneurysms (TAA) are asymptomatic. Risk factors include those for vascular disease in general, those with AAA, aortic valve disease, connective tissue disorders (Marfan's, Ehlers-Danlos), positive family history and cerebral aneurysms.

The indications for repair of thoracic aortic aneurysm include the following:

- The presence of symptoms, although most thoracic aortic aneurysms are asymptomatic.
- An end-diastolic aortic diameter of 5 to 6 cm for an ascending aortic aneurysm and 6 to 7 cm for a descending aortic aneurysm.
- For smaller patients, including many women, elective repair is performed for aneurysms greater than twice the size of the non-aneurysmal aorta (normal segment).

- Accelerated growth rate (≥ 10 mm per year) in aneurysms less than 5 cm in diameter.
- Evidence of dissection
- An ascending thoracic aortic aneurysm > 4·5 cm in diameter at the time of aortic valve surgery.
- In patients with aortic regurgitation of any severity and primary disease of the aortic root or ascending aorta (such as Marfan syndrome) aortic valve replacement and aortic root reconstruction are recommended when the degree of dilatation is ≥ 5 cm.

VALVULAR HEART DISEASE

It is important to recognise significant valvular heart disease as patients may benefit from surgical intervention, either in terms of valve repair or replacement. Left uncorrected, valvular heart disease often leads to irreversible ventricular dysfunction and/or pulmonary hypertension. It is therefore essential to refer patients for cardiological assessment **early**. These guidelines are based on the ESC Guidelines of 2012 ([226]).

Aortic Stenosis

The three classical symptoms of aortic stenosis (AS) are angina, heart failure and syncope, the most common initial symptom being a decrease in exercise tolerance or dyspnoea on exertion. In 'asymptomatic' patients with mild-moderate AS where there is doubt about whether there might be symptoms, cautious exercise testing can be useful - a fall or only minimal rise in blood pressure indicates symptomatic disease. Exercise testing is contraindicated in patients with symptomatic AS and should only be performed after review by a cardiologist.

Assessment and follow-up: AS is best assessed initially by echocardiography. This allows quantification of the severity of the stenosis and assessment of the rest of the heart. Severity of AS is assessed according to the following criteria:

	Mean gradient (mmHg)	**Peak gradient (mmHg)**	**AoV area (cm^2)**
Mild	< 25	< 36	> 1·2
Moderate	25 - 39	36 - 64	1·0 - 1·2
Severe	≥ 40	≥ 65	< 1·0

Once mild AS is present, a gradual increase in severity is seen in most patients, with an increase in mean gradient of 7 mmHg per year and a reduction in valve area of 0·1 cm^2 per year. However, there is a wide variation in the rate of progression between individuals, being faster in those with degenerative as opposed to those with congenital or rheumatic valve disease. It is recommended that:

Asymptomatic individuals with **mild** AS (mean gradient < 25 mmHg) should undergo annual outpatient review including echocardiography.

Asymptomatic individuals with **moderate** AS (mean gradient 25 - 49 mmHg) should undergo six-monthly outpatient review including echocardiography at least annually.

Asymptomatic individuals with **severe** AS (mean gradient > 50 mmHg) should be referred to a cardiologist for further assessment.

Symptomatic individuals with any degree of AS should be referred to a cardiologist for further assessment.

Echo reports usually quote mean and peak valve gradients; mean gradients are more useful in planning surgery and are used here. Be careful not to confuse the two - peak gradients are significantly higher than mean gradients. AS is notoriously difficult to assess in the presence of left ventricular dysfunction - the valve gradient assumes that LV function is normal. Echo gradients can be very misleading if LV

function is impaired - in such cases, always refer to a cardiologist for further advice. DSE may help identify patients who need surgery sooner rather than later.

Indications for surgery

Definite indications for surgery in AS are:

- Symptoms caused by AS (regardless of severity).
- Asymptomatic severe AS with left ventricular systolic dysfunction.
- Asymptomatic severe AS with abnormal exercise test (symptoms, drop in BP ST changes).
- Asymptomatic severe AS at the time of other cardiac surgery (e.g. CABG).

One might also consider surgery in patients with:

- Asymptomatic patients with severe AS and anticipated high levels of exertion, plans for pregnancy, etc.
- Patients with moderate AS undergoing CABG.
- Patients with moderate AS and LVH, especially in the absence of systemic hypertension.

Operative mortality in patients undergoing surgery for AS is 2 - 9% with a three-year survival rate of 80%. Old age is not a contraindication to surgery - the risk : benefit ratio is often favourable even in patients in their 80s.

Older patients require coronary angiography and ascending aortography before surgery. In addition CT scanning of the aorta can help determine operative strategy and should be considered in all patients. Bicuspid valves are common in AS, and there is a clear relationship between the presence of bicuspid valves and abnormalities of the aortic root even in the absence of severe AS. Concomitant treatment of a dilated aorta is, therefore, recommended at the same thresholds as in AR. Screening of first degree relatives is indicated in bicuspid AS. Carotid scans should also be considered in older patients as the radiated murmur could mask significant carotid disease.

In older patients, especially those with significant co-morbidities, transcatheter aortic valve implantation (***TAVI***) should be considered. Contra-indications to a transfemoral approach include those with a valve annulus < 18 mm or > 30 mm, peripheral arteries < 6 - 9 mm, severe peripheral artery calcification or tortuosity, AAA with thrombus, porcelain aorta. The trans-apical approach is an alternative.

Referral to the ***TAVI*** MDT is indicated (see page 39). Mortality is about 15%, stroke risk 5 - 8%, vascular complications 5 - 8%, tamponade 2 - 3%.

Aortic Regurgitation

Patients with chronic aortic regurgitation (AR) may remain asymptomatic for many years despite significant regurgitation. The increased volume load on the left ventricle leads to progressive LV dilatation and ultimately heart failure. The most common initial symptom is exertional dyspnoea or a reduction in exercise tolerance. There are many causes including idiopathic dilatation of the aorta, congenital abnormalities of the aortic valve (most notably bicuspid valves), calcific degeneration, rheumatic disease, infective endocarditis, systemic hypertension,

myxomatous degeneration, dissection of the ascending aorta, and Marfan syndrome. Less common causes include traumatic injuries to the aortic valve, ankylosing spondylitis, syphilitic aortitis, rheumatoid arthritis, osteogenesis imperfecta, giant cell aortitis, Ehlers-Danlos syndrome and Reiter's syndrome.

Afterload reduction (with ***ACEI***) can slow the rate of left ventricular dilatation and is now standard therapy in patients with severe AR and LV dilatation.

Assessment & follow-up

AR should always be assessed by echocardiography. This allows quantification of the severity of the regurgitation and assessment of the rest of the heart. Several parameters are used to determine overall severity on echocardiography and the echo report will contain a final conclusion based upon these parameters. It is recommended that:

- **Asymptomatic** individuals with **mild** AR do not usually require follow-up.
- **Asymptomatic** individuals with **moderate** AR and a normal LV should be seen every 12 months with echocardiography every 2 years.
- **Asymptomatic** individuals with **moderate** or **severe** AR and a **dilated or impaired LV** should be seen every 6 months with echocardiography every 12 months. The frequency of echocardiography should increase as the threshold for surgery approaches.

	Mild	**Moderate**	**Severe**
Colour Doppler jet width	Central jet, width less than 25% of LVOT	Greater than mild but no signs of severe AR	Central jet, width greater than 65% LVOT
Vena contracta width	Less than 0·3 cm	0·3 - 0·6 cm	Greater than 0·6 cm
Regurgitant volume	Less than 30 ml	30 - 59 ml	≥ 60 ml
Regurgitant fraction	Less than 30%	30 - 49%	≥ 50%

In patients with aortic root dilatation (but still < 5·0 cm), annual echocardiograms are needed to evaluate progression of aortic root size. For patients with poor echo windows assessment with CMR is a useful alternative imaging modality.

Echo markers of severity of AR include colour Doppler jet width, Doppler vena contracta width, regurgitant volume and regurgitant fraction:

Symptomatic individuals with **any degree** of AR should be referred to a cardiologist for further assessment.

Indications for surgery

In patients with chronic AR indications for surgery are:

- Symptomatic severe AR

- Asymptomatic severe AR with evidence of early LV systolic dysfunction (EF < 50% or LV end-systolic diameter > 5 cm or LV end-diastolic diameter > 7·0 cm)
- Asymptomatic AR of any severity with aortic root dilatation > 5·5 cm (or > 4·5 cm in Marfan syndrome or bicuspid aortic valve).

Operative mortality for elective aortic valve replacement for chronic AR is 4 - 10% with a five-year survival of 70 - 85%.

Mitral Stenosis

The prognosis for patients with asymptomatic mitral stenosis (MS) is thought to be good. There is little modern information on natural history. Generally, disease progression is gradual unless a complication (such as the onset of atrial fibrillation) occurs.

Assessment & follow-up

Severity of MS is assessed on echocardiography according to the following criteria:

	Mean MV gradient (mmHg)	MV area (cm2)
Mild	< 6	> 1·5
Moderate	6 - 9	
Severe	≥ 10	< 1·5

Asymptomatic patients with moderate to severe MS should be seen annually with an up to date echocardiogram. Asymptomatic patients with lesser degrees of MS can usually be reviewed less frequently. Symptomatic patients should always be referred to a cardiologist.

Indications for surgery

Invasive correction of MS can be undertaken either by percutaneous mitral balloon valvuloplasty or by surgical mitral valve repair or replacement. TOE is essential to select the most appropriate procedure by examining the mitral valve anatomy in detail. To be suitable for percutaneous mitral balloon valvuloplasty, patients should have a mitral valve with favourable echo features (minimal calcification, no more than mild MR, mild calcification, and no left atrial thrombus). In addition there should not be significant aortic or tricuspid valve disease. Indications for percutaneous mitral balloon valvuloplasty are:

- Symptomatic (NYHA functional class II - IV) patients with moderate-severe MS (MV area ≤ 1·5 cm^2).
- Asymptomatic patients with moderate-severe MS (MV area ≤ 1·5 cm^2) with pulmonary hypertension (PA systolic pressure > 50 mmHg at rest).
- Asymptomatic patients with moderate-severe MS (MV area ≤ 1·5 cm^2) with new onset atrial fibrillation.

Mitral valvuloplasty is carried out under general anaesthetic. TOE guidance is usually used. Femoral arterial and venous sheaths are inserted, and a catheter is passed through the right heart to measure pressures, saturations and do a

pulmonary angiogram and follow-through to visualise the left atrium (LA). A trans-septal puncture (RA to LA) is carried out, and a large balloon is passed through this into the LV. The balloon blows up in two stages, the distal part first, which is then pulled back against the MV, and then the whole balloon is inflated across the MV. The procedure takes about 2 hours. Risk of severe MR requiring emergency surgery is 1 in 100. Risk of causing MR is 1 in 20. Risk of stroke is 1 in 100. Risk of persistent ASD is 1 in 200. Risk of death is 1 in 200. There is a risk of developing AF (if not already present), which may require cardioversion. It is significantly less successful (< 50%) in patients over the age of 65 years.

Mitral valve surgery is usually indicated in:

- Patients with moderate-severe MS (MV area ≤ 1·5 cm^2) and NYHA functional class III - IV symptoms.
- Patients with severe MS (MV area < 1·0 cm^2), NYHA functional class I - II symptoms, and severe pulmonary hypertension (PA systolic pressure > 60 - 80 mmHg).

After successful percutaneous mitral balloon valvuloplasty, patients should be followed up annually with an echocardiogram, chest X-ray and ECG if they remain asymptomatic or minimally symptomatic.

Medical therapy of MS consists of diuretics and long acting ***nitrates*** for the management of dyspnoea. ***β-blockers*** and ***non-dihydropyridine calcium antagonists*** can improve exercise capacity. ***Warfarin*** is mandatory in the presence of atrial fibrillation and should be seriously considered in sinus rhythm when TOE shows dense spontaneous echo contrast or when the left atrium is > 50 mm in diameter.

Mitral Regurgitation

Patients with mitral regurgitation (MR) may remain asymptomatic for many years; the average interval from diagnosis to the onset of symptoms is 16 years. Most patients with chronic MR have mild-moderate disease and are unlikely ever to need surgical intervention.

Mitral valve prolapse is one aetiology and is more common in patients with Marfan's syndrome and those with pectus excavatum. It occurs in 1 - 2% of the population and may be familial. Prognosis is worse when there is moderate to severe MR and when the EF is < 50%.

Other common causes of MR are rheumatic heart disease, IHD, infective endocarditis, certain drugs, and collagen vascular disease. MR may also occur secondary to a dilated annulus from LV dilatation. In some cases, such as ruptured chordae, ruptured papillary muscle, or infective endocarditis, MR may be acute and severe. Alternatively, MR may worsen gradually over a long period of time.

Assessment & follow-up

MR is best assessed by echocardiography (TOE is particularly useful, especially if mitral valve surgery is being considered or if there is concern the degree of MR is being underestimated). In patients with known MR, the recommended follow-up intervals are as follows:

MR severity	LV function	Frequency of echocardiography
Mild	Normal LVESD and EF	Every 5 years
Moderate	Normal LVESD and EF	Every 2 years
Moderate	LVESD > 4.0 cm or EF < 60%	Every 1 year
Severe	Normal ESD and EF	Every 1 year
Severe	LVESD > 4·0 cm or EF < 60%	Every 6 months

LVESD indicates LV end-systolic diameter; EF indicates LV ejection fraction

It is obviously not necessary to adhere to these guidelines in patients deemed unsuitable for surgery.

Various echo criteria are used to quantify the degree of MR including colour Doppler jet area, Doppler vena contracta width, pulmonary venous flow patterns (specifically systolic flow reversal) and regurgitant volume and fraction.

	Mild	Moderate	Severe
Colour Doppler jet width	Central jet, width less than 4 cm^2 or less than 20% LA area	Greater than mild but no criteria of severe MR	Vena contracta width greater than 0·7 cm with large central MR jet (area > 40% of LA area) or with a wall impinging jet of any size, swirling in LA
Vena contracta width	< 0·3 cm	0·3 – 0·69 cm	> 0·7 cm
Regurgitant volume	< 30 ml	30 - 59 ml	≥ 60 ml
Regurgitant fraction	< 30%	30 - 49%	≥ 50%

Indications for surgery

The surgical options in MR include mitral valve replacement or mitral valve repair. Valve repair has several advantages, including an operative mortality of 1 - 2% (compared to 5 - 10% for valve replacement), and is usually performed if the anatomy of the valve is suitable.

Surgical intervention is generally indicated in **severe** MR for:

- Symptomatic patients (with symptoms due to the MR).

- Asymptomatic patients with mild-moderate LV dysfunction (EF 30 - 60% and LVESD 4·5 - 5·5 cm).

Surgery should also be considered in **severe** MR for:

- Asymptomatic patients with normal LV function but AF or pulmonary hypertension (> 50 mmHg at rest).
- Asymptomatic patients with EF 50 - 60% or LVESD 4·5 - 5·5 cm.
- Severe LV systolic dysfunction (EF < 30% and/or LVESD > 5·5 cm) only if it is highly likely that a valve repair (rather than replacement) can be performed.

Medical therapy of MR is restricted largely to the use of diuretics. There is no evidence that the routine use of ***ACEI*** confers any benefit in mild MR. However, in patients with functional or ischaemic MR (resulting from dilated or ischaemic cardiomyopathy), ***ACEI*** are beneficial. If LV systolic dysfunction is present, treatment with drugs such as ***ACEI*** and ***β-blockers*** such as ***Bisoprolol*** or ***Carvedilol*** and CRT have all been shown to reduce the severity of MR [227-230].

Tricuspid Regurgitation

Significant tricuspid regurgitation (TR) in adults is most commonly secondary to right heart dilatation. The disorders that induce pulmonary hypertension and secondary right ventricular dilatation include the following:

- Left-sided heart failure.
- Mitral stenosis or regurgitation.
- Primary pulmonary disease – cor pulmonale, pulmonary embolism, pulmonary hypertension of any cause.
- Left to right shunt – atrial septal defect, ventricular septal defect, anomalous pulmonary venous return.
- Eisenmenger syndrome.
- Stenosis of the pulmonic valve or pulmonary artery.
- Hyperthyroidism
- Diseases of the right ventricle causing dilatation include right ventricular cardiomyopathies and right ventricular myocardial infarction.

Causes of primary TR include:

- Direct valve injury from a permanent pacemaker or implantable cardioverter-defibrillator lead placement or removal or from endomyocardial biopsy.
- Chest trauma.
- Infective endocarditis.
- Ebstein's anomaly, the most common form of congenital disease affecting the tricuspid valve.
- Rheumatic fever.
- Carcinoid syndrome (poor prognosis, diagnosis with urine 5-HIAA)
- Ischaemic heart disease affecting the right ventricle with papillary muscle

dysfunction or rupture.

- Myxomatous degeneration associated with tricuspid valve prolapse, which occurs in as many as 40% of patients with prolapse of the mitral valve.
- Connective tissue disorder (eg, Marfan syndrome).
- Marantic endocarditis in systemic lupus erythematosus or rheumatoid arthritis
- Drug-induced disease. There was an association between TR and the combined use of the anorectic drugs, ***fenfluramine*** and ***phentermine***, in some studies. The dopamine agonist ***pergolide*** may induce TR by a mechanism similar to that with anorectic drugs and carcinoid syndrome.

Treatment for secondary TR is usually tricuspid annuloplasty performed at the time of left-sided valve surgery. Primary TR is treated in much the same way.

INFECTIVE ENDOCARDITIS

The incidence of infective endocarditis (IE) in Europe is around 3 - 10 episodes per year / 100,000 with increased incidence with age. Predisposing cardiac conditions include mitral valve prolapse, the presence of prosthetic material (e.g. valves and patches, but **not** coronary stents), rheumatic heart disease, degenerative and bicuspid aortic valve disease, and many forms of congenital heart disease. IE may also involve previously normal heart valves and may be associated with infection due to an intravascular device.

The commonest causative organism is now *Staphylococcus aureus* (30%) followed by the *viridans* group of *streptococci* (17% of episodes). In IV drug users *Staphylococcus aureus* is commonest, causing 50 - 60% of episodes. IE occurring ‘early’ (up to 1 year) after the implantation of prosthetic heart valves is thought to be due to perioperative contamination and is mainly caused by staphylococci (especially coagulase-negative). ‘Late’ prosthetic valve infections are commonly due to *viridans* streptococci, *Staphylococcus aureus* and coagulase-negative staphylococci.

Enterococcal endocarditis represents about 10% of all cases, and may be a pointer to disease of the GU or lower GI tract. Around 2 - 10% of cases are caused by fungi (mainly *Candida* or *Aspergillus* spp.), particularly in patients with immunosuppression, IV drug use, cardiac surgery, prolonged exposure to antimicrobial drugs and IV feeding. In around 5% of patients with proven IE, conventional blood cultures are negative. This may be due to recent exposure to antimicrobial drugs or infection with slow-growing or fastidious organisms (e.g. ‘HACEK’ organisms, nutritionally variant *streptococci*, *Coxiella burnetii* or *Brucella* spp.).

HACEK organisms: *Haemophilus parainfluenzae*, *Haemophilus aphrophilus, Actinobacillus actinomycetemcomitans*, *Cardiobacterium hominis*, *Eikenella corrodens*, *Kingella kingae*.

Mortality varies from 4 - 16% with viridans streptococci to 25 - 47% with *Staphylococcus aureus*, and over 50% with fungal infections. Mortality is chiefly from heart failure, CNS emboli or uncontrolled infection. Mortality from right-sided endocarditis in IV drug users is around 10%.

Investigation

IE should always be suspected in patients with unexplained fever, bacteraemia or systemic illness and/or with an apparently new murmur or other features of the illness. Patients with suspected IE should be admitted to hospital.

Routine initial investigations should include:

- Full blood count
- ESR and CRP
- U&Es
- Liver function tests
- Urine dipstick analysis and MSU for microscopy/culture
- Chest X-ray
- ECG
- However, the key diagnostic investigations are: BLOOD CULTURES & ECHOCARDIOGRAM

Blood cultures

At least three (and preferably six) sets of blood cultures should be taken from different sites over several hours. Sampling during a temperature peak does not improve the sensitivity of blood cultures. If the patient is stable it is reasonable to delay antibiotic treatment to allow for comprehensive sampling - once antibiotics have been given, it becomes much harder to identify a causative organism.

If cultures are negative despite a high level of suspicion of IE , samples can be taken in special media that allows the growth of fastidious organisms. Serology for *Coxiella burnetii*, *Tropheryma whipplei*, *Bartonella* should be considered. Liaise with the duty microbiologist for further advice.

Echocardiogram

Transthoracic echocardiography will detect 65% of vegetations. Transoesophageal echocardiography (TOE) will detect 95% of vegetations. TOE is particularly useful for the detection of mitral valve and prosthetic valve vegetations. TOE is also more sensitive at detecting aortic root and septal abscesses and leaflet perforations.

Diagnostic criteria

Clinical criteria for IE can be divided into major and minor. A diagnosis can be made on the basis of two major criteria or one major and three minor criteria or five minor criteria. Possible IE is the presence of one major and one minor or three minor.

Major criteria

- Positive blood cultures
  - Typical organism from 2 blood cultures (*viridans streptococci*, *Streptococcus bovis*, HACEK group, *Staphylococcus aureus* or community-acquired *enterococci*.
  - Other microorganisms consistent with IE
  - persistent positive blood cultures taken > 12 hours apart

- > 3 positive blood cultures taken over more than 1 hour
- Single positive blood culture for *Coxiella burnetii*

- Endocardial involvement
- positive echo findings (vegetation, abscess)
- new valvular regurgitation (worsening of pre-existing murmur not sufficient)
- dehiscence of prosthesis

Minor criteria

- Predisposing valvular or cardiac abnormality
- IV drug abuser
- Pyrexia > 38°C
- Embolic phenomenon
- Vasculitic phenomena, emboli, septic infarcts
- Immunological phenomena: nephritis, Osler's nodes, Roth's spots
- Blood cultures suggestive (organism grown but not achieving major criteria)
- Suggestive echo findings (but not meeting major criteria)

Other imaging modalities can aid in the diagnosis and evaluation of complications of IE including CT, MRI and PET scanning – specifically PET using the radionuclide tracer ^{18}F-fluorodeoxyglucose (^{18}F-FDG) which is a tracer taken up by any cell undergoing high glycolytic activity (as is the case in tumour cells, inflammation and infection).

Management

Antibiotic therapy

A tunnelled central venous line can be very useful when prolonged courses of IV antibiotics are required. Arrangements for their insertion can be made via ICE or by contacting the vascular access team on 6861.

Antibiotic regimens should always be discussed with the duty microbiologist. Current UK guidelines recommend the following:

Endocarditis caused by **streptococci**

eg. *Viridans streptococci*: **benzylpenicillin** IV 1·2 g QDS (or **vancomycin** if penicillin-allergic 30 mg/kg per 24 hours IV in two divided doses) plus low-dose **gentamicin** (e.g. 80 mg BD)

Endocarditis caused by **enterococci**

eg. *Enterococcus faecalis*: ***amoxicillin*** IV 2 g every four hours (or ***vancomycin*** if penicillin-allergic) plus low-dose ***gentamicin*** IV (e.g. 80 mg BD)

Endocarditis caused by **staphylococci**

eg. Staph. aureus, Staph. Epidermidis: ***flucloxacillin*** IV 2 g every four to six hours (or ***benzylpenicillin*** if penicillin-sensitive, or ***vancomycin*** if penicillin allergic or MRSA) plus ***gentamicin*** (or ***fusidic acid***).

Response to therapy

It is important to monitor response to therapy closely. As well as regular bedside reviews of clinical status, you should also check:

- Echocardiogram (once weekly) - to assess vegetation size and look for complications (e.g. valve destruction, intracardiac abscesses)
- ECG (at least twice weekly) - to detect conduction disturbances, which may indicate development of an aortic root abscess in aortic valve infection
- Blood tests (twice weekly) - ESR, CRP, full blood count and U&Es

Surgery

Referral for consideration of surgery is indicated in patients with:

- Moderate to severe cardiac failure due to valve compromise
- Valve dehiscence
- Uncontrolled infection despite appropriate antimicrobial therapy
- Relapse after optimal medical therapy
- Threatened or actual systemic embolism
- *Coxiella burnetii* and fungal infections
- Paravalvar infection (e.g. aortic root abscess)
- Sinus of Valsalva aneurysm
- Valve obstruction

It is prudent to inform the surgeons early in any case of endocarditis as, even patients without the above factors, may subsequently need surgery at short notice. A recent meta-analysis published online in Heart suggests early surgical intervention can be associated with improved outcomes.

Antibiotic Prophylaxis

There is no definitive evidence that antibiotic prophylaxis reduces the risk of IE. Guidelines have changed relatively recently and patients who may have been previously been advised to have antibiotic prophylaxis may no longer need it.

NICE guidelines (CG64, March 2008) state that antibiotic prophylaxis against IE is **not** recommended: for people undergoing dental procedures, for people undergoing non-dental procedures at the following sites: upper and lower GI tract, GU tract (this includes urological, gynaecological and obstetric procedures, and childbirth), upper and lower respiratory tract (this includes ENT procedures and bronchoscopy).

AHA/ACC guidelines still recommend antibiotic prophylaxis in patients with prosthetic cardiac valves or prosthetic material used for cardiac valve repair, patients with previous IE, unrepaired cyanotic CHD, including palliative shunts and conduits, completely repaired congenital heart defect repaired with prosthetic material or device (whether placed by surgery or by catheter intervention, during the first 6 months after the procedure, repaired CHD with residual defects at the site or adjacent to the site of a prosthetic patch or prosthetic device (both of which inhibit endothelialisation), cardiac transplant recipients with valve regurgitation due to a structurally abnormal valve.

MANAGEMENT OF PROSTHETIC VALVES

The routine follow up of patients with prosthetic valves is a contentious area. If patients have undergone successful surgery, and are asymptomatic, follow up should not be annually.

All patients should have a baseline echo after surgery. In individuals with a bioprosthetic aortic valve a routine echo at 7 years is recommended, for a bioprosthetic mitral valve at 5 years. Earlier assessment should only be undertaken if there is a change in clinical status, if there are findings consistent with valve dysfunction, or if there has been exposure to the clinical risk of valve thrombosis.

Repeat assessments should only be undertaken if intervention (with or without symptoms) would be undertaken.

In patients with mechanical valves, ***anticoagulation*** must be maintained unless there is a need for surgical intervention. Target INR for prosthetic valves is partly dependent upon the type and position of the valve. See the following table.

Recommended INR for mechanical prosthetic valves		
	Sinus rhythm normal left atrial size (i.e. most aortic valve replacement patients)	Atrial fibrillation enlarged left atrium (i.e. most mitral valve replacement patients)
Low thrombogenicity prosthesis	2·0 – 3·0	2·5 – 3·5
Other prostheses	3·5 – 4·5	3·5 – 4·5

Generally speaking ***warfarin*** should be stopped 5 days pre-op. ***Enoxaparin*** should be started 3 days pre-op, at 100 IU/kg OD. The dose should be omitted on the morning of surgery. Ideally ***enoxaparin*** 5000 U should be given 6 hours post-op providing haemostasis is secure. ***Enoxaparin*** should be increased to 100 IU/kg BD the following morning after reassessment for bleeding. ***Warfarin*** should be restarted at USUAL MAINTENANCE DOSE on the day after surgery and ***en*** continued until INR is therapeutic for TWO consecutive days. Some consultants prefer ***UFH*** rather than ***enoxaparin*** and, if possible, the relevant cardiologist should be contacted.

For emergency reversal of ***warfarin*** see the Appendix.

ADULT CONGENITAL HEART DISEASE (ACHD)

Glenfield Hospital is the home of the East Midlands Congenital Heart Centre (EMCHC). EMCHC provides inpatient and outpatient care for children with all forms of cardiac disease and for adults with congenital heart disease (ACHD) for the East Midlands region.

The majority of ACHD admissions are for elective cardiac catheterisation (diagnostic and interventional) and surgery. Catheter patients are looked after on Wards 32 and 34 and occasionally elsewhere. If you are an FY doctor on those wards you may be asked to clerk ACHD patients. They will be your responsibility. Surgical patients are looked after on Ward 31 and you will have little, if any, input to their care.

ACHD patients with acute cardiac problems are looked after on Ward 33 under the care of Drs Bolger, Bu'Lock and MacDonald. You will be notified of any admissions by the ACHD team, which also includes the specialist nurses Chris Thornborough and Karen Duncan and an adult cardiology registrar.

ACHD patients often have complex anatomy and pathophysiology and may be scheduled for interventions that you have little knowledge of (transcatheter pulmonary valve implantation, coarctation stenting, ASD closure etc). You are unlikely to have had responsibility for looking after such patients previously. The ACHD team have a very "hands on" approach and will provide clear instructions about management. If you are in any doubt about a management plan please contact an ACHD team member via consultants' secretaries, by contacting the relevant consultant on their mobile phone via switchboard (they're very approachable and will want to know about their patients), by bleeping the ACHD registrar on 2705 or by contacting a specialist nurse on x3338 or on their mobile via switchboard.

You are encouraged to learn more about ACHD, an expanding and fascinating sub-specialty of adult cardiology, by attending the EMCHC MDT on a Wednesday morning (8-10am, Ward 32 Large Seminar Room) and the catheter lab.

Elective ACHD Admissions

All interventions are performed under GA unless otherwise indicated (ASD/PFO closure, coarctation stents, percutaneous pulmonary valves or PPVI). Patients therefore need to be clerked with particular attention to their fitness for a GA. Do they have evidence of, for instance, coronary or respiratory disease? Is there a history of recent chest infections?

For female patients please ask date of LMP and check if there is any possibility of pregnancy. This must be documented in the notes for XR / medico-legal reasons. If they are uncertain of LMP and are not using contraception, a pregnancy test must be performed.

All patients who have not had X-rays at this institution should ideally have a PA film. X-rays should also be performed if one has not been done in the past 12 months. This also particularly applies to PPVIs which also include a lateral CXR post procedure.

Cyanotic and Fontan Patients

Cyanotic & Fontan patients should be given IV fluids overnight when NBM for any procedure. 1 litre of ***sodium chloride*** 0·9% over 12 hours should suffice. If late in

the day, they should also have IV fluid. This improves access and haemodynamic stability as they are critically dependent on filling pressures for their circulation.

Vessel cannulation for catheter procedures

Femoral vein cannulation: This vein is cannulated for ASD / PFO / PDA closures / pulmonary valvuloplasty (7-12F) and percutaneous pulmonary valve implants (22Fr sheaths). For PFO closure under local, 11Fr and 12Fr RFV sheaths (one for ICE catheter and one for delivery sheath) may be used. Z-sutures may be used for venous closure. These are released 4 hours post procedure by cutting the suture and gently pulling the suture material out.

Femoral artery cannulation: The artery is cannulated in coarctation stenting 10-14F sheaths / PDA closures (9-12F sheaths) / pulmonary valvuloplasty / pulmonary stent valve implants (6Fr). Angio-Seal, Perclose or Proglide devices may be used for arterial closure. A card will be issued to the patient when they are used.

Any previous problems with vessel cannulation should be documented from the procedure and femoral & pedal pulses palpated and documented. If there is a large haematoma, a thrill or bruit may indicate an arteriovenous fistula and vascular ultrasound should be obtained (see page 30). Groin scars should be noted and documented.

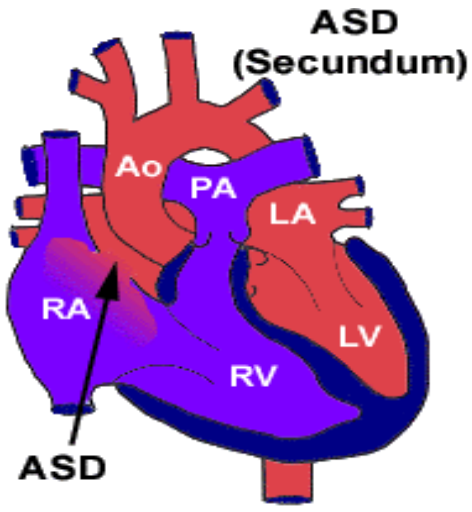
Blood Tests

All cases should have a group and save, FBC, U&E and INR with results documented in the notes.

Coarctation stent cases, valvuloplasty and percutaneous valve implant cases should be X-matched for 4 units (it takes 2 units to prime a bypass circuit). Some other cases are also X-matched and you will be advised by the consultant.

ASD Closures

Indication: significant shunt (RV volume overload, PVR <5 Woods units; paradoxical embolism). Not if Eisenmenger physiology/ PVR high). Access is usually via the femoral vein.

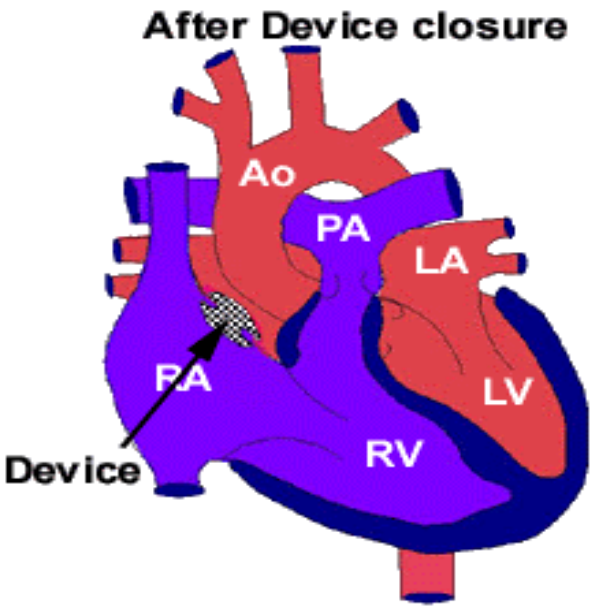


Post-procedure care:

- Bed rest - 4 hours.
- Start ***aspirin*** 75 mg OD and ***clopidogrel*** 75 mg OD pre-discharge for 3 months, then single agent for additional 3 months (6 months in total antiplatelet therapy).
- Re-start ***warfarin*** for patients with previous AF/PAF (INR 2·0-3·0).
- CXR / ECG / TTE in the morning - to be reviewed, and review findings documented in notes pre-discharge. Highest risk of embolisation is within 24 hours. The ECG is to examine the PR interval and rule out heart block caused by the device impinging on the AV node.

PFO closures (procedure as per ASD)

Indication: post MDT discussion (cryptogenic stroke in young person with no obvious other cause) Access is usually via the femoral vein.

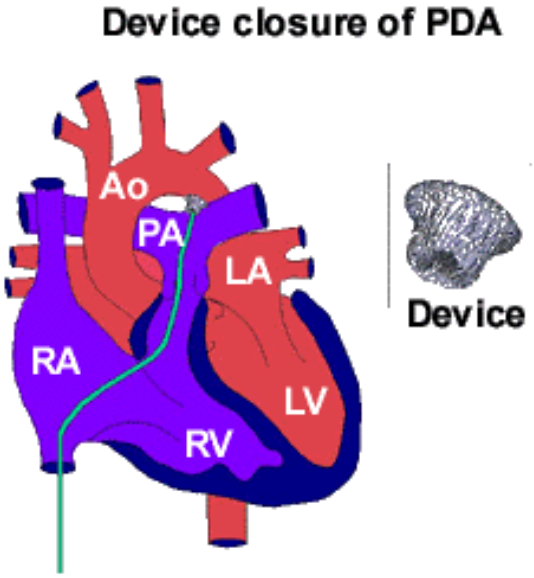


Post-procedure care:

- Bed rest - 4 hours.
- Start ***aspirin*** 75 mg OD and ***clopidogrel*** 75 mg OD pre-discharge for 3 months, then single agent for additional 3 months (6 months in total antiplatelet therapy).
- Patients ALREADY TAKING ***warfarin*** - Restart ***warfarin*** that evening. ***Warfarin*** is continued for 3 – 6 months aiming for INR 2·0 - 3·0.
- Patients not on ***warfarin***, start ***aspirin*** 75 mg OD and ***clopidogrel*** 75 mg OD for three months. Thereafter continue ***clopidogrel*** 75mg OD. With the Helix device, ***aspirin*** 75 mg OD for 3 months may be used.
- ECG / TTE in the morning – as per ASD closures. If the PFO closure is performed in the morning, these tests can be done in the afternoon to facilitate same day discharge.

PDA closures

Indication: signs of LV volume overload; if PAP <2/3s systemic pressure or PVR <2/3s systemic pressure; continuous murmur. Not if Eisenmenger or exercise induced lower limb desaturation). Access is usually via the femoral vein.



Post-procedure care:

- Bed rest - 4 hours.
- CXR / ECG / TTE in the morning - to be reviewed, and review findings documented in notes pre-discharge.

Coarctation of the Aorta stenting

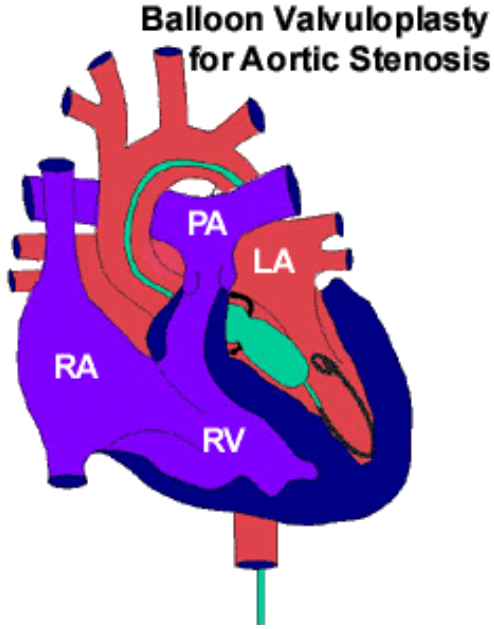
Indication: non-invasive pressure difference > 20 mmHg between upper and lower limbs and upper limb hypertension (> 140/90mmHg), pathological BP rise on exertion or significant LVH; if hypertensive and > 50 % aortic narrowing. Access is via the femoral artery.

Post-procedure care:

- Bed rest - 4 hours.
- Regular oral analgesia - chest pain is common after coarctation stenting but patients should be reviewed and examined if there is any pain as dissection must be excluded. Pain is more tearing in nature and felt from front through to the back. Be aware of unequal pulses.
- 12F-14F arterial puncture - close groin observations overnight. A Perclose or Proglide suture may have been used.
- AP & Lateral CXR / ECG / TTE following morning - examine stent position, no stent fractures.

Blood pressures should generally be measured in the right arm. There may be arch hypoplasia, former surgical subclavian flap repair meaning left axillary artery pulsations will be reduced and an incorrect measure of systemic pressure.

Pulmonary / Aortic valvuloplasty



Indication: post MDT discussion.

Pulmonary: if peak velocity > 4 m/s regardless of symptoms, systolic RVP > 80 mmHg (> 4·3 m/s) or less than this if symptoms/ decreased RV function)

Aortic: severe AS and valve related symptoms, symptomatic exercise test (MDT discussion- should have valve surgery first line as adult?)

Femoral vein and femoral artery cannulation used respectively.

- Bed rest - 4 hours.
- CXR / ECG / TTE in the morning

DC cardioversion of GUCH cases

Management is the same as for adults without ACHD with the exception of patients with a single ventricle and Eisenmenger patients.

A senior anaesthetist should be present. Procedures with anaesthesia are responsible for about 25% of deaths in Eisenmenger syndrome whilst in hospital. Brief sedation may be preferred. Dropping systemic arterial pressure can exacerbate

any right to left shunting and impair filling pressures which will be poorly tolerated. CVP monitoring at a constant level may be helpful.

Cyanotic Congenital Heart Disease and iron deficiency

These patients may be iron deficient despite their erythrocytosis. Red blood cell deformability decreases if the patient is iron deficient and traditional indices are not reliable eg MCV, reference Hb levels, ferritin. Hb should be higher than normal values due to their hypoxia. This reduced deformability predisposes to hyperviscosity syndrome (headaches/altered mental state/visual disturbance/tinnitus/dizziness) which occurs when viscosity increases so much that DO2 falls due to reduced flow despite high Hb levels. Higher Hct tolerated (> 70 %) as long as not Fe-deficient; hyperviscosity syndrome may occur at Hct < 65 % if they are Fe deficient.

Fe-deficiency is a major independent risk factor for CVA in cyanotic ACHD patients due to this change in RBC deformability and increased risk of microvascular problems. This hyperviscosity increases the risks of thromboembolism; the patients are both at increased risk of bleeding and increased risk of clotting. ***Anticoagulation*** recommendations are thus difficult to generalise.

If transferrin sats are low (< 16 %) consider oral FeSO4 or infusion. Ferinject (***ferric caboxymaltose***), expressed in mg of elemental iron is used. 500 mg in 100 ml of ***sodium chloride*** 0·9% as IV infusion over at least 15 minutes. Team may decide to give 1000 mg in 250 ml ***sodium chloride*** 0·9% by IV infusion over at least 30 - 40 minutes. If the solution is too dilute it is not stable and in general should not have < 2 mg per ml). Caution if infection present, liver dysfunction, asthma or atopy, pregnancy or lactating.

Herceptin levels may be a better indicator than transferrin saturations but this test is not widely available.

Guide to timelines for Outpatient review & Investigations

Repaired ASD / VSD: OPA 3 - 4 years. TTE / ETT every 4 years.

Repaired TOF PR+: OPA 1year. TTE / ETT every 1year.

Repaired TOF PR-: OPA 2 years. TTE / ETT every 2 years.

Mustard / Senning / Systemic RV: OPA 12 - 18 months. TTE every 12-18 months. ETT every 2 years.

Cyanotics / PHT: OPA every 6-12 months. TTE every 12 months. ETT with oxygen sats every 12 months. FBC every 12 months.

Native CoA / Stented CoA/ repaired CoA: OPA / TTE every 12 - 18months. ETT with RUL & RLL BP pre & post exercise every 2 years. MRI every 4 years.

Valvular heart disease: OPA / TTE / ETT every 6-18 months (depends on severity of lesion).

Marfan's Diagnostic criteria

Marfan's syndrome was discovered in 1896. The first diagnostic criteria came in 1956 and were revised in 1979. The Berlin criteria came in 1986 and were composed by a group of international geneticists. In 1996 the criteria was revised again to the Ghent criteria and then again in 2010 to the modified Ghent criteria as follows:

The 2010 Revised Ghent Nosology for Marfan syndrome relies on seven rules:

In the absence of family history:

1. **Aortic Root Dilatation Z score ≥ 2 AND Ectopia Lentis = Marfan syndrome**. The presence of aortic root dilatation (Z-score ≥ 2 when standardized to age and body size) or dissection and ectopia lentis, allows the unequivocal diagnosis of Marfan syndrome, regardless of the presence or absence of systemic features except where these are indicative of Shprintzen Goldberg syndrome, Loeys-Dietz syndrome, or vascular Ehlers Danlos syndrome.
2. **Aortic Root Dilatation Z score ≥ 2 AND FBN1 = Marfan syndrome. The** presence of aortic root dilatation (Z ≥ 2) or dissection and the identification of a bona fide FBN1 mutation are sufficient to establish the diagnosis, even when ectopia lentis is absent.
3. **Aortic Root Dilatation Z score ≥ 2 AND Systemic Score ≥ 7pts = Marfan syndrome**. Where aortic root dilatation (Z ≥ 2) or dissection is present, but ectopia lentis is absent and the FBN1 status is either unknown or negative, a Marfan syndrome diagnosis is confirmed by the presence of sufficient systemic findings (≥ 7 points, according to a scoring system) confirms the diagnosis. However, features suggestive of Shprintzen Goldberg syndrome, Loeys-Dietz syndrome, or vascular Ehlers Danlos syndrome must be excluded and appropriate alternative genetic testing (TGFBR1/2, collagen biochemistry, COL3A1, and other relevant genetic testing when indicated and available upon the discovery of other genes) should be performed.
4. **Ectopia lentis AND FBN1 with known Aortic Root Dilatation = Marfan syndrome**. In the presence of ectopia lentis, but absence of aortic root dilatation / dissection, the identification of an FBN1 mutation previously associated with aortic disease is required before making the diagnosis of Marfan syndrome.

In the presence of family history:

5. **Ectopia lentis AND Family History of Marfan syndrome (as defined above) = Marfan syndrome**. The presence of ectopia lentis and a family history of Marfan syndrome (as defined in 1 - 4 above) is sufficient for a diagnosis of Marfan syndrome.
6. **A systemic score ≥ 7 points AND Family History of Marfan syndrome (as defined above) = Marfan syndrome**. A systemic score of greater than or equal to 7 points and a family history of Marfan syndrome (as defined in 1 - 4 above) is sufficient for a diagnosis of Marfan syndrome. However, features suggestive of Shprintzen Goldberg syndrome, Loeys-Dietz syndrome, or vascular Ehlers Danlos syndrome must be excluded and appropriate alternative genetic testing (TGFBR1/2, collagen biochemistry, COL3A1, and other relevant genetic testing when indicated and available upon the discovery of other genes) should be performed.
7. **Aortic Root Dilatation Z score ≥ 2 above 20 yrs. old, ≥ 3 below 20 yrs. old) + Family History of Marfan syndrome (as defined above) = Marfan syndrome**. The presence of aortic root dilatation (Z ≥ 2 above 20 years old, ≥ 3 below 20 years old) and a family history of Marfan syndrome (as defined in 1 - 4 above) is sufficient for a diagnosis of Marfan syndrome. However, features suggestive of Shprintzen Goldberg syndrome, Loeys-Dietz syndrome, or vascular

Ehlers Danlos syndrome must be excluded and appropriate alternative genetic testing (TGFBR1/2, collagen biochemistry, COL3A1, and other relevant genetic testing when indicated and available upon the discovery of other genes) should be performed.

Caveat: Without discriminating features of Shprintzen Goldberg syndrome, Loeys-Dietz syndrome, or vascular Ehlers Danlos syndrome - AND after TGFBR1/2, collagen biochemistry. COL3A1 testing if indicated – other conditions/genes will emerge with time.

Systemic score

Clinical manifestations of MFS in other organ systems were critically evaluated for their specificity and diagnostic utility based on expert opinion and the available literature. Several of the “minor” criteria from the old Ghent nosology were eliminated, but the most selective systemic features were included in the “systemic score”.

Feature	Score
• Wrist AND thumb sign	3
• Wrist OR thumb sign	1
• Pectus carinatum deformity	2
• Pectus excavatum or chest asymmetry	1
• Hindfoot deformity	2
• Plain flat foot	1
• Spontaneous pneumothorax	2
• Dural ectasia	2
• Protucio acetabulae	2
• Scoliosis or thoracolumbar kyphosis	1
• Reduced elbow extension	1
• 3 of 5 facial features	1
• Skin striae	1
• Severe myopia	1
• Mitral valve prolapse	1
• Reduced upper segment / lower segment & increased arm span / height	0

(Online calculators available to score: http://www.marfan.org/dx/score)

*A score of ≥ 7 is considered a positive systemic score.

CARDIAC ASSESSMENT PRIOR TO NON-CARDIAC SURGERY

Not infrequently cardiologists are asked by surgical specialities to provide pre-operative assessment of patients with known or suspected cardiac disease. This is a challenging and controversial field which still requires on-going studies to provide the best advice. The following is based heavily on the latest ESC guidance published in 2014 ([231]) (https://www.escardio.org/Guidelines/Clinical-Practice-Guidelines/ESC-ESA-Guidelines-on-non-cardiac-surgery-cardiovascular-assessment-and-managem
It is also important to emphasise that the pre-operative risk assessment is a multidisciplinary process which should also involve anaesthetists, surgeons and, if appropriate, geriatricians.
Various risk calculators are available online and should help guide whether further cardiovascular assessment or interventions are required prior to surgery.

For estimation of the perioperative risk of myocardial infarction or cardiac arrest ([232]).

http://www.surgicalriskcalculator.com/miorcardiacarrest

The revised cardiac risk index (RCRI), sometimes referred to as the Lee index, was published in 1999 and has been used worldwide since then ([233]). It calculates overall risk of a 'major cardiovascular event after surgery'.

http://www.mdcalc.com/revised-cardiac-risk-index-for-pre-operative-risk/

Many patients with stable heart disease can undergo low and intermediate risk surgery without cardiac evaluation (Table 7). Patients who should be assessed are those with unstable coronary syndromes, decompensated new or worsening heart failure, significant arrhythmias and those with severe valve disease (aortic stenosis with AVA < 1 cm^2 or gradient ≥ 40 mmHg, symptomatic mitral stenosis) ([234]).

Table 7: Surgical risk assessment by type of surgery.

LOW RISK < 1%	INTERMEDIATE RISK 1-5%	HIGH RISK >5%
Superficial surgery	Intraperitoneal: splenectomy, Hiatus hernia, cholecystectomy	Aortic and major vascular surgery
Breast	Symptomatic carotid (CEA)	Open lower limb revasc or amputation / thrombectomy
Dental	Peripheral angioplasty	Duodeno-pancreatic surgery
Thyroid	Endovascular AAA repair	Liver resection, bile duct surgery
Eye	Head and neck surgery	Oesophagectomy
Asymptomatic carotid (CEA)	Hip or spine surgery	Repair of perforated bowel
Minor gynaecology	Urology or gynaecology major	Adrenal resection
Minor orthopaedic	Renal transplant	Cystectomy
Minor urology (TURP)	Intra-thoracic non-major	Pneumonectomy

Cardiac complications after surgery depend on patient related risk factors, the surgery and the urgency. Surgical related factors include invasiveness, duration, blood loss and fluid shifts. All surgery elicits a stress response. Some surgery can also alter the balance between prothrombotic and fibrinolytic factors. There are also anaesthetic considerations.

Vascular Procedures

These carry the highest cardiac risk. Generally speaking endovascular procedures carry a lower cardiac risk than open vascular procedures.

For those at low or intermediate risk, especially for patients are on ***β-blockers*** [235], non-invasive stress testing is of little value [236]. If it is not going to change the management, it should not be undertaken in patients deemed high risk. The main issue is that there is no evidence that revascularisation improves outcomes in patients with stable coronary disease [237;238].

Optimisation of medical therapy has a greater impact than coronary revascularisation in preventing MI in asymptomatic patients. Optimal therapy not only includes the use of ***β-blockers*** but things like control of hypertension, glycaemic control, smoking cessation, ***antiplatelets*** and perhaps most importantly, the use of ***statins***.

There is some evidence that, in those patients in whom they are not contra-indicated (and who are not already established on them), that ***β-blockers*** may reduce risk [239;240]. More recent studies have cast doubt on their routine use [241;242], but the main issues may be selecting an appropriate ***β-blocker*** and not causing excessive bradycardia or hypotension by dose adjustment (heart rate 50-60, systolic >100 mmHg). A reasonable option is to consider ***bisoprolol*** about 4 weeks prior to surgery (dose adjusted) in high risk patients and to continue ***β-blockers*** in those already established on them.

A number of trials, both retrospective and prospective have suggested a significant benefit of employing ***statins*** in patients undergoing vascular surgery [243-247]. ***Statins*** should be employed as soon as possible before surgery and continued in the perioperative period as there is some evidence that abrupt discontinuation may be harmful [248].

The use of ***antiplatelets*** has to be balanced against the bleeding risk of the surgical procedure. For those undergoing angioplasty and stenting procedures either ***aspirin*** alone or combined with ***clopidogrel*** are commonly used. For patients with previous coronary stents see later.

Open Versus Laparoscopic Procedures

Compared with open surgery, cardiac risk in patients with heart failure is not reduced in patients undergoing laparoscopy, and both should be evaluated in the same way. This is a consequence of the impact of the pneumoperitoneum on the vascular system. In patients with coronary disease a laparoscopic procedure may be marginally safer because of the reduced stress of the procedure and propensity to reduced blood loss. This may be particularly true in the elderly [249].

Thoracic surgery

Determination of functional capacity is a pivotal step in the pre-operative cardiac risk assessment in patients undergoing thoracic surgery but not in other forms of non-

cardiac surgery. The greater the functional capacity, the lower the risk and is measured in metabolic equivalents (METs).

One MET equals the basal metabolic rate. Exercise testing provides an objective assessment of functional capacity. Without testing, functional capacity can be estimated from the ability to perform the activities of daily living. One MET represents metabolic demand at rest; climbing two flights of stairs demands 4 METs, and strenuous sports, such as swimming, 10 METS. The inability to climb two flights of stairs or run a short distance (< 4 METs) indicates poor functional capacity and is associated with an increased incidence of post-operative cardiac events.

Cardiac Investigations

Generally speaking a 12 lead ECG is only of value in patients with risk factors undergoing intermediate or high risk surgery. Useful however to compare with a post-operative ECG if an event occurs.

A transthoracic echo is reasonable to consider in patients undergoing high risk surgery. Pre-operative LV systolic dysfunction, moderate-to-severe mitral regurgitation, and increased aortic valve gradients are associated with major cardiac events [250].

Treadmill testing is of limited value (especially in those with a poor exercise capacity) although gives an idea of functional status - which is itself related to perioperative risk in thoracic surgical procedures (see above). For other non-cardiac procedures, functional status is of limited value apart from when functional status is excellent. For the latter group, prognosis is excellent even in the presence of coronary disease.

A more accurate evaluation of ischaemia is of course achieved with functional imaging (MPS, DES, stress perfusion CMR). The problem is that, although you can identify patients at higher risk (those with a higher ischaemic burden), there is little evidence that revascularisation is of benefit [237;238]. The use of ***β-blockers*** in high risk (NOT low risk) patients may be of benefit but they should be started a few days before surgery to confirm safety and tolerability.

The indications for performing coronary angiography should generally be made using the same criteria as for patients in a non-surgical setting.

Surgery in patients who have had previous PCI

Elective surgery should be postponed for a minimum of 4 weeks and ideally for up to 3 months after elective BMS implantation [251]. Importantly, whenever possible, ***aspirin*** should be continued throughout surgery.

For the newer generation DES, DAPT no longer has to continue for 12 months. The general aim should be to continue DAPT for 6 months after new DES implants [252], but to continue ideally for a year <u>following a presentation with ACS</u> (including when a BMS has been employed) [253].

Clearly the risk of acute stent thrombosis needs to be weighed against the risk of postponing surgery.

Elective surgery should be delayed for at least 60 days after MI.

Surgery in patients on warfarin

In patients who require continued ***anticoagulation*** (CHA_2DS_2-VASc ≥ 4 in atrial fibrillation; mechanical heart valves; recent mitral valve repair, ≤ 3 months; recent

venous thromboembolism ≤ 3 months or thrombophilia), stopping ***anticoagulation*** is dangerous. Bridging therapy with either ***UFH*** or therapeutic ***LMWH*** is indicated. In patients on ***warfarin***, the drug should be stopped 3 - 5 days before surgery with daily INR levels, and ***UFH*** or ***LMWH*** commenced when the INR is < 2. Generally ***LMWH*** should be started about 48 hours after the last dose of ***warfarin***. The INR should be < 1·5 for surgery. ***Enoxaparin*** is the ***LMWH*** of choice and should be administered in therapeutic doses (100 IU/kg BD).

LMWH should be omitted 24 hours surgery.

After surgery at least 12 hours should pass before bridging is recommenced. ***Warfarin*** can be started 1 - 2 days after surgery dependent on the haemostatic situation, with the pre-operative maintenance dose plus a boosting dose of 50% for the first two days. Bridging should continue until therapeutic INR levels are achieved.

For the ***DOACs***, the recommendation is to stop ***DOACs*** for 2 - 3 times their respective biological half-lives prior to surgery in surgical interventions with 'normal' bleeding risk, and 4 - 5 times the biological half-lives before surgery in surgical interventions with high bleeding risk. The median half-life of ***rivaroxaban*** is 7-11 hours (marginally longer in the elderly), for ***apixaban*** is 12 hours, for ***dabigatran*** is 12-14 hours. Bridging is often unnecessary unless surgery is likely to be delayed for several days and thrombotic risk is high. Because of their rapid onset of action, recommencement should be at least 1 - 2 days and possibly longer if bleeding risk is high.

Revascularisation prior to planned surgery

As stated previously, there is no difference in terms of the decision to arrange revascularisation between patients undergoing surgery and those in the non-surgical setting [237;238]. The CARP study published in 2004 found that prophylactic revascularisation before vascular surgery did not improve outcomes [237].

In a more recent meta-analysis, asymptomatic patients or those with stable coronary disease, prophylactic coronary angiography - and, if needed, revascularisation before non-cardiac surgery does not confer any beneficial effects as compared with optimal medical management in terms of perioperative mortality, myocardial infarction, long-term mortality, and adverse cardiac events [254].

Surgery in patients with heart failure

Patients with heart failure have a significantly higher per-operative risk. Optimisation of heart failure medications is crucial. NT-proBNP measurements can guide the level of risk and is further enhanced by acquiring a sample post-operatively [255]. Pre-operative echo is not crucial if previous investigations have confirmed persistently poor LV function.

All heart failure medications should ideally be continued through surgery with very careful evaluation of fluid status and the avoidance of hypotension. Certainly ***β-blockers*** should be given whereas ***ACEI/ARBs*** may be omitted on the day of surgery taking the blood pressure into account. Minimal disruption to the normal regime is desirable dependent upon the haemodynamic status. Close attention to fluid balance is crucial.

Surgery in patients with severe valvular heart disease

In patients with severe aortic stenosis (as defined previously page 165), procedures should be performed under more invasive haemodynamic monitoring, avoiding rapid changes in volume status and heart rhythm as far as possible. In symptomatic patients, consideration to valve replacement prior to planned surgery is recommended.

In patients with mitral stenosis avoidance of tachycardia and attentive attention to fluid status is important. New atrial fibrillation in this context can cause serious compromise. In asymptomatic patients with significant mitral stenosis and systolic pulmonary artery pressure > 50 mm Hg, and in symptomatic patients, intervention to the mitral valve should be seriously considered.

In asymptomatic patients with severe aortic or mitral regurgitation, surgery is usually quite safe. Symptomatic patients - and those who are asymptomatic with severely impaired LVEF (<30%) - are at high risk. Optimisation of medication is indicated along with consideration of valve intervention before planned surgery.

Surgery in patients with pacemakers and ICDs

The use of unipolar electrocautery represents a significant risk, as the electrical stimulus from may inhibit 'demand' pacemakers, or may reprogramme the pacemaker. These problems can be avoided or minimised by using bipolar electrocautery, correct positioning the ground plate for the electrical circuit, keeping the electrocautery device away from the pacemaker, giving only brief bursts, and using the lowest possible amplitude. The pacemaker should be set in an asynchronous or non-sensing mode in patients who are pacemaker-dependent. This is most easily done in the operating room by placing a magnet on the skin over the pacemaker.

Interference with the function of ICDs can also occur during non-cardiac surgery as a result of electrocautery. The ICD should be turned off during surgery and switched on in the recovery phase before discharge to the ward. The defibrillator function of an ICD can be temporarily deactivated by placing a magnet on the skin over the ICD. While the device is deactivated, an external defibrillator should be immediately available.

Assessment of potential renal transplant patients

Patients with advanced renal failure, especially those with diabetes, are at high risk of IHD. In patients with multiple additional risk factors or documented disease, non-invasive testing is usually considered. DSE and MPS are the tests most commonly employed. DSE may be marginally better [256]. Angiography remains the gold standard but in patients not yet undergoing dialysis the risk of precipitating the need for immediate dialysis is high. This needs to be explained carefully to the patient as they may wish to defer going onto the transplant list until they are undergoing dialysis.

CARDIAC SURGERY

For patients selected for in-patient cardiac surgery pre-operative management will usually be largely dictated by the cardiac surgeons themselves. A few issues need to be considered.

Many patients referred for bypass surgery will be taking ***antiplatelets***. Most surgeons are happy to operate on patients taking ***aspirin***, and many are happy with ***clopidogrel*** but ASK. ***Ticagrelor*** is associated with significant bleeding risk and should definitely be discontinued for at least 4 - 5 days pre-op.

Ensure patients are cross-matched for four units prior to surgery.

Many patients will require carotid duplex scans prior to surgery particularly those with a prior history of stroke/TIA or with carotid bruits. A carotid stenosis of 50-69% or greater should be considered for endarterectomy, over 70% endarterectomy is generally recommended. In asymptomatic patients, men with bilateral 70-99% stenoses should be discussed with vascular surgery.

Patients referred for valve surgery should have their dental hygiene status reviewed.

The risks of cardiac surgery obviously need to be discussed with patients. A risk score (EuroSCORE II) is also available online: http://www.euroscore.org/calc.html. An alternative is the STS risk score: http://riskcalc.sts.org/stswebriskcalc/#/calculate.

Post-operative atrial fibrillation

Atrial fibrillation (AF) occurs quite commonly following cardiac surgery and is associated with increased LOS and a poorer long-term prognosis ([257]). Risk factors include: increasing age, previous history of AF, mitral valve disease (particularly mitral stenosis), increased left atrial size or cardiomegaly, COPD, diabetes, Caucasian race, obesity, absence of ***β-blockers*** or ***ACEI*** treatment (or withdrawal of previous treatment), severe right coronary artery stenosis, hypokalaemia and hypomagnesaemia.

AF occurs in 15 to 40% of patients in the early postoperative period following CABG, in 37 to 50% after valve surgery, and in as many as 60% undergoing valve replacement plus CABG. The incidence increases with increasing age.

Atrial arrhythmias occur most often within the first few days after surgery. Almost half of patients with AF had more than one episode. Among patients with post-op AF who have no prior history of atrial arrhythmias, the AF is usually self-limited, as 15 to 30% convert within two hours and up to 80% in 24 hours. The mean duration of AF in one report was 11 to 12 hours and more than 90% are in sinus rhythm six to eight weeks following surgery.

AF may also occur late after cardiac surgery and the incidence is likely higher than appreciated because many patients may have continued asymptomatic episodes of AF. Atrial flutter is relatively uncommon compared to AF.

β-blocker administration is the most widely used prophylactic strategy based on numerous studies showing benefit, ease of use, and cost considerations. The benefit is seen when ***β-blockers*** are begun prior to or immediately after surgery.

The optimal duration of therapy for prevention of postoperative atrial arrhythmias is uncertain. However, many patients who undergo CABG have a clear indication for the long-term use of ***β-blocker*** therapy (eg, previous MI, LVSD, or hypertension).

While prevention with ***β-blockers*** lowers the risk of postoperative AF, many patients still develop AF. Initial management should include correction of predisposing factors such as hypoxaemia, electrolyte abnormalities, and haemodynamic instability as well as pain management and withdrawal of stimulating factors such as inotropic agents. Subsequent management relates to the issues of rate control, cardioversion, and ***anticoagulation***.

Given the transient nature of the arrhythmia, initial control of the ventricular response rate is an effective and relatively safe strategy, compared to early cardioversion, in patients who develop postoperative AF. Rate control is most commonly achieved with ***β-blockers***. Slowing of the ventricular rate in many AF patients receiving inotropic agents post-op can be achieved by lowering the dose or discontinuation of these agents. The optimal rate goal is a ventricular rate of less than 100-110 bpm will prevent symptoms such as palpitations and allow for optimal cardiac performance.

Cardioversion from well tolerated postoperative AF is usually not necessary because of the high early recurrence rate and the eventual self-limited course. Cardioversion may be indicated in highly symptomatic patients or in those when rate control is difficult to achieve. In addition, cardioversion in asymptomatic patients may be reasonable when well tolerated AF occurs near the time of anticipated hospital discharge or when it does not spontaneously terminate within 24 hours, so that oral ***anticoagulation*** can be avoided. ***Amiodarone*** is over used in this setting.

For patients with multiple episodes of AF or where AF persists for more than 24 hours, ***anticoagulation*** is indicated.

DRIVING AND CARDIOVASCULAR DISEASES

In the following table, Group 1 entitlement refers to an ordinary driving licence (car and motorcycle), Group 2 entitlement refers to HGV/PSV (bus and lorry) driving. The following guidelines were as stated on the official DVLA website in November 2017. If there is any doubt about a patient's eligibility to drive, the patient should be advised to contact the DVLA Medical Adviser.

Website: www.dft.gov.uk/dvla/medical/ataglance.aspx

EXERCISE TESTING

Exercise evaluation for DVLA purposes shall be performed on a bicycle* or treadmill. Drivers should be able to complete 3 stages of the standard Bruce protocol or equivalent safely, free from signs of cardiovascular dysfunction (angina, syncope, hypotension, sustained VT, and/or ST segment shift which accredited medical opinion interprets as being indicative of ischaemia (usually > 2 mm horizontal or down-sloping) during exercise or the recovery period. In the presence of established coronary disease, exercise evaluation shall be required at regular intervals not to exceed 3 years.

* Cycling for 10 minutes with 20 watt increments/minute to a total of 200W

Medication no longer needs to be discontinued for the test.

Should atrial fibrillation develop de novo during exercise testing, the licensing requirements will be the same as for individuals with pre-existing atrial fibrillation – that is, provided all the DVLA exercise tolerance test criteria above are met, licensing will be subject to echocardiogram and confirmation of left ventricular ejection fraction of at least 40%.

STRESS MYOCARDIAL PERFUSION SCAN OR STRESS ECHOCARDIOGRAPHY

When the DVLA requires these imaging tests, the relevant licensing standards are as follows, provided the LV ejection fraction is 40% or more:

- no more than 10% of the myocardium is affected by reversible ischaemic change on myocardial perfusion imaging or
- no more than one segment is affected by reversible ischaemic change on stress echocardiography.

CORONARY ANGIOGRAPHY

For licensing purposes, the DVLA considers functional implication to be more predictive than anatomical findings in coronary artery disease. 'Predictive' refers to the risk of an infarct within 1 year. Grafts are considered as 'coronary arteries'.

For this reason, exercise tolerance testing and, where necessary, myocardial perfusion imaging or stress echocardiography are the investigations of relevance (outlined above) with the standards as indicated to be applied.

Angiography is therefore not commissioned by the DVLA.

If there is a conflict between the results of the functional test and a recent angiography, the case will be considered individually. Licensing will not normally be granted, however, unless the coronary arteries are unobstructed or the stenosis is not flow-limiting. The LV ejection fraction must also be at least 40%.

HYPERTROPHIC CARDIOMYOPATHY AND EXERCISE TOLERANCE TESTING

For the purpose of assessing hypertrophic cardiomyopathy, the DVLA would consider an exercise tolerance test (see above) falling short of 9 minutes acceptable provided:

- there is no obvious cardiac cause for stopping the test in under 9 minutes
- there is a rise of at least 25mm Hg in systolic blood pressure during exercise testing
- all other requirements are met as outlined under hypertrophic cardiomyopathy

MARFAN SYNDROME: AORTIC ROOT REPLACEMENT

The DVLA will refuse or revoke a licence if there has been:

- emergency aortic root surgery
- elective aortic root surgery associated with complications or high risk factors – for example, aortic root, valve and arch (including de-branching) surgery, external aortic support operation. A bus or lorry licence for annual review may be issued in elective aortic root replacement surgery provided:
- surgery is successful without complications
- there is satisfactory regular specialist follow-up
- no evidence of suture-line aneurysm postoperatively and on 2-yearly MRI or CT surveillance following valve-sparing surgery for root replacement plus valve replacement.

SEVERE AORTIC STENOSIS

'Severe' is defined (European Society of Cardiology guidelines) as:

- aortic valve area – less than 1 cm^2 or – less than 0·6 cm^2/m^2 body surface area (BSA)
- mean aortic pressure gradient – greater than 40mmHg
- maximum jet velocity – greater than 4 metres/second.

KEY:

Must not drive
Might be allowed to drive subject to medical advice and/or notifying the DVLA
May drive and need not notify the DVLA

	GROUP 1 ENTITLEMENT	GROUP 2 ENTITLEMENT
ANGINA	Must not drive when symptoms occur: • at rest • with emotion • at the wheel Driving may resume after satisfactory symptom control. Need not notify the DVLA.	Must notify the DVLA. Must not drive when symptoms occur. A licence will be refused or revoked if symptoms continue (treated or untreated). May be relicensed/licensed (provided there is no other disqualifying condition) if: • no angina for at least 6 weeks • the requirements for exercise or other functional tests can be met
PCI (elective)	Must not drive for at least 1 week but need not notify the DVLA. Driving may resume after 1 week provided there is no other disqualifying condition.	Must not drive and must notify the DVLA. Licence will be refused or revoked. May be relicensed/licensed after at least 6 weeks if: • the requirements for exercise or other functional tests can be met • there is no other disqualifying condition.
ACUTE CORONARY SYNDROMES including MYOCARDIAL INFARCTION	Must not drive but need not notify the DVLA. Driving may resume 1 week after ACS if successful coronary angioplasty and if: • no other urgent revascularisation planned (urgent means within 4 weeks of acute event) • LV ejection fraction is at least 40% before hospital discharge • there is no other disqualifying condition. If not treated by successful coronary angioplasty, driving may resume only after 4 weeks from the acute event, provided there is no other disqualifying condition.	Must not drive and must notify the DVLA – for all ACS. Licence will be refused or revoked. May be relicensed/licensed after at least 6 weeks if: • the requirements for exercise or other functional tests can be met • there is no other disqualifying condition.
CABG	Must not drive for at least 4 weeks but need not notify the DVLA. Driving may resume after 4 weeks provided there is no other disqualifying condition.	Must not drive and must notify the DVLA. Licence will be refused or revoked. May be relicensed/licensed after 3 months if: • LV ejection fraction is at least 40% • the requirements for exercise or other functional tests can be met postoperatively • there is no other disqualifying condition.

	GROUP 1 ENTITLEMENT	GROUP 2 ENTITLEMENT
ARRHYTHMIA	Must not drive if arrhythmia has caused or is likely to cause incapacity and may need to notify the DVLA. Driving may resume without DVLA notification only after: • underlying cause has been identified • arrhythmia is controlled for at least 4 weeks. • Must notify the DVLA if there are distracting or disabling symptoms.	Must notify the DVLA. Must not drive if arrhythmia has caused or is likely to cause incapacity. Licence will be refused or revoked. May be relicensed/licensed (provided there is no other disqualifying condition) only after: • ■ underlying cause has been identified • ■ arrhythmia has been controlled for at least 3 months • ■ LV ejection fraction is at least 40%.
PACEMAKER IMPLANT **Includes box change**	Must not drive for at least 1 week and must notify the DVLA. Driving may resume after 1 week provided there is no other disqualifying condition.	Must not drive for at least 6 weeks and must notify the DVLA. Driving may resume after 6 weeks provided there is no other disqualifying condition.
SUCCESSFUL CATHETER ABLATION For arrhythmia causing or likely to cause incapacity	Must not drive for at least 2 days but need not notify the DVLA. Driving may resume after 2 days provided there is no other disqualifying condition.	Must not drive and must notify the DVLA. Driving may resume after 6 weeks provided there is no other disqualifying condition.
ICD implanted for sustained ventricular arrhythmia associated with incapacity		
Without further sequelae	Must not drive and must notify the DVLA. Driving may resume after 6 months following implantation – except that any of the sequelae 1-4 below require further specific restrictions and may require notification to the DVLA.	Must not drive and must notify the DVLA. Licence will be refused or revoked permanently.
1. **With any shock therapy and/or symptomatic anti-tachycardia pacing**	Must not drive for 6 months from the time of any shock therapy and/or symptomatic anti-tachycardia pacing. Must notify the DVLA.	Must not drive and must notify the DVLA. Licence will be refused or revoked permanently

	GROUP 1 ENTITLEMENT	GROUP 2 ENTITLEMENT
2. **With incapacity following implantation or therapy** (whether incapacity caused by device or arrhythmia)	Must not drive and may need to notify the DVLA. Must not drive for 2 years after symptoms of incapacity and must notify the DVLA. Exceptions to this 2 year requirement apply as follows, but the minimum initial restriction of 6 months off driving after implantation still applies. A). If therapy delivery was due to an inappropriate cause such as atrial fibrillation or, programming issues: • driving may resume 1 month after complete control of any cause to the satisfaction of the cardiologist. The DVLA need not be notified. B). If therapy delivery was due to sustained ventricular tachycardia or ventricular fibrillation: • driving may resume 6 months after event • provided preventive steps against recurrence have been taken with anti-arrhythmic drugs or ablation procedure, for example • and provided there is an absence of further symptomatic therapy.	Must not drive and must notify the DVLA. Licence will be refused or revoked permanently.
3. With any revision of electrodes or alteration of anti-arrhythmic drug treatment	Must not drive for 1 month but need not notify the DVLA. Driving may resume 1 month after electrode revision or drug alteration.	Must not drive and must notify the DVLA. Licence will be refused or revoked permanently
4. With defibrillator box change	Must not drive for 1 week but need not notify the DVLA. Driving may resume 1 week after box change.	Must not drive and must notify the DVLA. Licence will be refused or revoked permanently.

	GROUP 1 ENTITLEMENT	GROUP 2 ENTITLEMENT
ICD implanted for sustained ventricular arrhythmia NOT associated with incapacity	Must not drive for 1 month following implantation and must notify the DVLA. Driving may resume 1 month after implantation provided: • presentation was a 'non-disqualifying' cardiac event – i.e. haemodynamically stable sustained ventricular tachycardia without incapacity • LV ejection fraction is greater than 35% • no fast ventricular tachycardia (VT) induced on electrophysiological study – i.e. RR interval of less than 250 milliseconds • during the postimplantation study, any induced VT could be paceterminated by the ICD twice, without acceleration. **Note**: should ICD subsequently deliver anti-tachycardia pacing and/or shock therapy (except during normal clinical testing), the DVLA must be notified and the restrictions must be applied as for sustained ventricular arrhythmia associated with incapacity.	Must not drive and must notify the DVLA. Licence will be refused or revoked permanently
Prophylactic ICD		
In asymptomatic individuals with a high risk of significant arrhythmia	Must not drive for 1 month following implantation and must notify the DVLA: • driving may resume 1 month after implantation if remain asymptomatic and no ICD therapy needed • should the ICD subsequently deliver symptomatic anti-tachycardia pacing and/or shock therapy (except during normal clinical testing), the DVLA must be notified and the restrictions must be noted as for sustained ventricular arrhythmia associated with incapacity.	Must not drive and must notify the DVLA. Licence will be refused or revoked permanently.

	GROUP 1 ENTITLEMENT	GROUP 2 ENTITLEMENT
Hypertension	May drive and need not notify the DVLA, except: Must not drive if treatment for any level of hypertension causes side-effects that affect or are likely to affect safe driving (but need not notify the DVLA).	May drive and need not notify the DVLA, except: Must not drive and must notify the DVLA if resting BP is consistently: • 180mm Hg or higher systolic and/or • 100mm Hg or more diastolic. May be relicensed/licensed after BP is controlled, provided there are no side-effects from treatment that affect or are likely to affect safe driving.
Peripheral arterial disease	May drive and need not notify the DVLA. There must be no other disqualifying condition.	May drive but must notify the DVLA. May be relicenced/licensed only if: • there is no symptomatic myocardial ischemia, and • the exercise or other functional test requirements can be met.
Aortic aneurysm – ascending or descending thoracic and/or abdominal	May drive and need not notify the DVLA if aneurysm diameter is **less than 6cm**. May drive but must notify the DVLA if aneurysm diameter is **between 6cm and 6.4cm**. May be relicensed/licensed subject to annual review. Must not drive and must notify the DVLA if aneurysm diameter **is 6.5cm or greater**. Licence will be refused or revoked. May be relicenced/licensed after successful surgical treatment without evidence of further enlargement and no other disqualifying condition. In cases of bicuspid aortopathy, maximum aortic diameter should be less than 6.5cm.	May drive if the aneurysm diameter **is less than 5.5cm**. Must notify the DVLA. Must not drive and must notify the DVLA if the aneurysm diameter **is greater than 5.5cm**. Licence will be refused or revoked. May be relicenced/licensed after successful surgical treatment without evidence of futher enlargement and no other disqualifying condition. Note: the exercise or other functional test requirements will need to be met in case of abdominal aortic aneurysm. May drive and may need to notify the DVLA – see following. In cases of bicuspid aortopathy, maximum aortic diameter should be less than 5.5cm provided there is no associated aortic coarctation, systemic hypertension, family history of aortic dissection and aneurysmal growth no greater than 3mm per annum. If any of the above apply, the maximum aortic diameter allowed would be less than 5cm.

	GROUP 1 ENTITLEMENT	GROUP 2 ENTITLEMENT
Aortic dissection	Must not drive. Must notify the DVLA if aortic diameter greater than 6cm. Driving may resume only after satisfactory surgical intervention and/or: • satisfactory medical therapy (blood pressure well controlled) • medical follow-up (chronic dissection) • no other disqualifying condition. If aortic diameter is 6 cm or greater, the driving restrictions given under aortic aneurysm (see above) must take effect, with the DVLA notified.	Must not drive and must notify the DVLA. Licence will be refused or revoked. May be relicensed/licensed only after satisfactory surgical intervention and/ or all the following are met: • satisfactory medical therapy (blood pressure well controlled) • if chronic aortic dissection maximum transverse diameter of the aorta is less than 5.5cm (including the false lumen/thrombosed segment) • complete thrombosis of the false lumen • medical follow up in place.
Marfan syndrome and other inherited aortoathies	May drive and need not notify the DVLA if no aneurysm. If there is an aortic aneurysm must notify the DVLA and must not drive if aortic diameter greater than 5cm.	Must notify the DVLA. Must not drive if maximum aortic diameter greater than 5cm or associated with severe aortic regurgitation. Licence will be revoked/ refused. Relicensing will be considered only if: • maximum aortic diameter is less than 5cm • no family history of aortic dissection • no severe aortic regurgitation • is under annual cardiac review to include aortic root measurement. If there is a family history of dissection, relicensing will only be allowed if aortic diameter is less than 4.5cm. Aortic root replacement – debarred if emergency aortic root surgery. Elective aortic root surgery – individual assessment. For aortic root replacement, driving may be relicensed after an individual assessment.

	GROUP 1 ENTITLEMENT	GROUP 2 ENTITLEMENT
NOTE: the DVLA bars Group 2 bus and lorry licensing whenever left ventricular ejection fraction is less than 40%		
Dilated cardiomyopathy – asymptomatic (See also arrhythmia, pacemaker, ICD and heart failure sections)	May drive and need not notify the DVLA. There must be no other disqualifying condition.	May drive but must notify the DVLA. There must be no other disqualifying condition.
Dilated cardiomyopathy – symptomatic (See also arrhythmia, pacemaker, ICD and heart failure sections)	May drive and need not notify the DVLA. There must be no other disqualifying condition (must meet all other standards e.g. angina arrhythmia).	Must not drive and must notify the DVLA. Driving may be relicensed if there is no other disqualifying condition.
Hypertrophic cardiomyopathy (HCM) - asymptomatic (See also arrhythmia, pacemaker and ICD sections)	May drive and need not notify the DVLA. There must be no other disqualifying condition.	Must not drive and must notify the DVLA. Must not drive if in the High Risk group (as per ESC HCM Risk-SCD calculator) and/or if ICD is indicated/implanted. If in the Low Risk or Intermediate Risk group licensing will be permitted if the exercise tolerance test requirements are met. May be relicensed/licensed only after at least a 25mm Hg increase in systolic blood pressure during exercise testing (testing to be repeated every 3 years) has been demonstrated **and at least two** of the following three criteria are met: 1. no first-degree family history of sudden premature death from presumed HCM 2. HCM not anatomically severe – wall thickness no greater than 3cm confirmed by cardiologist 3. no serious abnormality of heart rhythm such as non-sustained ventricular tachycardia (NSVT).
Hypertrophic cardiomyopathy (HCM) – symptomatic (See also arrhythmia, pacemaker and ICD sections)	May drive and need not notify the DVLA. There must be no other disqualifying condition (must meet all other relevant standards e.g. angina, arrhythmia).	Must not drive and must notify the DVLA. Licence will be refused or revoked. Relicensing will be considered once symptoms are satisfactorily controlled and the criteria for asymptomatic HCM met as detailed above. If there is a history of associated syncope the standards for syncope need to be met in addition.

	GROUP 1 ENTITLEMENT	GROUP 2 ENTITLEMENT
Arrhythmogenic right ventricular cardiomyopathy – and allied disorders	**Asymptomatic:** May drive and need not notify the DVLA. **Symptomatic**: Must not drive and must notify the DVLA if arrhythmia has caused or is likely to cause incapacity. May be relicensed/licensed once arrhythmia is controlled, provided there is no other disqualifying condition.	**Asymptomatic:** Must not drive and must notify the DVLA. May be relicensed/licensed following specialist EP assessment, provided there is no other disqualifying condition. **Symptomatic**: Must not drive and must notify the DVLA. Licence will be refused or revoked. Relicensing may be permitted if: • the applicant is on treatment • the applicant has remained asymptomatic for a period of 1 year and • the applicant remains under regular specialist electrophysiological review. A 1–3 year licence may be considered if the specialist electrophysiological review is satisfactory.
Heart failure	**Asymptomatic:** May drive and need not notify the DVLA. **Symptomatic**: Must not drive if there are any symptoms likely to distract the driver or otherwise affect safe driving but need not notify the DVLA.	**Asymptomatic:** May drive and need not notify the DVLA. **Symptomatic**: Must not drive and must notify the DVLA. Licence will be refused or revoked. Relicensing would require: • LV ejection fraction at least 40% • no other disqualifying condition. Depending on likely cause for heart failure, exercise or other functional testing for heart failure may be required
Left ventricular assist device implanted	Must not drive and must notify the DVLA. Driving may be relicensed under individual assessment only after 3 months from implantation.	Must not drive and must notify the DVLA. Licence will be refused or revoked permanently
CRT pacemaker	Must not drive for 1 week and must notify the DVLA. Driving may resume after at least 1 week following implantation if: • there are no symptoms likely to affect safe driving • there is no other disqualifying condition.	Must not drive and must notify the DVLA. Driving may resume after at least 6 weeks following implantation if: • the requirements under heart failure section (see above) are met • there is no other disqualifying condition.

	GROUP 1 ENTITLEMENT	GROUP 2 ENTITLEMENT
CRT defibrillator	May drive subject to following provisions being met but must notify the DVLA. Provisions: • the requirements under implantable cardioverter defribillator (ICD) are met • there is no other disqualifying condition.	Must not drive and must notify the DVLA. Licence will be refused or revoked permanently
Heart transplant – including heart and lung transplant	Must not drive for at least 6 weeks after surgery. Need not notify the DVLA. There must be no other disqualifying condition.	Must not drive for at least 3 months following surgery and must notify the DVLA. May be relicensed after 3 months provided: • remains asymptomatic • any exercise or other functional testing requirements from the DVLA are met • LV ejection fraction at least 40% • there is no other disqualifying condition.
Heart valve disease	**Asymptomatic:** May drive and need not notify the DVLA. There must be no other disqualifying condition. **Symptomatic**: May drive and need not notify the DVLA. There must be no other disqualifying condition. May be licensed/relicensed if there are no other disqualifying conditions and free of symptoms.	**Asymptomatic:** May drive and need not notify the DVLA. There must be no other disqualifying condition. **Symptomatic**: Must not drive and must notify the DVLA. If there is cerebral embolism, relicensing may be after 12 months and following specialist assessment required by the DVLA to determine fitness.
Heart valve surgery – including transcatheter aortic valve implantation and other cardiac or pulmonary percutaneous devices	Must not drive for at least 4 weeks but need not notify the DVLA. Driving may resume only after at least 4 weeks, provided there is no other disqualifying condition.	Must not drive for at least 3 months and must notify the DVLA. May be relicensed/licensed only after at least 3 months, provided: • no evidence of significant left ventricular impairment – that is, LV ejection fraction at least 40% • no ongoing symptoms • no other disqualifying condition.

	GROUP 1 ENTITLEMENT	GROUP 2 ENTITLEMENT
Aortic stenosis (to include sub-aortic and supra-aortic stenosis)	**Asymptomatic:** May drive and need not notify the DVLA. **Symptomatic**: Must not drive and must notify the DVLA. Licence will be refused or revoked pending assessment and treatment.	**Asymptomatic:** Must not drive and must notify the DVLA. If, although asymptomatic, aortic stenosis is severe, an annual review licence may be issued, provided: • the exercise tolerance test requirements from the DVLA are met (see Appendix C, page 118) • there is satisfactory medical follow-up. Licensing will be refused if: • during an exercise test symptoms develop, blood pressure falls or there is sustained arrhythmia • a cardiologist considers that exercise testing would be unsafe for the individual • a test is not possible for any other reason. **Symptomatic**: Must not drive and must notify the DVLA. Licence will be refused or revoked pending assessment and treatment.
Congenital heart disease (CHD) – Asymptomatic	May drive and need not notify the DVLA if completely asymptomatic and does not fall under any other category which requires notification to the DVLA.	May drive but must notify the DVLA. Licence will be refused or revoked if CHD is complex or severe. Otherwise, the DVLA may issue a licence subject to medical review at 1, 2 or 3 years, depending on specialist assessment and provided there is: • minor disease • successful repair of defects or relief of valvular problems, fistulae and so on • no other disqualifying condition.

	GROUP 1 ENTITLEMENT	GROUP 2 ENTITLEMENT
Congenital heart disease (CHD) – Symptomatic	Must not drive and must notify the DVLA. Symptoms include angina, arrhythmias/palpitations, dyspnoea, uncontrolled hypertension, symptomatic heart failure, symptomatic heart valve disease. For patients with congenital heart disease who have had ablation, pacemaker including CRT, ICD, heart valve intervention (surgical or percutaneous) or percutaneous cardiac/pulmonary devices (ASD/ VSD/coarctation/MAPCAs/pulmonary systemic shunts etc). If symptoms develop after being asymptomatic or if fall under any other category which requires notification to the DVLA. Individual assessment of symptomatic cases. Certain conditions may require a medical review licence to be issued for 1,2, or 3 years. The DVLA may require specialist assessment to issue a licence, which may be subject to medical review at 1,2, or 3 years. There must be no disqualifying condition.	Must not drive and must notify the DVLA. Licence will be refused or revoked if CHD is complex or severe. Otherwise, the DVLA may issue a licence subject to medical review at 1, 2 or 3 years, depending on specialist assessment and provided there is: • minor disease • successful repair of defects or relief of valvular problems, fistulae and so on • no other disqualifying condition.
ECG abnormality – suspected myocardial infarction	May drive and need not notify the DVLA. There must be no other disqualifying condition.	Must not drive and must notify the DVLA. May be relicensed/licensed only after at least 3 months, provided: • exercise or other functional test requirements from the DVLA are met • there is no other disqualifying condition
Left bundle branch block	May drive and need not notify the DVLA. There must be no other disqualifying condition.	May drive but must notify the DVLA. May be relicensed/licensed if: • myocardial perfusion scan or stress echocardiography requirements from the DVLA are met • there is no other disqualifying condition.
Pre-excitation	May drive and need not notify the DVLA. There must be no other disqualifying condition.	May drive and need not notify the DVLA, except: If associated with arrhythmia must meet the relevant requirements. There must be no other disqualifying condition.

LOSS OF CONSCIOUSNESS (SOLITARY EPISODE)

	GROUP 1 ENTITLEMENT	GROUP 2 ENTITLEMENT
Typical vasovagal syncope		
While standing While sitting	May drive and need not notify the DVLA. May drive and need not notify the DVLA if there is an avoidable trigger which will not occur whilst driving. Otherwise must not drive until annual risk of recurrence is assessed as below 20%.	Must not drive and must notify the DVLA. Must not drive for 3 months and must notify the DVLA. Will require investigation for identifiable and/or treatable cause.
Syncope with avoidable trigger whilst driving or otherwise reversible cause		
While standing While sitting	May drive and need not notify the DVLA. Must not drive for 4 weeks. Driving may resume after 4 weeks only if the cause has been identified and treated. Must notify the DVLA if the cause has not been identified and treated.	Must not drive and must notify the DVLA. Must not drive for 3 months. Driving may resume after 3 months only if the cause has been identified and treated. Must notify the DVLA if the cause has not been identified and treated.
Unexplained syncope, including syncope without reliable prodrome (no cardiac abnormality)		
While standing or sitting	Must not drive and must notify the DVLA. If no cause has been identified, the licence will be refused or revoked for 6 months.	Must not drive and must notify the DVLA. If no cause has been identified, the licence will be refused or revoked for 12 months.
Cardiovascular, excluding typical syncope		
While standing or sitting	Must not drive and must notify the DVLA. Driving may be allowed to resume after 4 weeks if the cause has been identified and treated. If no cause has been identified, the licence will be refused or revoked for 6 months.	Must not drive and must notify the DVLA. Driving may be allowed to resume after 3 months if the cause has been identified and treated. If no cause has been identified, the licence will be refused or revoked for 12 months.
Blackout with seizure markers		
While standing or sitting	Must stop driving and notify the DVLA. 6 months off driving from the date of the episode. If there are factors that would lead to an increased risk of recurrence, 1 year off driving would be required	Must stop driving and notify the DVLA. 5 years off driving from the date of the episode

LOSS OF CONSCIOUSNESS (RECURRENT EPISODES)

	GROUP 1 ENTITLEMENT	GROUP 2 ENTITLEMENT
Typical vasovagal syncope with identifiable consistent prodrome		
While standing	May drive and need not notify the DVLA.	Must not drive and must notify the DVLA.
While sitting	Must not drive and must notify the DVLA. Must not drive until annual risk of recurrence is assessed as below 20%. May drive and need not notify the DVLA if there is an avoidable trigger which will not occur whilst driving. Otherwise must not drive until annual risk of recurrence is assessed as below 20%.	Must not drive and must notify the DVLA. Must not drive until annual risk of recurrence is assessed as below 2%. Will require investigation for identifiable and/or treatable cause.
Syncope with avoidable trigger whilst driving or otherwise reversible cause		
While standing	May drive and need not notify the DVLA.	Must not drive and must notify the DVLA.
While sitting	Must not drive for 4 weeks. Driving may resume after 4 weeks only if the cause has been identified and treated. Must notify the DVLA if the cause has not been identified and treated.	Must not drive for 3 months. Driving may resume after 3 months only if the cause has been identified and treated. Must notify the DVLA if the cause has not been identified and treated.

	GROUP 1 ENTITLEMENT	GROUP 2 ENTITLEMENT
Unexplained syncope, including syncope without reliable prodrome		
While standing or sitting	Must not drive and must notify the DVLA. If no cause has been identified, the licence will be refused or revoked for 12 months.	Must not drive and must notify the DVLA. If no cause has been identified, the licence will be refused or revoked for 10 years.
Cardiovascular, excluding typical syncope		
While standing or sitting	Must not drive and must notify the DVLA. If there are factors that would lead to an increased risk of recurrence, then 1 year off driving would be required.	Must not drive and must notify the DVLA. Driving may resume after 3 months only if the cause has been identified and treated. If no cause has been identified, the licence will be refused or revoked for 12 months.

	GROUP 1 ENTITLEMENT	GROUP 2 ENTITLEMENT
Blackout with seizure markers		
While standing or sitting	Must stop driving and notify the DVLA. Depending on previous medical history, the standards for isolated seizure or epilepsy will apply.	Must stop driving and notify the DVLA. Depending on previous medical history, the standards for isolated seizure or epilepsy will apply.
Cough syncope or presynsope		
	Must not drive and must notify the DVLA. Must not drive for 6 months following a single episode and for 12 months following multiple episodes over 5 years. Reapplication may be considered earlier if all of the following can be satisfied: • any underlying chronic respiratory condition is well controlled • for smokers, reliable cessation of smoking has been achieved and will be continued after relicensing • body mass index is below 30 • any gastro-oesophageal reflux is treated.	Must not drive and must notify the DVLA. Must not drive for 5 years from the date of the last episode. Reapplication may be considered after 1 year if the all the following can be satisfied: • any underlying chronic respiratory condition is well controlled • for smokers, reliable cessation of smoking has been achieved and will be continued after relicensing • body mass index is below 30 • any gastro-oesophageal reflux is treated • confirmation of these by a specialist doctor.

FLYING AND CARDIOVASCULAR DISEASES

Patients often ask how soon they can fly and the CAA (see useful links, page 14) and British Cardiac Society have issued guidelines ([258]).

When advising patients, reference to this guidance is helpful, but a common sense approach should apply. For many patients the reason for flying is for a holiday that may be best postponed until they have completed a period of convalescence and, in many cases, rehabilitation.

ANGINA	CCS I - II CCS III CCS IV	No restriction Consider in-flight O_2 Defer until stable or needs escort and O_2
ACUTE CORONARY SYNDROMES including MYOCARDIAL INFARCTION	**Low risk:** age < 65, first event, successful reperfusion, EF > 45%, no complications, no planned tests or interventions **Medium risk:** EF > 40%, no symptoms of failure, no evidence of ischaemia or arrhythmia, no planned tests or interventions **High risk:** EF < 40%, signs and symptoms of failure, those pending further tests, revascularisation or device therapy	Fly after 3 days Fly after 10 days Defer travel until condition stable
ANGIOPLASTY (elective)		Fly after 2-3 days in most cases
CABG (elective)		Fly after 10-14 days if no complications. If symptomatic, follow guidance for specific symptoms
SYMPTOMATIC VALVULAR HEART DISEASE		Relative contrainidcation
ACUTE HEART FAILURE		Fly after 6 weeks if stabilised
CHRONIC HEART FAILURE	NYHA I and II NYHA III NYHA IV	No restriction May need in-flight O_2 Advised not to fly without in-flight O_2 and airport assistance available
RF ABLATION		Fly after 2 days but higher risk of DVT/PTE
PACEMAKER / ICD IMPLANT		Fly after 2 days if no pneumothorax. In the event of a pneumothorax, flying should be deferred for 2 weeks following complete resolution

TELEPHONE NUMBERS

WHERE FULL NUMBERS ARE GIVEN FOR UHL STAFF OR DEPARTMENTS, WHEN DIALING FROM WITHIN UHL, USE LAST FOUR RED DIGITS ONLY

CARDIOLOGY CONSULTANTS

	SECRETARY	OFFICE	FAX
DR ADLAM	0116 2583236	0116 2502480	0116 2563422
DR BEHOUNEK	0116 2563029		0116 2563422
DR BOLGER (ACHD)	0116 2502530	0116 2563780	0116 2502422
DR BU'LOCK	0116 2563799		
DR CHELLIAH	0116 2563402	0116 2502378	0116 2502405
DR GARIMELLA	0116 2583361		0116 2583422
PROF GERSHLICK	0116 2563887	3966 / 2677	0116 2563956
DR HUDSON	0116 2583361	0116 2502920	0116 2583422
DR HUSSAIN			
DR KHOO	0116 2583888	0116 2582627	0116 2314751
PROF KOVAC	0116 2502780	0116 2563914	0116 2314751
DR LADWINIEC	0116 2502348	0116 2562920	0116 2563422
DR LOKE	0116 2563029	0116 2563036	0116 2563422
DR MACDONALD	0116 2502530	0116 2502669	0116 2502422
PROF MCCANN	0116 2583997		0116 2583422
PROF NG	0116 2583297	3360 / 2438	0116 2314751
DR NICOLSON	0116 2583977	0116 2502972	0116 2583422
DR PATHMANATHAN	0116 2583977	0116 2502845	0116 2583422
DR ROBERTS	0116 2502780	0116 2562540	0116 2314751
PROF SAMANI	0116 2583236	0116 2563909	0116 2563422
DR SANDILANDS	0116 2583297	0116 2583655	0116 2320368
DR SHARAF			
DR SKEHAN	0116 2583888	0116 2563889	0116 2314751
DR SOMANI	0116 2563887	0116 2563372	0116 2563956
DR STAFFORD	0116 2563183	0116 2563372	0116 2320368
DR STANLEY	0116 2583877	0116 2502972	0116 2502405
PROF SQUIRE	0116 2502348	0116 2044750	0116 2502405

CARDIAC RADIOLOGISTS

	OFFICE	SECRETARY	FAX
DR BAJAJ	0116 2502593	0116 2502561	
DR DAS	0116 2583275	0116 2583357	
DR DESHPANDE	0116 2583275	0116 2583357	
DR RAO		0116 2583357	

CARDIAC SURGEONS

	OFFICE	SECRETARY	FAX
MR EFTHYMIOU		0116 2583994	
MR HADJINIKALAOU	0116 2583444	0116 2502450	
MR MARISCALCO	0116 2583019	0116 2583077	
PROF MURPHY	0116 2583054	0116 2583021	
MR SZOSTEK		0116 2583077	0116 2563078
MR ZLOCHA	0116 2503059	0116 2583077	
ON CALL CARDIAC SURGERY SPR	07432 699592		

DEPARTMENTAL NUMBERS

	GLENFIELD	LRI	LGH
ACHD LIASON NURSES	0116 2583338		
ARRHYTHMIA NURSES	0116 2583848		
BIOCHEMISTRY	0116 2583572		
BLOOD BANK	0116 2583577		
BRU RECEPTION	0116 2583385		
CARDIAC REHAB	0116 2583986	7544	8069
CARDIOLOGY AUDIT OFFICE	0116 2583099		
CARDIOLOGY ENQUIRIES	0116 2502944	5128	4280
CARDIOLOGY SPRS	0116 2502934		
CARDIOVERSION SERVICE	0116 2502494		
CARDIOVERSION FAX	0116 2563956		
CATH LAB A	0116 2583988		
CATH LAB B	0116 2583937		
CATH LAB C	0116 2583189		
CATH LAB D	0116 2583968		
CATH LAB E	0116 2583858		
CATH LAB F	0116 2583148		
CATH LAB COORDINATOR	0116 2583347		
CATH LAB RADIOGRAPHERS	0116 2502452		
CATH SUITE RECEPTION	0116 2583092		
CATH SUITE RECOVERY	0116 2583929		
CCU	0116 2583774 / 3719		
CCU FAX	0116 2563228		
CDU	0116 2583718 / 3772		
COAGULATION	0116 2583883		
CT CONTROL ROOM	0116 2502358		
CT RECEPTION	0116 2583265	5582	
ECG & TAPES	0116 2583461 / 3840		
ECHO OFFICE	0116 2502537		
EXERCISE TEST ROOM	0116 2583371		
HAEMATOLOGY	0116 2583575		
HOT REPORTING	0116 2583678		

	GLENFIELD	LRI	LGH
ITU	0116 2583154 / 3159 / 3485		
JDA OFFICE	0116 2583972		
MICROBIOLOGY	0116 2586544		
MRI CONTROL ROOM	0116 2502359		
MRI RECEPTION	0116 2583265	7743	
OCCUPATIONAL HEALTH	0116 2502393		
ODA	0116 2583068		
PACEMAKER CLINIC	0116 2583837		
PALLIATIVE CARE	0116 2583540	5414	4680
PERFUSIONISTS	0116 2583604		
PHARMACY	0116 2583701	5743	
RACPC	0116 2583084		
RESUS LRI ED	5282 / 5590 / 6786		
RADIOISOTOPES	0116 2583850	5627	4624
THEATRE 1	0116 2583541		
THEATRE 2	0116 2583541		
THEATRE 3	0116 2583588		
THEATRE 4	0116 2583542		
THEATRE RECEPTION	0116 2583632		
THEATRE RECOVERY	0116 2583622		
USS	0116 2583678		
WARD 24	0116 2583656		
WARD 27	0116 2583671		
WARD 28	0116 2583646 / 3755		
WARD 29	0116 2583320		
WARD 31	0116 2583503 / 3781		
WARD 32	0116 2583731 / 3313		
WARD 33	0116 2583733 / 3849		
WARD 33 HDU	0116 2502351		
WARD 33A	0116 2502894		
X-RAY RECEPTION	0116 2583675		

HOSPITAL NUMBERS

BOSTON PILGRIM	01205 364801
BURTON (QUEENS HOSPITAL)	01283 566333
DERBY	01332 340131
GRANTHAM	01476 565232
KETTERING	01536 492000
LINCOLN	01522 512 512
NORTHAMPTON	01604 634700
NOTTINGHAM CITY	0115 9691169
NOTTINGHAM QMC	0115 9249924
NUFFIELD LEICESTER	0116 2989277
NUNEATON (GEORGE ELIOT)	02476 351351
PETERBOROUGH	01733 678000

SPIRE LEICESTER	0116 2720888

BLEEP NUMBERS

Use the following chart to determine which bleep prefix to use:

SITE YOU ARE AT	**LRI**	*88
	LGH	*88
	GH	*7

Then dial the relevant bleep number (below) followed by your extension number and #.

CONSULTANT	SpR	FY2	FY1
DR ADLAM	2501	2505	2850
DR BOLGER	2705		
PROF GERSHLICK	2500	2508	
DR HUDSON	2895	2565	
DR HUSSAIN			
PROF KOVAC	2566	2537	2512
DR LADWINIEC			
DR LOKE	2504	2621	2605
DR MACDONALD	2705		
PROF NG	2865	2539	
DR NICOLSON	2504	2621	2605
DR PATHMANATHAN	2867	2511	2851
DR ROBERTS	2895	2565	
DR SANDILANDS	2517	2513	2506
DR SKEHAN	2566		
DR STAFFORD	2580	2507	
DR SOMANI	2580	2507	
DR STANLEY			
PROF SQUIRE	2504	2621	2605

ON CALL CARDIOLOGY SPR	2584
CCU SPR	2548
ON CALL CARDIAC SURGERY SPR	07432 699592
ACHD SPR	2705
ON CALL RESP SPR	2903
BED MANAGER	2550

APPENDIX

The medicines listed below are not a complete formulary but are drugs that are mostly on the Leicestershire Medicines Formulary: http://leicestershire.formulary.co.uk/

For guidance on injectable medicines see: http://medusa.wales.nhs.uk/LocalSelect.asp

DIURETICS

In pulmonary oedema and more advanced heart failure, loop diuretics should be used. ***Furosemide*** and ***bumetanide*** are similar in activity, although ***bumetanide*** is better absorbed orally and may have advantages when administered to patients with congestive cardiac failure where bowel oedema may be an issue. ***Torasemide*** may be better tolerated due to its smoother mode of action but requires a consultant to prescribe. Thiazide diuretics are useful for mild heart failure and can be extremely good for severe congestive cardiac failure when used with a loop diuretic, although careful monitoring of weight and electrolytes is crucial. ***Metolazone*** is a powerful thiazide derivative, and needs particularly careful monitoring. In severe CCF, consider prolonged infusions of ***furosemide*** (e.g. 250 - 500 mg over 24 hours, rate must not exceed 4 mg/min). IV ***furosemide*** is not compatible with ***dobutamine*** or ***dopamine***.

Spironolactone is a potassium sparing diuretic and aldosterone antagonist and has a particular use in heart failure when used in addition to an ***ACEI*** at a dose of 25 mg OD [206]. Monitoring of potassium is important. Bigger doses may be needed in ascites.

Loop diuretics:

Furosemide (***Lasix***): 40 - 250 mg daily

Bumetanide (***Burinex***): 1 - 6 mg daily

Torasemide (***Torem***): 5 - 40 mg daily

Thiazide diuretics:

Bendroflumethiazide: 2·5 mg OD

Metolazone (***Metenix 5***): 2·5 - 5 mg daily or less

Potassium sparing diuretics:

Spironolactone (***Aldactone***, ***Spiroctan***): 12·5 - 25 mg OD in heart failure

Eplerenone **(Inspra)**: 25 - 50 mg in heart failure post-MI and in patients who develop gynaecomastia on Spironolactone.

Amiloride: 5 - 10 mg OD

ACE INHIBITORS

ACEI should be considered in all grades of heart failure and following large or anterior wall infarcts. They should also be considered in hypertensive patients, particularly those with vascular disease or diabetes. Patients should be treated with the highest dose that can be tolerated. Electrolytes should be checked after one

week and within 3 months of starting to exclude deterioration in renal function. They should be avoided in renovascular disease and severe aortic stenosis.

Ramipril (***Tritace***): 1·25 - 10 mg OD and **Lisinopril** (***Carace***, ***Zestril***): 2·5 - 20 mg OD are the preferred ***ACEI*** in Leicestershire.

ANGIOTENSIN-II RECEPTOR ANTAGONISTS

Generally currently used when ***ACEI*** are not tolerated because of dry cough, this class of drugs has an increasing role in the management of patients with heart failure. Good evidence exists for **valsartan** and **candesartan** in heart failure. Also used in hypertension, especially those with renal disease and type 2 diabetes.

Valsartan (***Diovan***): 40 - 160 mg BD (OD in hypertension), **candesartan** (***Amias***): 4 - 32 mg OD, **losartan** (***Cozaar***): 25 - 100 mg OD, **irbesartan** (***Aprovel***): 150 - 300 mg OD.

ANGIOTENSIN RECEPTOR-NEPRILYSIN INHIBITOR (ARNI)

Sacubitril valsartan is the only ***ARNI*** available. Licensed for use in symptomatic patients with NYHA II-IV with LVEF < 35% already taking ***ACEI*** or ***ARBs***. Marketed as ***Entresto***, the dosing is outlined in the main text. Main side effects are hypotension, hyperkalaemia and renal impairment.

BETA - BLOCKERS

β-blockers are effective as single agents in unstable angina and work by reducing myocardial oxygen demands by slowing the heart rate, lowering the blood pressure, and reducing contractility. There is evidence that progression to myocardial infarction is reduced by about one-sixth. In high-risk patients intravenous preparations should be used to achieve rapid effects (within 15 minutes); oral therapy may take 12 hours.

They should be avoided in marked first-degree AV block (> 0·24 s), second- or third-degree block, asthma, or severe left ventricular dysfunction (unless very carefully introduced). ***Atenolol***, ***bisoprolol***, ***metoprolol***, and ***nebivolol*** have less effect on the β2 (bronchial) receptors and are, therefore, relatively cardioselective.

Atenolol: 2·5 - 10 mg IV (***Tenormin***). Comes as 0·5 mg/ml (5 mg in 10 ml). Administered undiluted in increments of 2·5 mg, repeated at 5 minute intervals and given by slow bolus (1 mg/min). Start 50 mg OD orally. For oral ***β-blockade***, alternative drugs include the following:

Bisoprolol (***Emcor***, ***Monocor***): 2·5 - 20 mg daily. This medication is also licensed for use in patients with heart failure.

Metoprolol (***Betaloc***, ***Lopressor***): 25 - 100 mg, two to three times daily. Sustained release (once daily) preparations ***Betaloc-SA*** and ***Lopressor SR*** are available as 200 mg doses, maximum 400 mg daily.

Available in IV form with ampoules containing 5 mg/5ml. Dose is 1 - 2 mg/min given at 5 minute intervals. Use should be restricted for management of tachycardia post MI.

Carvedilol (***Eucardic***): 3·125 - 25 mg twice daily orally. This medication is also licensed for use in patients with heart failure.

Propranolol (***Inderal***): 40 mg two to three times daily orally, maximum 240 mg daily.

Esmolol ***(Brevibloc)***: a relatively cardioselective ***β-blocker*** for IV use. Steady state is achieved in 5 minutes with loading dose; lasts about 10 - 20 minutes after infusion stopped. Renal elimination. Useful for rapid control of tachycardia. May be used for hypertension. Short-term use only. Diluted in ***glucose*** 5% or ***sodium chloride*** 0·9%. Supplied ready to use as 10 mg vial of 10 mg/ml and also a premixed bag containing 2500 mg in 250 ml. A 10 ml ampoule containing 250 mg/ml is also available which MUST BE DILUTED.

Loading dose is 500 µg/kg/min for 1 minute.

Maintenance is 50 - 200 µg/kg/min continuous.

Esmolol Dosage Flowchart

Dosage of ***esmolol*** in supraventricular tachycardia must be individualised by titration in which each step consists of a loading dose followed by a maintenance infusion.

1. Administer loading dose (500 µg/kg) over 1 minute then
2. Initiate maintenance infusion of 50 µg/kg/min over 4 minutes
3. If an adequate therapeutic response is observed over the first 5 minutes then maintain the same maintenance infusion rate
4. If an adequate therapeutic response is NOT observed, then repeat the same loading dose over 1 minute followed by an increased maintenance infusion rate of 100 µg/kg/min
5. Continue titration procedure as above, repeating the original loading dose of 0·5 mg/kg over 1 minute, but increasing the maintenance infusion rate by 50 µg/kg/minute increments
6. The maximum infusion rate is 200 µg/kg/min

As the desired heart rate or blood pressure is approached, omit subsequent loading doses and titrate the maintenance up or down. The interval between titration steps may be increased from 5 to 10 minutes.

The use of ***esmolol*** infusions for up to 24 hours is usual and the dosage of ***esmolol*** should be reduced gradually before stopping - for more information see the ***esmolol*** data sheet.

Maintenance infusion rate in ml/hr when using a 10 mg/ml solution for infusion of **Esmolol**

Patient weight (kg)	Loading dose (ml)	Maintenance infusion rate (ml/hour)			
		50 micrograms	100 micrograms	150 micrograms	200 micrograms
40	2·0	12·0	24·0	36·0	48·0
45	2·25	13·5	27	40·5	54·0
50	2·5	15·0	30·0	45·0	60·0
55	2·75	16·5	33·0	49·5	66·0
60	3·0	18·0	36·0	54·0	72·0
65	3·25	19·5	39·0	58·5	78·0
70	3·5	21·0	42·0	63·0	84·0
75	3·75	22·5	45·0	67·5	90·0
80	4·0	24·0	48·0	72·0	96·0
85	4·25	25·5	51·0	76·5	102·0
90	4·5	27·0	54·0	81·0	108·0
95	4·75	28·5	57·0	85·5	114·0
100	5·0	30·0	60·0	90·0	120·0
105	5·25	31·5	63·0	94·5	126·0
110	5·5	33·0	66·0	99·0	132·0

***Labetalol hydrochloride* (*Trandate*)**

In ***glucose*** 5% or ***sodium chloride*** 0·9%. Supplied as 100 mg in a 20 ml ampoule (5 mg/ml). Central administration is preferable as the preparation has a low pH. For infusions, dilute to 1 mg/ml: remove 90 ml from a 250 mg bag and add 40 ml (200 mg) ***labetalol***.

Following myocardial infarction, the infusion should be commenced at 15 mg/hr and gradually increased to a maximum of 120 mg/hr depending on the control of blood pressure. In other cases where rapid control of blood pressure is indicated, the rate of infusion should be about 2 mg/min, until a satisfactory response is obtained.

If it is essential to reduce blood pressure quickly, as for example, in hypertensive encephalopathy, a dose of 50 mg should be given by intravenous injection over a period of at least one minute. If necessary, doses of 50 mg may be repeated, up to three times, at five minute intervals until a satisfactory response occurs. The total dose should not exceed 200 mg.

DIGOXIN

Digoxin is used for the control of ventricular rate in atrial flutter and fibrillation. It should not necessarily be the first choice in these arrhythmias, but is particularly useful if ***β-blockers*** or ***non-dihydropyridine calcium antagonists*** are inadequate or contraindicated. ***Digoxin*** is also a weak inotrope and should be considered for

atrial flutter/fibrillation in the context of heart failure. It may also be beneficial in the presence of sinus rhythm and heart failure.

For rapid oral loading give 0·75 - 1·5 mg over 24 hours in divided doses. Maintenance dose is usually 62·5 - 250 µg daily.

For emergency IV loading, administer 0·75 - 1 mg by IV infusion over at least 2 hours. Dilute in 50 - 100 ml of either ***sodium chloride*** 0·9% or ***glucose*** 5%.

Reference levels are usually between 0·5 and 2·0 g/L.

CALCIUM CHANNEL BLOCKERS

These drugs act as coronary vasodilators, and exert negatively inotropic effects. They also lower blood pressure and may improve left ventricular compliance. They should usually be avoided in heart failure.

The ***dihydropyridine calcium antagonists*** do not exert an effect on the AV node and therefore should be reserved for patients who already have a resting heart rate between 50 and 60 achieved physiologically or with ***β-blockade***. They should generally not be used in patients as monotherapy unless thought to have coronary artery spasm in association with ST-segment elevation. Drugs which do act on the AV node (non-dihydropyridines) should be used with caution in the presence of (***β-blockers***, and in this setting ***verapamil*** should not be used unless recommended by a consultant. They can be used as monotherapy if ***β-blockers*** are contraindicated.

There is little evidence showing any significant benefit in terms of morbidity and mortality when using ***calcium antagonists***, with the possible exception of ***diltiazem***.

Dihydropyridines:

Amlodipine (***Istin***): 5 - 10 mg OD is the only formulary drug. ***Nicardipine*** and ***lercanidipine*** are non-formulary.

Non-dihydropyridines:

Verapamil (***Securon***): Usual dose is 80 - 120 mg TDS. Sustained-release preparations are available (***Securon SR***) 240 - 480 mg daily in 2 divided doses, occasionally once daily).

Diltiazem: starting dose 60 mg BD/TDS, titrating up to 360 mg/day. Longer-acting formulations should be used carefully as the doses and timing vary between preparations. In Leicestershire ***Angitil*** is the preferred BD brand (90 - 180 mg BD). Once daily the preferred brand is ***Viazem*** (120 mg OD, 180 mg OD, 240 mg OD, 300 mg OD and 360 mg OD).

NITRATES

There is no evidence that ***nitrates*** reduce the incidence of myocardial infarction or death, but they are very useful for the relief of angina. They should rarely, if ever, be used in isolation for unstable angina. Their major mechanism of action is probably via venodilation, which reduces preload. The major problem is that tolerance can develop within 24 hours.

Nitroglycerin should be given immediately, as either a sublingual tablet or spray, to relieve angina. If symptoms persist, intravenous ***GTN*** starting at 1·0 mg/hr. The dose should be steadily increased in increments 0·5 - 1 mg/hr until the desired clinical response is achieved. Usual dosage range is 0·5 mg - 12 mg/hr.

Titration should avoid excessive falls in systolic blood pressure (stop if < 90 mmHg). It is probably not necessary to wean patients off. Oral therapy should be substituted after 24 hours. Remember ***nitrate*** tolerance occurs even when IV therapy is employed.

Dilution is NOT NECESSARY unless concentrated solution is greater than 1 mg/ml. If required, dilute in ***glucose*** 5% or ***sodium chloride*** 0·9% in a syringe not a bag. Polyethylene tubing should be used, as polyvinyl chloride may absorb up to 50% of the GTN. Adverse effects include headache, dizziness, flushing, hypotension and tachycardia. Reducing rate of infusion can often alleviate these effects.

Glyceryl Trinitrate: 300 - 500 µg SL (1 - 2 tablets), 400 µg SL (1 - 2 sprays).

Isosorbide Mononitrate: usual dose is 10 - 60 mg BD (with doses being 6 - 8 hours apart and not 12 hourly). Modified release tablets can be given once daily (***Elantan LA*** 25 - 100 mg as capsules, ***Imdur*** 30 - 120 mg as tablets).

Sodium Nitroprusside

Reconstituted in 5% ***glucose***. Supplied as 5 ml vials each containing 50 mg ***nitroprusside*** (10 mg/ml). Dissolve 50 mg in 250 ml (200 µg/ml) or in 500 ml (100 µg/ml) or in 1000 ml (50 µg/ml). ***Need to add 5 ml of 10% sodium thiosulphate per 50 mg dose of nitroprusside to every infusion***.

Dose depends on indication.

For hypertensive crisis, initially 0·5 - 1·5 µg/kg/min is used, titrating up by 0·5 µg/kg/min in 5 minute intervals to a maximum of 10 µg/kg/min.

In heart failure, 10 - 15 µg/min is employed initially, increased 10 - 15 µg/min every 5 - 10 minutes to a maximum of 200 µg/min.

ATP-DEPENDENT POTASSIUM CHANNEL ACTIVATORS

Nicorandil is a potassium-channel activator with a nitrate component, and has both arterial and venous vasodilating properties and is indicated for the prevention and long-term treatment of angina. It may have a role to play in the management of unstable angina when added to maximal therapy.

Nicorandil (***Ikorel***): 5 - 30 mg BD.

STATINS

There is considerable evidence to support the use of ***statins*** in patients with documented coronary artery disease. The aim is to lower total cholesterol below 4·0 mmol/l and LDL-cholesterol below 2·0 mmol/l. Only ***Pravastatin***, ***Simvastatin***, ***Atorvastatin*** and ***Rosuvastatin*** can be recommended for use in Leicestershire for cardiac patients. ***Fluvastatin*** can be used in renal transplant patients.

Atorvastatin (***Lipitor***): 10 - 80 mg OD

Pravastatin (**Lipostat**): 10 - 40 mg ON

Simvastatin (***Zocor***): 40 - 80 mg ON (lower doses if eGFR < 30)

Fluvastatin (***Lescol***)**:** 20 - 80 mg ON (lower doses if eGFR < 30)

Rosuvastatin (***Crestor***): 5 - 40 mg OD (start at 5 mg OD in Asians and those with eGFR 30 - 60, avoid if eGFR < 30, maximum dose 20 mg OD).

ANTIARRHYTHMIC DRUGS

Antiarrhythmic drugs should be avoided with antidepressants and antihistamines.

Adenosine (***Adenocor***) is useful for the termination of supraventricular tachycardias, and as an aid in the diagnosis of broad complex tachycardias - terminating the majority of tachycardias of supraventricular origin, but not of ventricular origin. It commonly causes transient chest discomfort and flushing and the patient should be accordingly advised. It should be given by *rapid* intravenous injection starting at 3 to 6 mg and at 2 minute intervals the dose should be increased to 12 mg and occasionally 18 mg if unsuccessful at lower doses.

Weight (kg)	Rate (ml/hr)	Weight (kg)	Rate (ml/hr)	Weight (kg)	Rate (ml/hr)
45	378	75	630	105	882
50	420	80	672	110	924
55	462	85	714	115	966
60	504	90	756	120	1008
65	546	95	798	125	1050
70	588	100	840	130	1092

In the catheter lab ***Adenosine*** is used for no-reflow and also in the context of pressure wire studies if the FFR is above 0·8.

For no-reflow, draw up ***Adenosine*** 5 mg (1·7 ml) from a 3 mg/ml ampoule) and dilute in 500 ml 0·9% ***sodium chloride***. This gives a concentration of 10 µg/ml. For the **left coronary artery**, boluses of 40 - 80 µg (4 - 8 ml) are given and for the **right coronary artery**, 20 - 40 µg (2 - 4 ml). For pressure wire studies, IV administration via the femoral vein is preferred at a rate of 140 µg/kg/min. 0·9% ***sodium chloride*** bags are stocked at 130 mg in 130 ml. A slightly bigger dose may be needed via a peripheral vein.

Amiodarone (***Cordarone X***) is useful for both supraventricular and ventricular arrhythmias. It may be administered intravenously or orally.

Amiodarone administered orally requires a loading regime which is usually 200 mg TDS for a week, 200 mg BD for a week and 200 mg OD maintenance. ***Amiodarone*** potentiates both ***digoxin*** and **warfarin** and so doses of these drugs may need reducing subsequent to ***amiodarone*** initiation. Photosensitivity affects about 50%, hypothyroidism occurs in about 6% and hyperthyroidism in 1 - 2%. Patients should also be counselled regarding risk of liver impairment and pulmonary fibrosis. Grey pigmentation is more likely if barrier creams are not used.

IV ***amiodarone*** is supplied in ampoules of 3 ml (150 mg). Dilute in ***glucose*** 5%. Do not give via same line as ***heparin***, ***dobutamine***, ***insulin***, ***GTN*** or ***sodium bicarbonate***. Maintenance infusions should generally be given centrally. If given peripherally must be via a grey catheter in a large vein and NEVER in the hand.

Loading: 300 mg over the FIRST 60 minutes (dilute in 100 - 250 ml ***glucose*** 5%). In extreme clinical emergency, ***amiodarone*** may be given as a slow injection of 150 - 300 mg in 10 - 20 ml 5% ***glucose*** over a minimum of 3 minutes. This should not be repeated for at least 15 minutes.

Followed by Slow infusion: 900 mg over the NEXT 23 hours, diluted in 250 - 500 ml ***glucose*** 5%.

Oral loading is 200 mg TDS for a week, 200 mg BD for a week and 200 mg OD maintenance. Patients should be advised of the long-term risk of side-effects such as thyroid and liver dysfunction and phototoxicity.

Sotalol (***Beta-Cardone***, ***Sotacor***) is a ***β-blocker*** which is very useful for supraventricular arrhythmias and occasionally ventricular arrhythmias. It is usually given at a dosage of 40 - 160 mg BD. For class III effect, at least 80 mg BD is needed.

Flecainide (***Tambocor***) is very useful for supraventricular arrhythmias, particularly paroxysmal atrial fibrillation and re-entry tachycardias. It should be avoided in patients with documented coronary disease (unless being administered intravenously under cardiac monitoring) or in those with LV dysfunction. Oral dose is 50 - 150 mg BD.

Flecainide can be very effective IV, especially with atrial fibrillation of recent onset. Diluted in ***glucose*** 5% or ***sodium chloride*** 0·9%. Supplied as 150 mg in a 15 ml ampoule (10 mg/ml).

Flecainide injection can be given in an emergency or for rapid effect by a slow injection of 2 mg/kg over not less than 10 minutes, or in divided doses. If preferred, the dose may be diluted with 5% ***glucose*** and given as a mini-infusion.

When prolonged IV administration is required, it is recommended that therapy is initiated by slow injection of 2 mg/kg over 30 minutes and continued by intravenous infusion at the following rates:

First hour: 1·5 mg/kg/hr.

Second and later hours: 0·1 - 0·25 mg/kg/hr.

It is recommended that the infusion duration should not exceed 24 hours. The maximum cumulative dose given in the first 24 hours should not exceed 600 mg. In patients with severe renal impairment, each of the above dosage recommendations should be reduced by half.

Propafenone (***Arythmol***) is useful for supraventricular arrhythmias, especially paroxysmal atrial fibrillation. It should be avoided in patients with coronary disease or LV dysfunction. Dose is usually 150 mg TDS or if necessary 300 mg BD or TDS.

Lidocaine is useful for stabilising ventricular arrhythmias. Usual loading dose is 50 to 100 mg administered intravenously. This dose may be injected at a rate of approximately 25 to 50 mg per minute (2·5 to 5·0 ml using a 1% solution or 1·25 to 2·5 ml using a 2% solution). A sufficient period of time should be allowed to enable a slow circulation to carry the drug to the site of action. If the initial dose of 50 to 100 mg does not produce the desired response, a second dose may be given after 5 minutes. No more than 200 to 300 mg of ***lidocaine*** should be administered during a one hour period.

If an infusion is indicated, give 4 mg/min for 30 minutes, 2 mg/min for 2 hours, then 1 mg/min for a maximum of 24 hours.

SEDATION FOR CARDIOVERSION

This should only be undertaken by personnel experienced in cardioversion under sedation. If inexperienced, an anaesthetist should be called for assistance.

Midazolam (***Hypnovel***) has a half-life of ~ 2·5 hours. Ampoules come as 10 mg in 5 ml. The contents of one should be diluted to give a concentration of 10 mg in 10 ml (= 1 mg in 1 ml)

First dose: 2·5 mg = 2·5 ml of 1 mg/1 ml dilution to be given over 30 seconds (patients under 50 kg, first dose 1·5 mg = 1·5 ml of 1 mg/1 ml dilution to be given over 30 seconds). Patients with a serum creatinine > 200 µmol/l should have the first dose of ***midazolam*** reduced).

Subsequent doses: 1 mg = 1 ml of 1 mg/1 ml dilution to be given over 30 seconds at 2 minute intervals if required as per main protocol. The maximum total dose of ***midazolam*** should not exceed 12 mg. After each dose of ***midazolam***, the cannula should be flushed with 0·9% ***sodium chloride***.

Flumazenil (***Anexate***) has a half-life of ~ 40 - 80 minutes. Ampoules come as 500 µg/5 ml (100 µg/ml). It is used to reverse the sedation of ***midazolam***. It should only be given when absolutely necessary and not as a matter of routine.

First dose: 200 µg = 2 ml from ampoule to be given over 15 seconds.

Subsequent doses: 100 µg = 1 ml from above ampoule at 60 second intervals if required.

Maximum total dose of ***flumazenil*** not to exceed 1 mg (= 1000 µg)

(NB ***Flumazenil*** has a shorter half-life than ***midazolam*** and there is a risk that patients may become re-sedated).

UNFRACTIONATED HEPARIN (UFH)

When using ***UFH***, coagulation parameters need to be monitored and maintained at 2·5 - 4·0 x control.

Loading dose: 5000 U (using 1000 U/ml ***heparin***) over 5 minutes by slow IV injection.

Initial infusion rate: 1400 U/hr.

Check APTT at 4 - 6 hours - adjust rate as follows:

APTT ratio	Dose/Rate change
> 6	stop for 30 min to 1 hour and reduce by 500 U/hr
5·1 - 6·0	reduce by 300 U/hr
4·1 - 5·0	reduce by 100 U/hr
2·5 - 4·0	no change
1·8 - 2·4	increase by 100 U/hr
1·2 - 1·7	increase by 200 U/hr
< 1·2	increase by 400 U/hr

Heparin reversal occurs relatively quickly as the half-life is 90 minutes. If more rapid reversal is required, ***protamine sulphate*** can be employed (1 mg for each 100 U of

heparin given in the previous 4 hours). Administration is by slow bolus over several minutes. If > 30 minutes has passed since the infusion was discontinued, reduce the dose of ***protamine sulphate*** by 50%.

LOW-MOLECULAR WEIGHT HEPARIN (LMWH)

A number of studies have now shown that ***LMWH*** is as good, if not better than ***UFH***. Their ease of use, and predictable ***anticoagulant*** effect, make them preferable to ***UFH***.

Dosing depends on the indication. Dose reduction may be required in severe renal impairment (CrCl < 30 ml/min).

WARFARIN

Patients with liver disease, heart failure, or other possible causes of increased sensitivity to ***warfarin*** should have their INR checked prior to commencing ***warfarin***.

Ensure you are familiar with how to refer to the ***anticoagulant*** outpatient service.

Tait and Sefcick Slow Initiation Warfarin Regime:

Pre Treatment INR < 1.3 and not on ***amiodarone***

Warfarin 5 mg days 1 - 4

Check INR day 5, 8 & 12

INR Day 5	Warfarin Dose From Day 5	INR Day 8	Warfarin Dose From Day 8
< 1·7	5 mg	< 1·7 1·8 - 2·4 2·5 - 3·0 > 3·0	6 mg 5 mg 4 mg 3 mg for 4 days
1·8 - 2·2	4 mg	< 1·7 1·8 - 2·4 2·5 - 3·0 3·1 - 3·5 > 3·5	5 mg 4 mg 3·5 mg 3 mg for 4 days 2·5 mg for 4 days
2·3 - 2·7	3 mg	< 1·7 1·8 - 2·4 2·5 - 3·0 3·1 - 3·5 > 3·5	4 mg 2·5 mg 2 mg 1·5 mg for 4 days 1 mg for 4 days
2·8 - 3·2	2 mg	< 1·7 1·8 - 2·4 2·5 - 3·0 3·1 - 3·5 > 3·5	3 mg 2·5 mg 2 mg 1·5 mg for 4 days 1 mg for 4 days
3·3 – 3·7	1 mg	< 1·7 1·8 - 2·4 2·5 - 3·0 3·1 - 3·5 > 3·5	2 mg 1·5 mg 1 mg 0·5 mg for 4 days omit for 4 days
> 3·7	0 mg	< 2·0 2·0 - 2·9 3·0 - 3·5	1·5 mg for 4 days 1 mg for 4 days 0·5 mg for 4 days

Fennerty Algorithm

Day	INR	Warfarin Dose (mg)	Day	INR	Warfarin Dose (mg)
1	< 1·4	**10**	**Maintenance**	< 1·4	> 8
2	< 1·8	10		1·4	8
	1·8	1		1·5	7·5
	> 1·8	0·5		1·6 - 1·7	7
3	< 2·0	10		1·8	6·5
	2·0 - 2·1	5		1·9	6
	2·2 - 2·3	4·5		2·0 - 2·1	5·5
	2·4 - 2·5	4		2·2 - 2·3	5
	2·6 - 2·7	3·5		2·4 - 2·6	4·5
	2·8 - 2·9	3		2·7 - 3·0	4
	3·0 - 3·1	2·5		3·1 - 3·5	3·5
	3·2 - 3·3	2		3·6 - 4·0	3
	3·4	1·5		4·1 - 4·5	**Miss next dose then give 2 mg**
	3·5	1			
	3·6 - 4·0	0·5		> 4·5	**Miss next 2 doses then give 1 mg**
	> 4·0	0			

For the emergency reversal of ***warfarin***, concentrates of factors II, VII, IX and X (e.g. ***Octaplex***) are available and will normalise the INR in 10 minutes. The dose is 25 - 40 U/kg. FFP has virtually no role, providing around 25% reversal. Also give 1 mg of IV ***Vitamin K***. ***Vitamin K*** alone will reverse ***anticoagulation*** in about 6 hours.

DOACs

Rivaroxaban is prescribed at a dose of 20 mg OD. Creatinine clearance (CrCl) should be calculated (not eGFR) using the Cockcroft-Gault equation (need age, weight in kg, serum creatinine and sex). There are numerous web based calculators.

http://www.mdcalc.com/creatinine-clearance-cockcroft-gault-equation/

Reduce the dose to 15 mg OD if CrCl is 30 - 49 mL/minute; refer to haematologist if CrCl is 15 - 29; avoid if CrCl less than 15 mL/minute. In patients with hepatic disease associated with coagulopathy and clinically significant bleeding risk, including cirrhotic patients, ***rivaroxaban*** should not be prescribed. NICE recommends

rivaroxaban in patients with previous stroke or TIA, heart failure, hypertension, diabetes and those aged over 75.

Apixaban is recommended by NICE in patients with non-valvular AF with one or more risk factors of prior stroke or TIA, age 75 or over, hypertension, diabetes or heart failure. Prescription is done under a shared care agreement. The dose is 5mg BD (2·5 mg BD if over 80, weighs less than 60 kg, or if CrCl 15 - 29 mL/minute, or if serum-creatinine ≥ 133; avoid if CrCl less than 15 mL/minute). ***Apixaban*** should be considered in preference to ***rivaroxaban*** in patients with a history of previous GI blood loss or current dyspepsia.

Dabigatran is prescribed at 150 mg BD unless there is a higher risk of bleeding when the lower dose of 110 mg BD should be used. It is not used in AF in Leicester. It must be stopped if the eGFR is less than 30. It should be used with caution with other p glycoprotein substrates e.g. ***verapamil***, ***amiodarone***, ***clarithromycin***) with at least a 2 hour gap between taking ***dabigatran*** and these drugs. NICE recommends its use in patients with previous stroke, TIA or embolism, LVEF less than 40%, NYHA heart failure class 2 or above, aged 75 or older, and aged 65 or older if there are other risks such as diabetes, coronary disease or hypertension.

ANTIPLATELET THERAPY

Aspirin has been shown to reduce the incidence of death and myocardial infarction in patients with unstable angina. In the absence of contraindications, all patients should receive 75 mg/day, after an initial dose of 300 mg. In the RISC study, even low dose ***aspirin*** (75 mg/day) reduced the risk of death or MI after an episode of ACS by 50% at three months.

Clopidogrel (***Plavix***®): In patients unable to tolerate ***aspirin***, ***clopidogrel*** (an antagonist of ADP-induced platelet aggregation) should be used. ***Clopidogrel*** (75 mg/day) does appear to be at least as effective as ***aspirin***.

Ticagrelor: ***Ticagrelor*** is a relatively new non-thienopyridine ADP receptor blocker causing reversible inhibition of platelet function ***Ticagrelor*** is given as a loading dose of 180 mg daily followed by 90 mg BD. For patients who cannot have ***prasugrel*** (weight < 60 kg, age > 75) in STEMI, ***ticagrelor*** should be considered. ***Ticagrelor*** is the first choice drug in patients with confirmed acute coronary syndrome (NSTEMI) whether or not they undergo PCI. It should be given for 12 months in the context of ACS along with ***aspirin*** 75 mg OD. A side effect to be aware of is dyspnoea which can occur at rest.

Prasugrel: ***Prasugrel*** is a thienopyridine and works in a similar way to ***clopidogrel***, by inhibiting platelets' ADP receptors to achieve its ***antiplatelet*** effects. The onset of action is significantly quicker with ***prasugrel*** compared to ***clopidogrel***. ***Prasugrel*** is administered as a loading dose of 60 mg followed by 10 mg daily (for up to 12 months). Guidance from the National Institute of Clinical Excellence (NICE) states that ***prasugrel*** should be used alongside ***aspirin*** in place of ***clopidogrel*** in patients presenting with STEMI who require treatment with PPCI, and in those who have suffered stent thrombosis whilst on ***clopidogrel*** therapy.

Particular benefit is apparent in patients with diabetes and those under the age of 75. **It is contraindicated in patients who have had prior stroke or TIA and should be avoided in patients who weigh less than 60kg.**

GLYCOPROTEIN IIB/IIIA INHIBITORS:

Tirofiban (***Aggrastat***®)

In ***glucose*** 5% or ***sodium chloride*** 0·9%. Given intravenously at an initial infusion rate of 0·4 µg/kg/min for 30 minutes. At the end of the initial infusion, ***Aggrastat*** should be continued at a maintenance infusion rate of 0·1 µg/kg/min. infusion should be between 48 and 108 hours. ***Aggrastat*** should be given with ***UFH*** (usually an intravenous bolus of 5000 U simultaneously with the start of ***Aggrastat*** therapy, then approximately 1000 U/hr, titrated on the basis of the APTT, which should be about twice the normal value). Check APTT after 6 hours. In renal failure (creatinine clearance < 30 ml/min), the dosage of ***Aggrastat*** should be reduced by 50%. Half-life is 1·5 hours. Should not be administered in same line as diazepam. Compatible with ***heparin***, ***dopamine***, ***lidocaine*** and ***potassium*** infusions.

Contraindications are not dissimilar to thrombolysis:

- Pregnancy and lactation
- Hypersensitivity
- Thrombocytopenia with previous GP IIb/IIIa inhibitor
- Stroke in previous 30 days
- Any history of haemorrhagic stroke
- History of intracranial disease
- Clinically relevant bleeding within past 30 days
- Malignant hypertension
- Trauma or major surgery within past 6 weeks
- Thrombocytopenia (platelet count < 100000/mm3)
- Disorders of platelet function
- Clotting disturbances
- Severe liver failure

In patients undergoing PCI, continue ***tirofiban*** if already running, through the intervention. As far as the ***UFH*** is concerned, it should be stopped (this can be up to 6 hours before procedure). A bolus dose of ***UFH*** of about 70 IU/kg will be given in the catheter lab. Continue ***tirofiban*** infusion for 18 - 20 hours post PCI.

	Most Patients		Renal Failure (Creatinine > 150)	
Patient weight (kg)	**30 min Loading Infusion Rate (ml/hr)**	**Maintenance Infusion Rate (ml/hr)**	**30 min Loading Infusion Rate (ml/hr)**	**Maintenance Infusion Rate (ml/hr)**
30 - 37	16	4	8	2
38 - 45	20	5	10	3
46 - 54	24	6	12	3
55 - 62	28	7	14	4
63 - 70	32	8	16	4
71 - 79	36	9	18	5
80 - 87	40	10	20	5
88 - 95	44	11	22	6
96 - 104	48	12	24	6
105 - 112	52	13	26	7
113 - 120	56	14	28	7
121 - 128	60	15	30	8
129 - 137	64	16	32	8
138 - 145	68	17	34	9
146 - 153	72	18	36	9

Femoral sheaths can be removed when activated clotting time (ACT) is less than 180 seconds (or aPPT ratio < 1·5) – usually 2 - 6 hours after discontinuation of UFH.

Abciximab (***ReoPro***®)

In **glucose** 5% or **sodium chloride** 0·9%. The recommended dose of ***ReoPro*** is a 0·25 mg/kg intravenous bolus immediately followed by a 0·125 µg/kg/min (to a maximum of 10 µg/min) continuous intravenous infusion. The infusion should continue for 12 hours following PTCA.

If a patient's activated clotting time (ACT) is less than 200 seconds prior to the start of the PTCA procedure, an initial bolus of ***UFH*** should be given upon gaining arterial access according to the following algorithm: ACT < 150 seconds: administer 70 IU/kg; ACT 150 - 199 seconds: administer 50 IU/kg. The initial ***UFH*** bolus dose should not exceed 7000 IU.

Check ACT prior to arterial sheath removal: do not remove sheath unless ACT ≤ 180 seconds. Initial half-life is less than 10 minutes.

INOTROPES

Dobutamine (*Dobutrex*®)

Dobutamine is a sympathomimetic agent with direct effects on β_1-adrenergic receptors, which confer upon it a prominent inotropic action on the heart. Supplied as 250 mg in 20 ml vials.

6x body weight of ***dobutamine*** (in mg) is diluted to a total volume of 100 ml with 5% ***glucose***, this allows 1 ml/hr = 1 µg/kg/min.

Dopamine (*Intropin*®)

3x body weight of ***dopamine*** (in mg) is diluted to a total volume of 50 ml with 5% ***glucose***, this allows 1 ml/hr = 1 µg/kg/min. Change solution every 24 hours.

Compatible with ***dobutamine*** via Y site. Incompatible with alkaline solutions e.g. bicarbonate solutions. Best infused into a large vein or centrally as extravasation can cause tissue necrosis. If this occurs, infiltration of the affected area with 10 - 15 ml of 0·9% ***sodium chloride*** containing 5 - 10 mg ***phentolamine mesylate*** may help. A syringe with a fine hypodermic needle should be used to liberally infiltrate the ischaemic area as soon as extravasation is noted.

Adverse effects: The most frequently reported include ectopic beats, tachycardia, anginal pain, palpitations, dyspnoea, nausea, vomiting, hypotension and peripheral vasoconstriction.

In IV doses of 0·5 - 2 µg/kg/min, the drug acts predominantly on dopaminergic receptors; in IV doses of 2 - 10 µg/kg/min, the drug also stimulates β_1-adrenergic receptors. In higher therapeutic doses, α-adrenergic receptors are stimulated and the net effect of the drug is the result of α-adrenergic, β_1-adrenergic, and dopaminergic stimulation. The main effects of ***dopamine*** depend on the dose administered. In low doses, cardiac stimulation and renal vascular dilation occur and in larger doses vasoconstriction occurs.

Dopamine has a plasma half-life of about 2 minutes. Predominantly renally excreted.

Dilute 800 mg in 500 ml or 400 mg in 250 ml (= 1600 µg/ml).

If given peripherally, use a large vein and a dilution of 200 mg in 50 ml (= 4 mg/ml).

Using 200 mg in 50 ml ***Dopamine*** solution the following infusion rates apply:

Dose: 3 µg/kg/min		**Dose: 5 µg/kg/min**		**Dose: 10 µg/kg/min**	
Patient weight (kg)	**Infusion rate (ml/hr)**	**Patient weight (kg)**	**Infusion rate (ml/hr)**	**Patient weight (kg)**	**Infusion rate (ml/hr)**
50kg	2·2	50kg	3·7	50kg	7·5
60kg	2·7	60kg	4·5	60kg	9·0
70kg	3·1	70kg	5·2	70kg	10·5
80kg	3·6	80kg	6·0	80kg	12·0
90kg	4·0	90kg	6·7	90kg	13·5
100kg	4·5	100kg	7·5	100kg	15·0
110kg	4·9	110kg	8·2	110kg	16·5

Dobutamine can be administered as a dilution of 250 mg in 50 ml (= 5 mg/ml).

Using 250 mg in 50 ml ***dobutamine*** solution the following infusion rates apply:

Dose (µg/kg/min)	**Patient's body weight**					
	40 kg	**60 kg**	**80 kg**	**100 kg**	**120 kg**	**140 kg**
2·5	1·2 ml/hr	1·8 ml/hr	2·4 ml/hr	3·0 ml/hr	3·6 ml/hr	4·2 ml/hr
5	2·4 ml/hr	3·6 ml/hr	4·8 ml/hr	6·0 ml/hr	7·2 ml/hr	8·4 ml/hr
7·5	3·6 ml/hr	5·4 ml/hr	7·2 ml/hr	9·0 ml/hr	10·8 ml/hr	12·6 ml/hr
10	4·8 ml/hr	7·2 ml/hr	9·6 ml/hr	12 ml/hr	14·4 ml/hr	16·8 ml/hr
15	7·3 ml/hr	10·8 ml/hr	14·4 ml/hr	18 ml/hr	21·6 ml/hr	25·2 ml/hr

IV DRUG COMPATIBILITY TABLE

	Adrenaline	Amiodarone	Digoxin	Dobutamine	Dopamine	Furosemide	GTN	Heparin	Insulin	Isoprenaline	Lidocaine	Magnesium	Midazolam	Morphine	KCl	Nitroprusside
Adrenaline		?	?	C	?	I	?	?	?	I	I	?	?	?	?	?
Amiodarone	?		?	C	G	I	C	I	G	C	C	?	C	C	C	?
Digoxin	?	?		I	R	C	C	C	R	?	C	I	G	?	C	?
Dobutamine	C	C	I		C	I	C	R	I	C	C	R	R	C	R	C
Dopamine	?	G	R	C		I	C	C	I	?	C	I	G	G	C	C
Furosemide	I	I	C	I	I		C	C	?	I	C	I	I	I	C	?
GTN	?	C	C	C	C	C		C	G	?	C	?	?	G	?	C
Heparin	?	I	C	R	C	C	C		C	C	C	C	C	I	C	C
Insulin	?	G	R	I	I	?	G	C		?	R	C	G	C	C	G
Isoprenaline	I	C	?	C	?	I	?	C	?		?	C	?	?	C	?
Lidocaine	I	C	C	C	C	C	C	C	R	?		?	?	R	C	C
Magnesium	?	?	I	R	I	I	?	C	C	C	?		C	C	C	?
Midazolam	?	C	G	R	G	I	?	C	G	?	?	C		C	C	G
Morphine	?	C	?	C	G	I	G	I	C	?	R	C	C		C	G
KCl	?	C	C	R	C	C	?	C	C	C	C	C	C	C		?
Nitroprusside	?	?	?	C	C	?	C	C	G	?	C	?	G	G	?	

I	incompatible
C	compatible in saline and glucose
G	compatible with glucose only
S	compatible in saline only
R	compatibility is conditional, consult pharmacy
?	no information available

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