

Auscultation - Dx

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CIRCULATORY SYSTEM

Auscultation of thorax

IM-WW 139; I2M 8; Cat 822; H-Pic 24; H-T/M 9;
VC-Dx 208; H2B 6; H-hb 7; Pys-B 180; NB 3.4

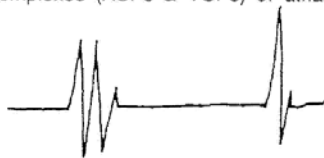
• Heart auscultation essential - standing

- Artifacts (respiratory sounds, shivering & twitching, purring, crackling due to hair coat & external noises in the room)
- Heart rate (HR) & rhythm
 - . Changes in HR & rhythm due to respiration (normal)
- Heart sounds: normal & abnormal, loudness
- Listen at 4 valve areas - PMI, thoracic inlet & sternum
- Lung auscultation in heart problems:
 - ↑ Pulmonary sounds (crackles & wheezes)
- Pulse (femoral) & heart rate
 - Normal: pulse for every heart beat or something is wrong (pulse deficit = arrhythmia), caused by heartbeat before complete filling of ventricles
 - Pulse deficits: indicate incomplete ventricular filling (atrial fibrillation, ventricular premature complexes & atrial premature complexes)
 - Pulse irregularities: cyclic in sinus arrhythmias & noncyclic w/ other arrhythmias (atrial fibrillation)
 - Low intensity pulse - premature complexes (ACPs & VCPs) or atrial fibrillation



Percussion of thorax: difficult

- Determine masses or fluid lines
- Requires practice - difficult technique



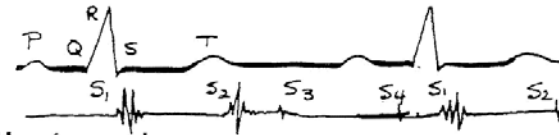
Valvular dzs

- Endocardiosis
- Congenital aortic stenosis
- Congenital pulmonic stenosis
- Congenital AV valve dysplasia
- Bacterial endocarditis
- AV valvular regurgitation due to cardiomegaly

PMI heart valves (point of maximum intensity)

(Rule of thumb: left P^AM 3⁴5)

- Pulmonic valve - low lt. 3rd ICS (intercostal space)
- Aortic valve - high lt. 4th ICS
- Lt. AV (mitral) valve - low lt. 5th ICS
- Rt. AV (tricuspid) valve - rt. low 4th ICS



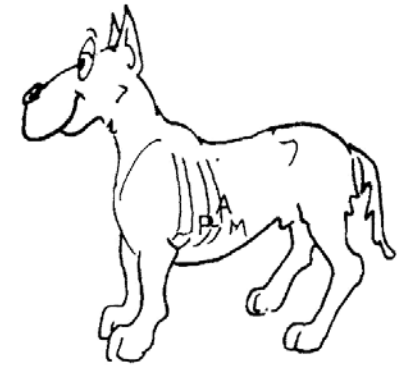
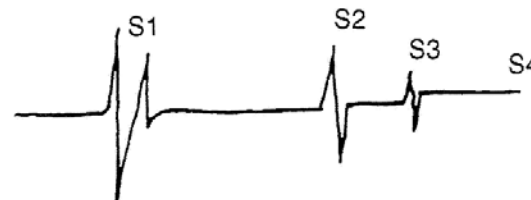
Heart sounds

• Normal

- S1 (lub): closure of AV valves (start of ventricular systole)
- S2 (dub): closure of semilunar (aortic & pulmonic) valves (start of ventricular diastole)

• Abnormal heart sounds

- Split S2 due to delayed closure of a semilunar (aortic or pulmonic) valve, most commonly w/ HWD (heartworm dz)
- S2 may be absent in arrhythmias if the ventricles do not fill adequately (semilunar valves don't open)
- Diastolic
 - . Gallop rhythm S3 & S4 sounds (early heart failure)
 - .. S3: associated w/ rapid ventricular filling - dilated ventricle (mitral insufficiency or cardiomyopathy)
 - .. S4: due to atrial contraction (hypertrophy or AV dysplasia)
 - .. Low frequency - bell of stethoscope
- Systolic clicks (may suggest lt. AV [mitral] valve problems)



Left P^AM 3⁴5

Valves of heart: prevents retrograde (regurgitation) flow

- Rt. & Lt. atrioventricular valves (AV): prevent backflow of blood into atria during ventricular systole
 - Rt. AV ("tricuspid") valve Rt. 4th low
 - Lt. AV ("mitral/bicuspid") valve Lt. 5th low
- Pulmonic & aortic semilunar valves, prevent backflow of blood into ventricles during ventricular diastole
 - Pulmonic valve Lt. 3rd low
 - Aortic valve Lt. 4th high

Valve dysfunction

- Stenosis: obstruction of flow (usually congenital)
- Regurgitation (insufficiency): incomplete closure of valve (congenital or acquired)

Murmurs

M8k 76; H2B 95t; IM 10;

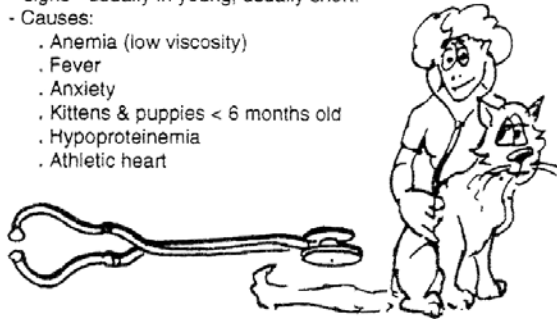
SAP 453; Pys-B 180; NB 3.4;

• Hallmark of valvular diz

- Due to turbulent blood flow over valve
- Severity of diz & severity of murmur are not correlated
- Progression of murmur over time indicates progression of diz
- Innocent or physiologic murmurs needn't be worked up, note & check over time

- Examples would be low grade murmur with no other cardiac signs - usually in young, usually short.
- Causes:

- . Anemia (low viscosity)
- . Fever
- . Anxiety
- . Kittens & puppies < 6 months old
- . Hypoproteinemia
- . Athletic heart



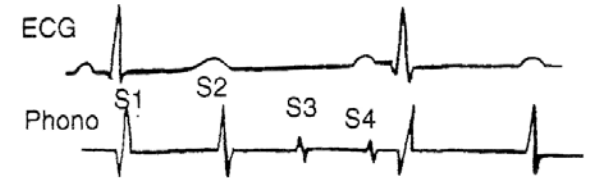
• Murmurs to work up with ECG, Rads, Echo

- +Cardiac diz CS
- Continuous or diastolic murmur
- Gallop rhythm
- Pulse deficit
- Progression of murmur
- Murmur when anesthesia contemplated (↑ risk)
- Grade 2-6: check for cardiac diz (enlarged atria)
- . Extra caution if clinical signs of heart diz

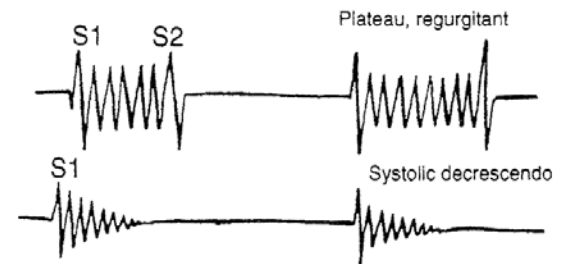
Grading of cardiac murmurs

Grade 1/6	Very soft, minutes to hear in a quiet room
Grade 2/6	Soft murmur, but definite
Grade 3/6	Moderate
Grade 4/6	Loud, no precordial thrill
Grade 5/6	Loud w/ palpable precordial thrill
Grade 6/6	Loud, precordial thrill & heard w/ stethoscope off chest wall

Shapes of murmur (phonocardiogram)



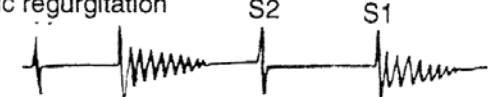
- Systolic - Plateau, regurgitant
- Systolic - Decrescendo
- AV valve regurgitation, ventricular septal defect



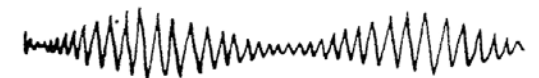
- Crescendo-decrescendo (diamond)
- Aortic or pulmonic stenosis



- Diastolic decrescendo - uncommon
- Aortic regurgitation



- Continuous (machinery)
- Patent ductus arteriosus



Pathologic murmurs: stenosis, regurgitation, shunts

• Systolic murmur

- Lt. AV (mitral) regurgitation	Lt. 5th low (Lt. apex)	Plateau or decrescendo	Harsh, blowing, rarely musical "whoop"
- Aortic stenosis	Lt. 4th high	Diamond (crescendo-decrescendo)	
- Pulmonic stenosis	Lt. 3th low	Diamond (crescendo-decrescendo)	

- Rt. AV regurgitation	Rt. 4th low	Plateau or decrescendo	(Low-pitched harsh blowing)
- VSD (ventricular septal defect)	Right side	Plateau or decrescendo	

• Diastolic murmur

- Aortic valve regurgitation	Left side	Decrescendo (prominent pulse)	
• Continuous (diastolic - systolic)			
- Patent ductus arteriosus	Left side	#1 CHD (dog), "machinery murmur"	

Atrial septal defect, pulmonic regurgitation, Tetralogy of Fallot are rare causes of murmurs

Radiography

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CIRCULATORY SYSTEM

Radiographs - Heart:

X4T 335; X-Ger 144, 234(f); Cat 826; F3IM 249; IM-WW 144; H-Pic 32

- At least 2 views - Lat. (lateral) & DV (dorsoventral) - at peak inspiration

Survey films for:

- Cardiac enlargement (true or distention of pericardial sac)
- Chamber enlargement (rarely just one - usually 2 or all 4)
- Pulmonary edema (alveolar pattern/air bronchograms)
- Pleural effusion (interstitial pattern: more opaque, vessels fuzzy)
- Pulmonary congestion (vascular pattern, enlarged vessels)
- Peritoneal effusion (ascites) (ground glass)
- Hepatomegaly



LATERAL VIEW

- a. Cranial vena cava: ventral edge seen
- b. Caudal vena cava: between heart & diaphragm
- c-e. Right side heart: 6 to 11 o'clock - cranial aspect
- c. Right atria (RA): upper part of the cranial heart
- d. Right ventricle (RV): 6 to 9 o'clock - lower cranial heart
- e. Pulmonary trunk (main pulmonary artery [MPA] to radiologists): not seen on lat. view (superimposed)
- f-g. Left heart: 1 to 6 o'clock - caudal aspect
- f. Left atrium: 1 to 3 o'clock - upper, caudal heart
- g. Left ventricle: 3 to 6 o'clock - ventral, caudal heart & apex
- g'. Apex: 5 o'clock
- h. Aortic arch: 11 to 12 o'clock - out of heart base
- i. Brachiocephalic trunk & lt. subclavian a.: not seen, unless pneumomediastinum
- j. Descending aorta: high against the vertebrae
- k. Cranial waist: 9 o'clock - between the cranial vena cava & right atrium
- l. Caudal waist: 3 o'clock - coronary groove
- m. Sternopericardiac ligament: pericardium to sternal floor
- n. Trachea
- n' "Carina": bifurcation of trachea

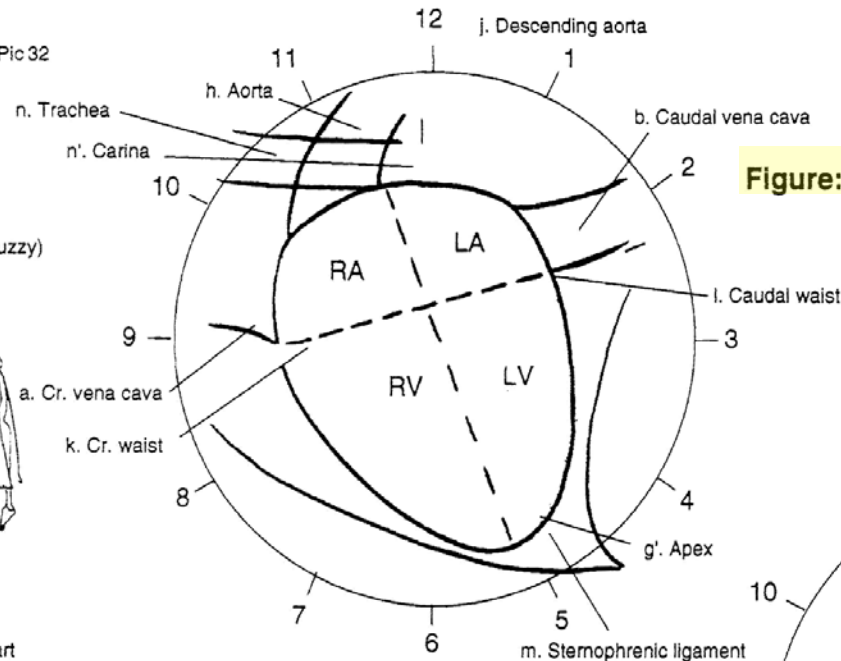
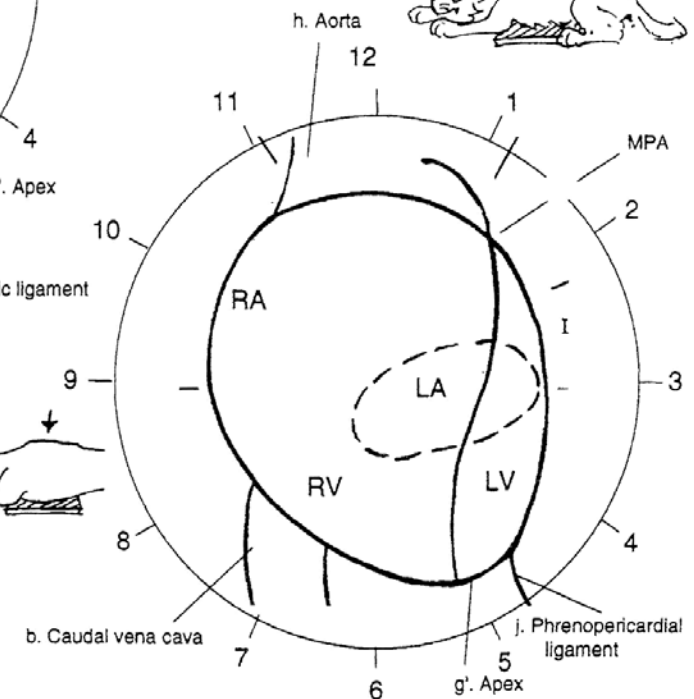


Figure: lateral radiographic view

Figure: DV radiographic view

DV VIEW:

- a. Cranial vena cava: not seen
- b. Caudal vena cava: right heart to diaphragm
- c. Right atria: 9 to 11 o'clock
- d. Right ventricle: 6 to 9 o'clock
- e. Pulmonary trunk (MPA): 1 to 2 o'clock
- f. Left atrium: 2 to 3 o'clock, superimposed unless enlarged
- g. Left ventricle: 2 to 6 o'clock
- g'. Apex: 5 o'clock - points to the left
- h. Aortic arch: not 11 - 1 o'clock position
- i. Descending aorta: left edge seen
- j. Phrenicopericardiac ligament: left mediastinal margin



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Heart chamber enlargement - indicates:

Lateral view

- Elevation of trachea
- Loss of cranial waist
- Apex off the sternum
- Backwards "D"
- Apex off sternum
- Separation of main stem bronchi
- Loss of caudal cardiac waist
- Bowing caudally - 3 to 5 o'clock
- > 3 sternbrae contact

Any chamber
RAE
RVE
RVE
LAE
LAE
LVE
RVE

DV view

- 9 to 11 o'clock bulge
- Backwards "D" - 6-9 o'clock
- Apex to left
- "Cowboy legs" (main bronchi)
- 3 to 5 o'clock bulge
- Apex to right

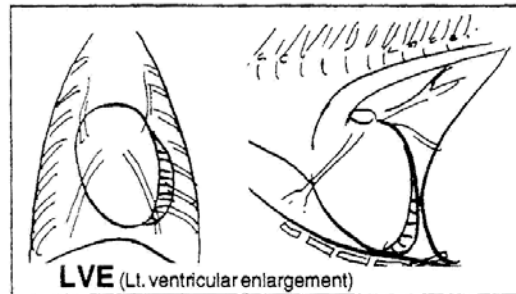
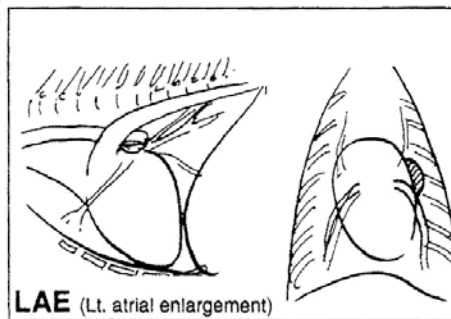
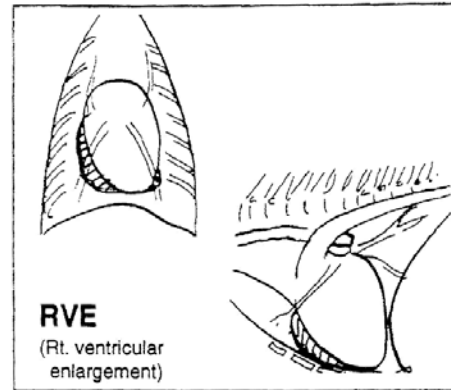
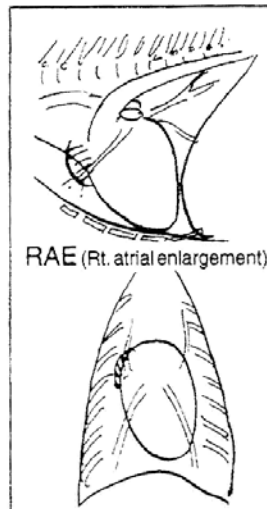
RAE
RVE
RVE
LAE
LVE
LVE

RAE Lat view Elevation of trachea (carina)
Loss of the cranial waist
DV view 9 to 11 o'clock bulge

RVE Lat. view 6 to 9 o'clock bulging
More sternal contact
Trachea & carina elevation
Apex elevation off sternum
DV view 6 to 9 o'clock bulge (backwards or reverse "D")
Apex more to left

LAE Lat. view Elevated trachea & carina
Separation of mainstem bronchi (left above right)
DV view 2 to 3 o'clock bulge (auricle)
"Cowboy legs" (spread mainstem bronchi)

LVE Lat. view Loss of caudal waist
3 to 6 o'clock bulging
DV view Rounding 3 to 5 o'clock
Apex shifted to right



2/5-3/5 rule: Draw a line from the "carina" of the trachea to heart apex (lateral view)

- > 2/5th of the heart in back of the line = Lt. heart enlargement
- > 3/5th of the heart in front of the line infers rt. heart enlargement

Major vessels

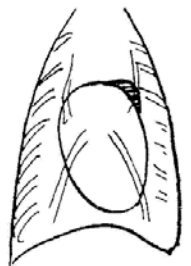
• Enlarged aortic arch

- Findings:
 - . Lat.: elongated cardiac silhouette, protrusion of cranial heart border 11-1 o'clock
 - . DV: widened aortic arch 11-1 o'clock
- Causes
 - . Patent ductus arteriosus
 - . Aortic stenosis
 - . Aortic aneurysm



• Enlarged pulmonary trunk (MPA/main pulmonary artery, pulmonary artery segment)

- Findings
 - . DV/VD: 1-2 o'clock bulge
- Causes:
 - . Pulmonic stenosis
 - . Heartworm
 - . Patent ductus arteriosus
 - . Septal defects w/ left to right shunting (VSD, ASD)



Radiography

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CIRCULATORY SYSTEM

Radiographs - Chest & Abdomen

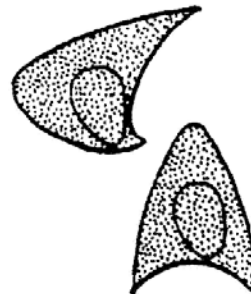
X-RP 101, 109, 123; X-T 353; I2M 30

- Chest is evaluated for air & fluid in lungs & fluid in pleural space
- Abdomen is evaluated for ascites (peritoneal fluid) due to right heart failure & back up of fluid into abdomen
- If labored breathing (dyspnea) take a DV view instead of a VD view so animal is not further compromised

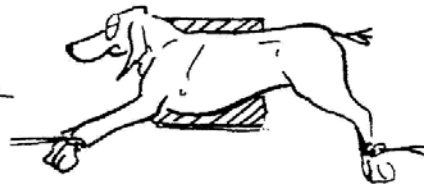
Pulmonary edema

- Usually caused by congestive left heart failure - fluid backs up into the pulmonary circulation, may also have noncardiogenic causes
- Types of pulmonary edema
 - **Interstitial edema** - fluid in lung tissue (parenchyma)
 - Vessels fuzzy, but evident
 - More opaque lung field - linear or nodular, greater in perihilar area
 - Air still evident in lung
 - **Alveolar edema** - alveoli filled w/ fluid
 - Opaque lung field - "fluffy", ill defined radiopacity
 - No air in lungs
 - **Air bronchograms** (black worm holes in white patches)
 - **No vasculature seen**

Interstitial pattern



Alveolar pattern



Pulmonary circulation

• Under circulation (hypovascularity)

- Findings: more radiolucent lung fields

• Pulmonary arteries smaller than veins

- Causes:

- Right to left shunt
- Pulmonic stenosis
- Hypovolemic shock (small heart)
- Adrenal insufficiency (small heart)

- DDx:

- Emphysema
- Over inflation
- Overexposure



• Overcirculation

- Findings

• Arteries larger than veins

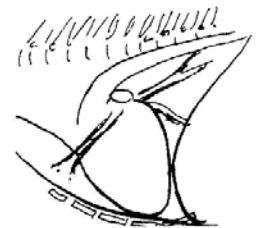
- More opaque lungs

- Causes:

- Heartworm
- PDA (patent ductus arteriosus)
- Left to right shunts (VSD, ASD)
- Congestive heart failure
- Fluid overload

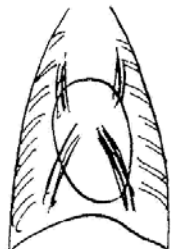
- DDx

- Expiratory radiograph
- Underexposure



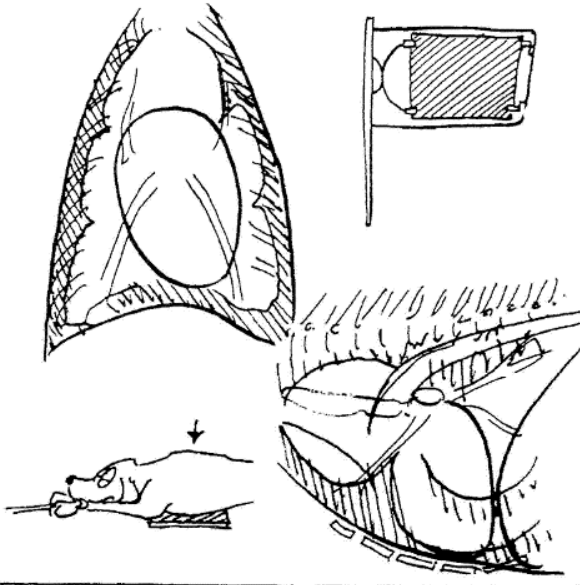
Memory aid :

Veins are ventral & central



Pleural (hydrothorax) effusion

- Right heart failure causes blood to back up into pleural space as well as the rest of body
- Lateral view - recumbent
 - ↑ Opacity to ventral thorax
 - Scalloped appearance (fluid in fissures of lungs)
- DV view
 - **Retraction of lungs from thoracic wall**
 - Blunting of costophrenic angles
 - Widening of mediastinum
 - **Scalloped appearance**
 - Blurring/disappearance of cardiac shadow



Ascites (fluid in peritoneal cavity) & hepatomegaly

- Right heart failure causes fluid to back up into the body (systemic veins)

DDx - Pulmonary edema

• Cardiac causes - left side failure (backs up into lungs)

- Cardiogenic edema w/ visible cardiomegaly
 - Chronic mitral valve dz
 - Cardiomyopathy
 - Ruptured chordae tendineae
 - Heart block
 - Left to right shunts

• Cardiogenic edema w/o cardiomegaly

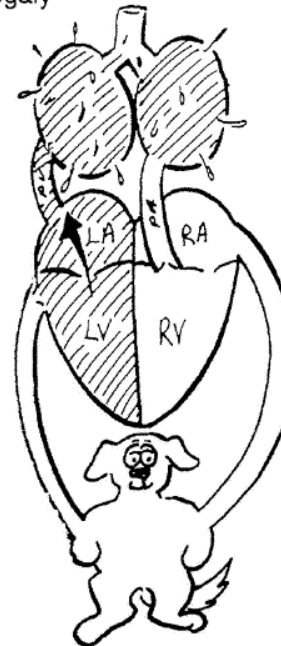
- Electrical shock
- Cardiomyopathy in some cases
- Trauma
- Tachyarrhythmias or heart block
- Myocardial depressants

• Noncardiogenic edema

- Infection
- Toxic (smoke, endotoxins, venom, ANTU)
- Allergy, anaphylaxis
- Trauma
- Uremia
- Over transfusion
- Lymphatic obstruction
- Venous obstruction (tumors masses)
- Hypoalbuminemia (nephrosis, liver failure, enteropathies)
- Neurogenic (head trauma, encephalitis, brain tumors)

• ↑ Tissue density, not fluid mistaken for edema

- Interstitial fibrosis
- Interstitial pneumonia
- Atelectasis
- Allergic conditions
- Lung worms



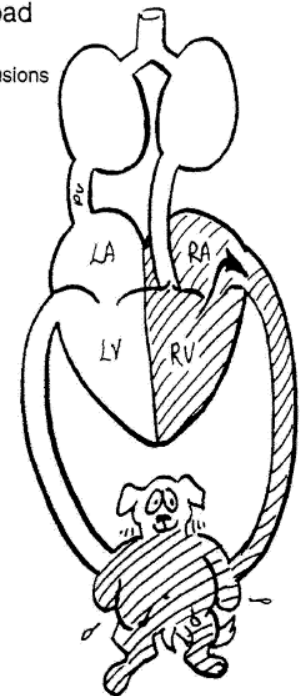
DDx - Pleural effusions - hydrothorax - Ascites

• Right sided failure

- Rt. AV (tricuspid) valve regurgitation
- Pulmonic stenosis
- Heartworm
- Pericardial effusion or pericarditis
- Tetralogy of Fallot
- Uremia
- Hypoproteinemia
- Fluid overload

Other pleural effusions not considered:

- Pyothorax
- Hemothorax
- Chylothorax
- Neoplasia
- Pleuritis



Echocardiography

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CIRCULATORY SYSTEM

Echocardiography (Cardiac Ultrasound/US/Echo)

H-T/M 80, 474; H-hb 31; IM 30; SAP 448, 501; I2M 40; Cat 835;
IM-WW 146; H-Pic 43

Types of cardiac US (ultrasound)

• M-mode (motion)

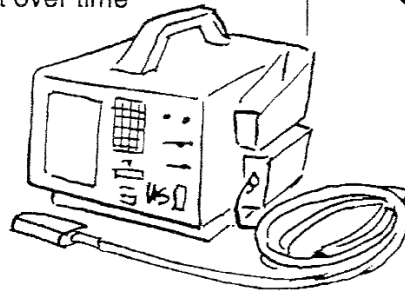
- Ice pick images of heart
 - . Gives lines for ventricles, left atria, aorta, valves
- Requires viewing movement of heart over time
- Uses:
 - . Measuring cardiac wall thickness
 - . Chamber size
 - . Cardiac contractility (i.e., fractional shortening)
 - . Valve in motion

• 2D (two-dimensional) or grey scale

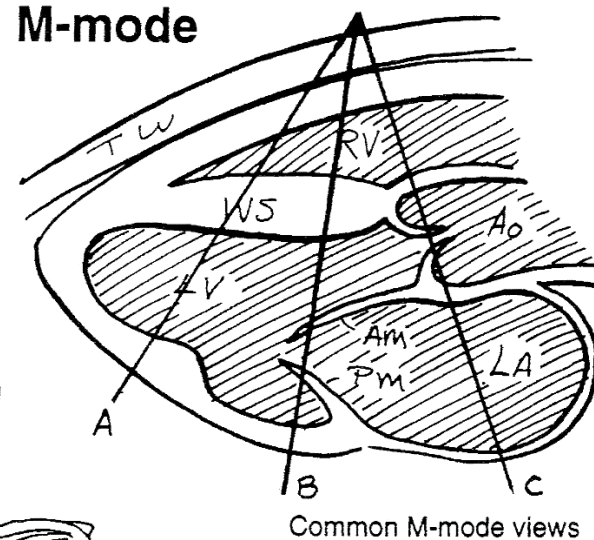
- "Pie section" view of heart
- Both real time & static images
- Uses:
 - . Overall impression of cardiac chamber size & motion
 - . Valvular structure & function

• Doppler: ultrasonic cinetoarteriography

- Compares frequency of transmitted ultrasound w/ received US of moving cells (blood cells), cells moving towards transducer have higher frequency than those moving away
- Used to estimate velocity of blood flow



M-mode



AMV	Anterior septal mitral valve cusp
Ao	Aorta (M)
APM	Anterior papillary muscle
IVS	Interventricular septum
LA	Left atrium
LC	Left cusp of aortic valve (2D)
LV	Left ventricle
LVW	Left ventricular wall
NC	Noncoronary cusp of aortic valve (2D)
PMV	Posterior mitral valve cusp
PPM	Posterior papillary muscle
PV	Pulmonic valve (2D)
RA	Right atrium
RC	Right cusp of aortic valve (2D)
RVW	Right ventricular wall
TV	Tricuspid (Rt AV) valve
TW	Thoracic wall

Fig. A Apex

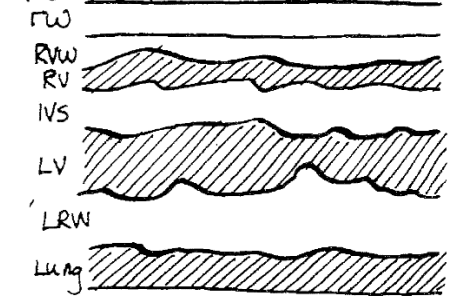


Fig. B Lt AV valve

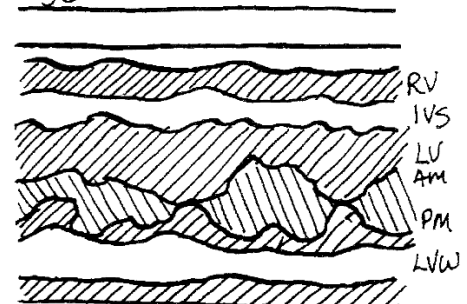
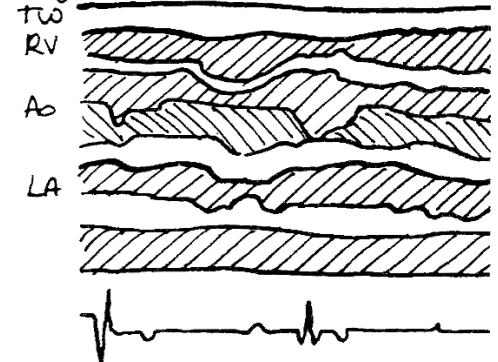


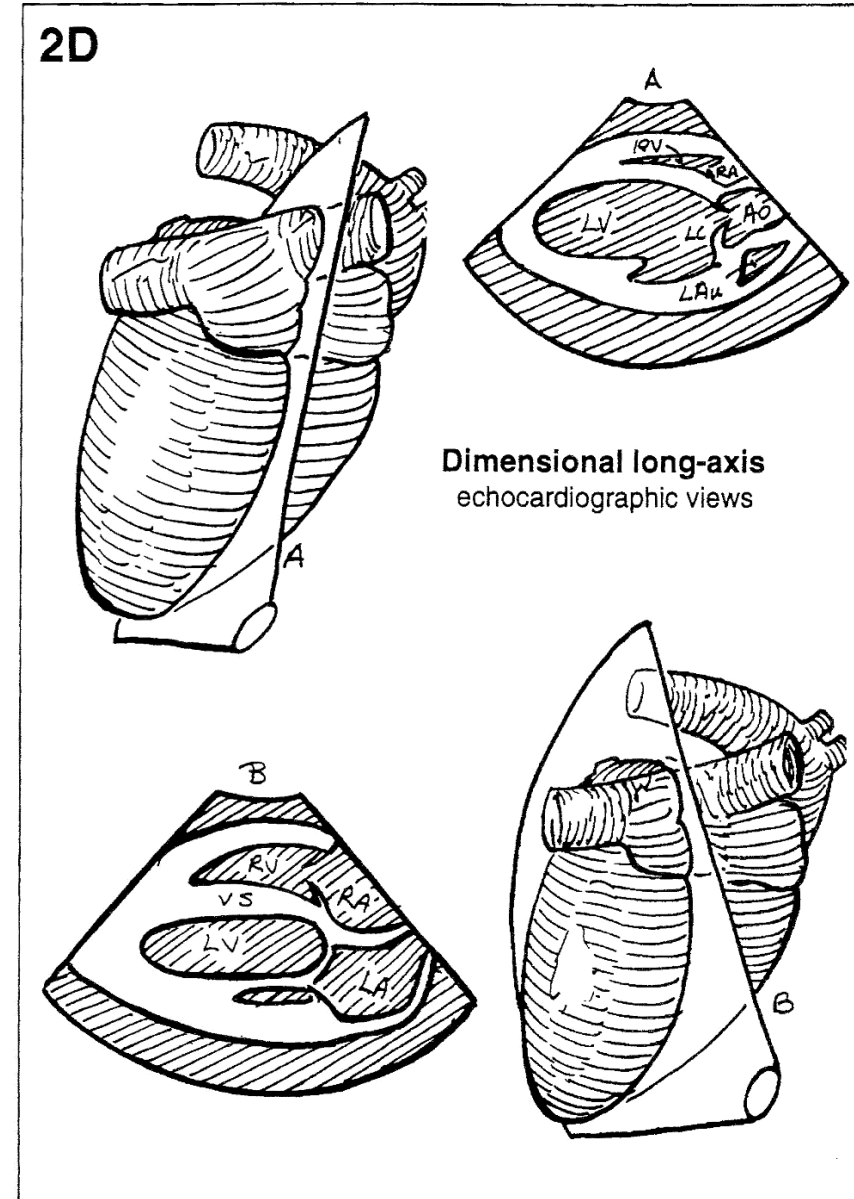
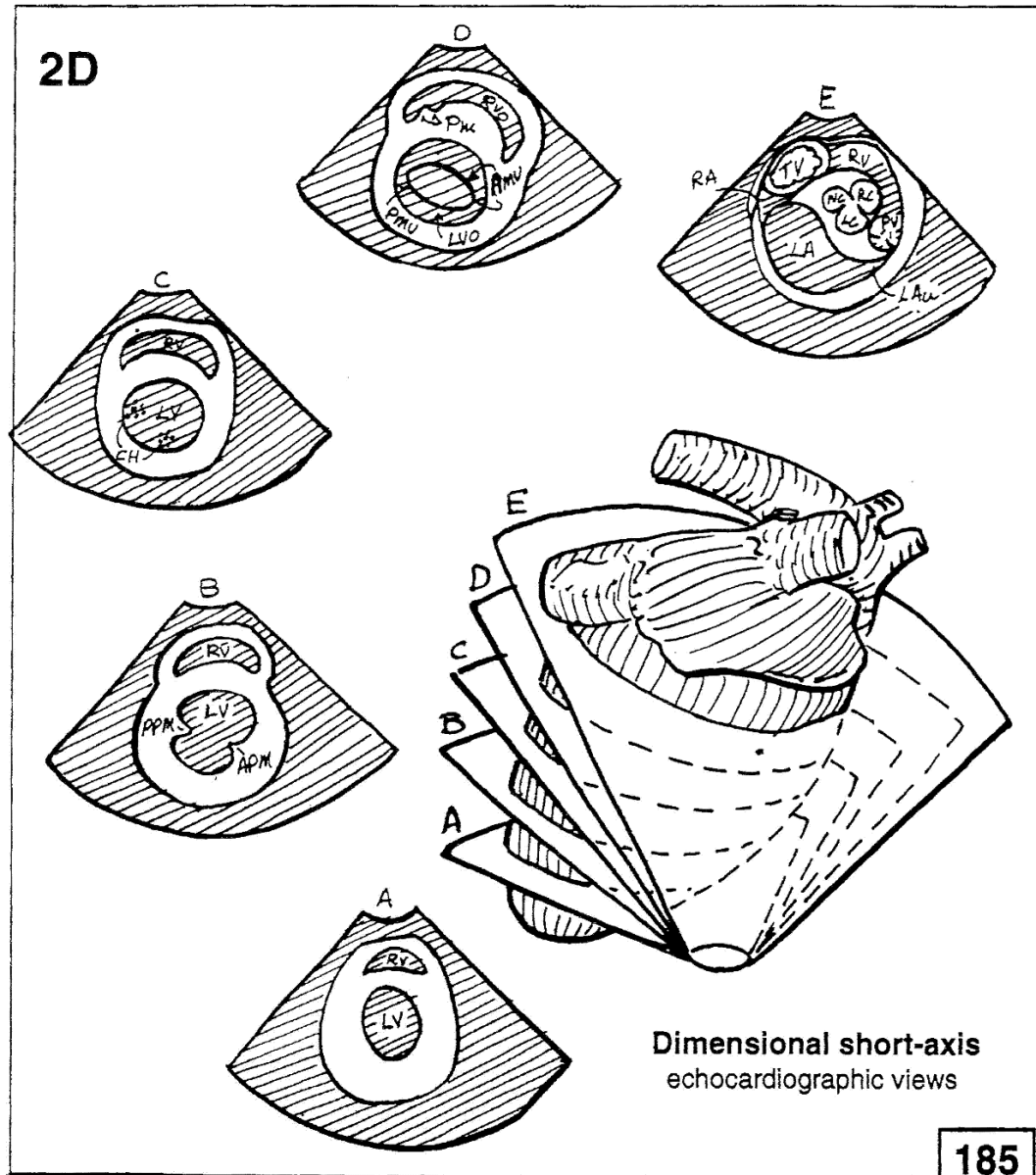
Fig. C Aortic valve



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ECG

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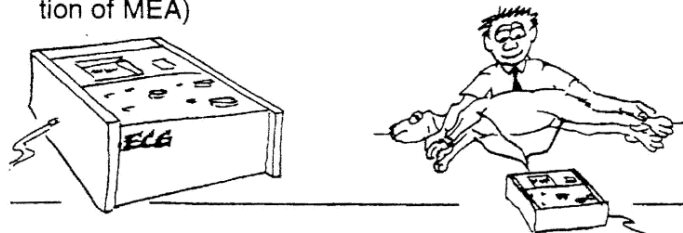
CIRCULATORY SYSTEM

Electrocardiography, ECG

SAP 412; H-T/M 47, 474; H2B 72; I2M 13; IM-WW 140; CAT 837; H-HB 17; H-F 43, 113; H-T 8; H-Pic 37; Pys-B 142, 159, VC-Dx 217

- Graphic representation of electrical activity of the heart
- Electrocardiograms (ECGs): graphs of activity
- **ECG analysis:** evaluate from left to right in basic limb leads (I, II, III, aVR, aVL & aVF), compare to normal values

1. **Calculate heart rate** (50 mm/sec): count complexes between 3 markers (3 sec), multiply by 20
2. **Determine rhythm** (measure & compare distance between successive R waves)
 - Sinus rhythm = "P" wave for every "QRS" complex; normal & consistent "P-R" & "R-R" intervals, Sinus arrhythmia: constant P-R interval, but variable R-R intervals
 - Dysrhythmia = no "P" wave for every "QRS" complex, short, long or inconsistent "P-R" intervals
3. **Measure complexes & intervals** for height & duration
 - P-R interval - determine
 - QT interval - determine
 - S-T segment - evaluate
 - Compare to normal values (heart rate, rhythm & sizes)
4. **Determine mean electrical axis (MEA)** in frontal plane for ventricular chamber enlargement (find isoelectric lead [equally positive or negative, or 0], find perpendicular lead, if negative or positive deflection indicates direction of MEA)



Normal dog & cat ECG values (τ 60) Speed: 50 mm/sec, Sensitivity: 1 mv = 10 mm

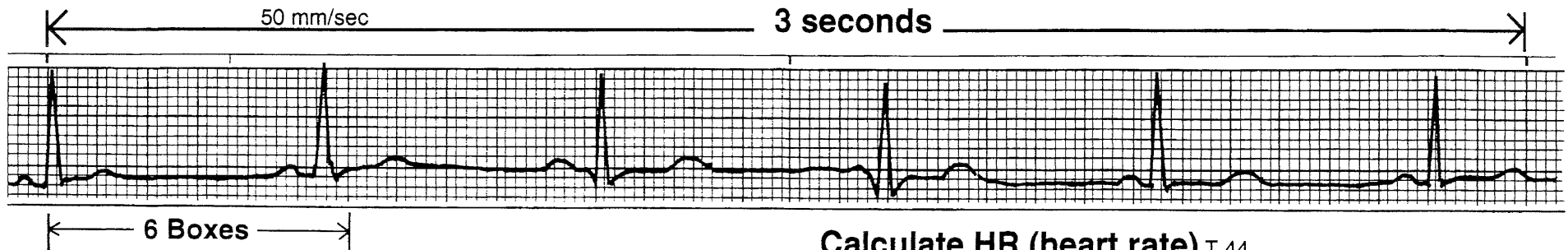
	Canine	Feline
Heart rate (HR) bpm (beats per min)	Standard: 70-160 bpm Puppies: up to 220 bpm Toy breeds: up to 180 bpm Giant breeds: 60-140 bpm	120-200 bpm
Rhythm	Sinus rhythm Sinus arrhythmia Wandering pacemaker	Sinus rhythm
P wave Height Width	≤ 0.4 mV (< 4 boxes) 0.04 sec (< 2 boxes)	≤ 0.2 mV (< 1 box) ≤ 0.04 sec (< 2 boxes)
PR interval	0.06-0.13 sec (3-6.5 boxes) > 0.13 in giant breeds (> 6.5 boxes)	0.05-0.09 sec (2.5- 4.5 boxes)
QRS complex Height Width	Small breeds: ≤ 2.5 mV 3rd° 25 boxes) Large breeds: ≤ 3.0 mV (≤ 30 boxes) Small breeds: ≤ 0.05 sec (≤ 2.5 boxes) Large breeds: ≤ 0.06 sec (≤ 3 boxes)	≤ 0.9 mV (≤ 9) < 0.04 sec (2 boxes)
S-T segment Depression Elevation	No more than 0.2 mV (2 boxes) No more than 0.15 mV (1.5 boxes)	None None
Q-T interval	0.15-0.25 sec (normal HR) (7.5-12.5 boxes)	0.12-0.18 sec (normal HR) (6-9 boxes)
T wave	Positive or negative	Usually positive
Electrical axis	+ 40 to + 100°	0° to + 160°



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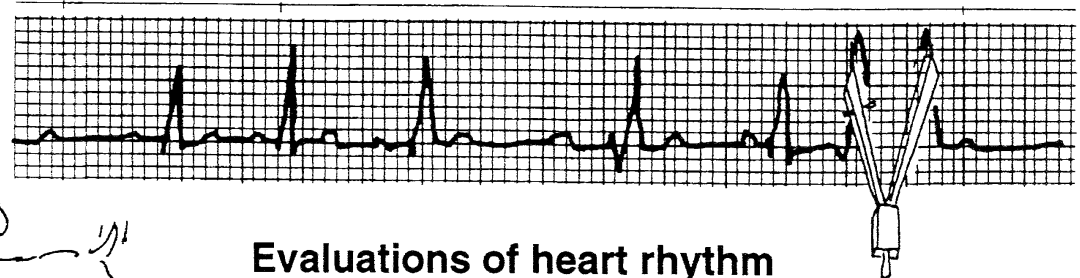
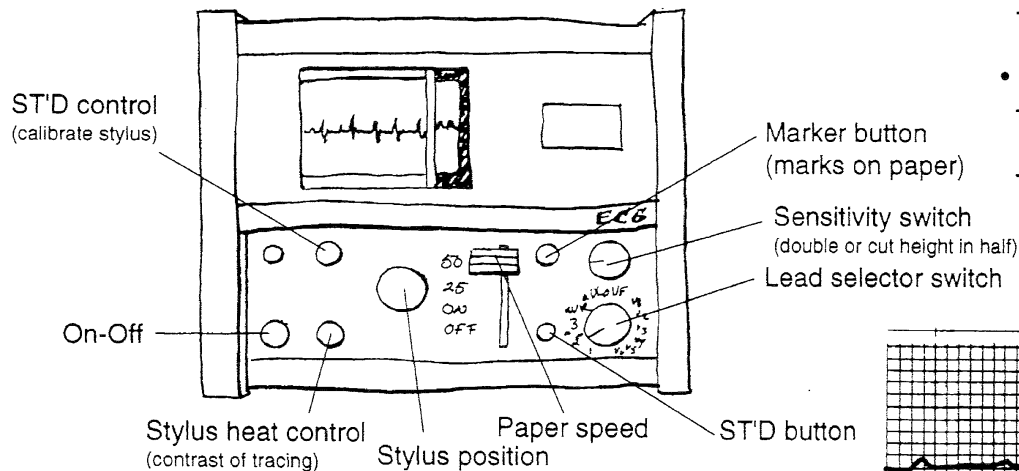
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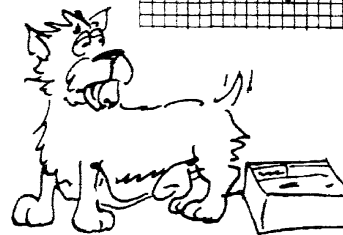
Calculate HR (heart rate) T 44

- Irregular rates
 - Count R-R intervals in 3 seconds (2 sets of time markers at 50 mm/sec)
 - Multiply by 20 6 complexes x 20 = 120
- Regular rates
 - Count number of large boxes in 1 R-R interval
 - Divide into 600 600/6 = 100
 - Count number of small boxes in one R-R interval
 - Divide into 3000 3000/27 = 111



Technique to record an ECG

- Right lateral recumbency (if dyspnic or if restraint is dangerous, any comfortable position is used for lead II)
- Wet skin w/ alcohol or ECG electrode gel
- Attach electrodes at elbows & stifles
- Hold upper limbs perpendicular to long axis of animal & parallel to floor so limbs don't contact
 - Thoracic limbs must be parallel or alters mean electrical axis
- Record: push standard calibration button at beginning of each recording
 - ≥ 3-4 complexes in each of 6 limb leads
 - A long lead 2 [II] strip for rhythm evaluation



Evaluations of heart rhythm

- General inspection: for normal sinus rhythm or cardiac arrhythmia
- Identify P waves & QRS complexes
- Measure between successive R waves or P waves (w/ calipers or marks on a card)
- Compare distances between other waves

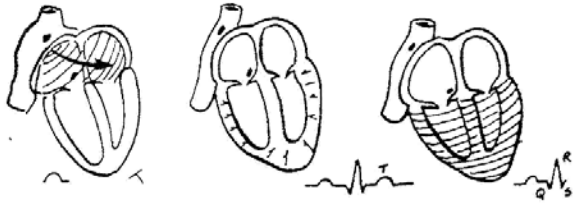
ECG

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CIRCULATORY SYSTEM

ECG - What it indicates T-10, 48; I2M 13; CAT 837

P wave:	Depolarization of atria
P-R interval:	Delay of impulse through AV node & bundle of His
QRS complex:	Ventricular depolarization
- Q wave:	Depolarization of septum
- R wave:	Depolarization of left ventricle
- S wave:	Depolarization of right ventricle
S-T segment:	Interval of ventricular systole
T wave:	Repolarization of ventricles
Q-T interval:	Ventricular depolarization & repolarization

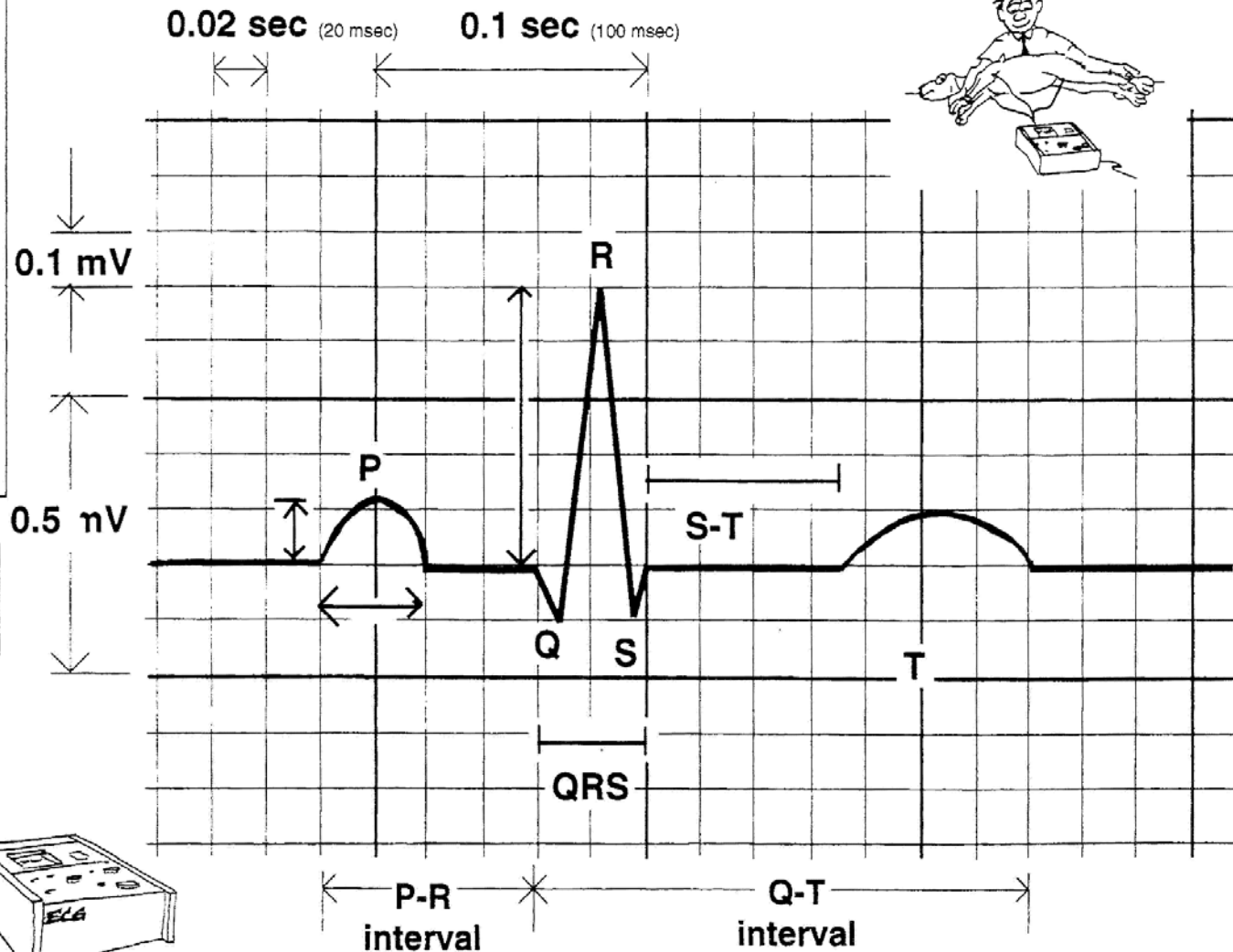
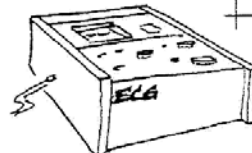


Evaluation of this ECG

Paper speed of 50 mm/sec

Time in sec.: horizontal axis 0.02 sec (20 msec)
Voltage: vertical axis 0.1 mV/box

P wave	0.04 sec (40 msec), 0.12 mV
P-R interval	0.08 sec (80 msec)
R	0.5 mv
Q	-0.1 mv
S	-0.1 mv
QRS complex	0.04 sec (40 msec)
S-T segment	No depression or elevation
Q-T interval	0.18 sec (180 msec)
T wave	Positive (0.1 mv)
HR	Need at least 2 QRS complexes to calculate

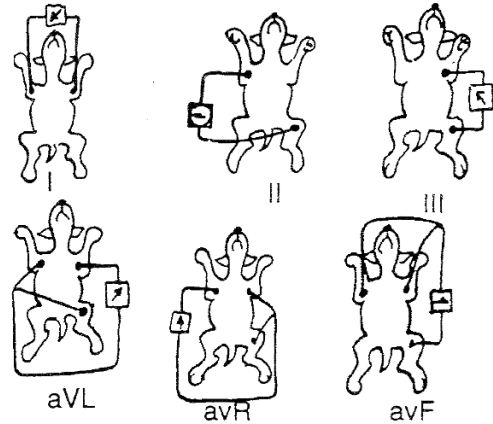


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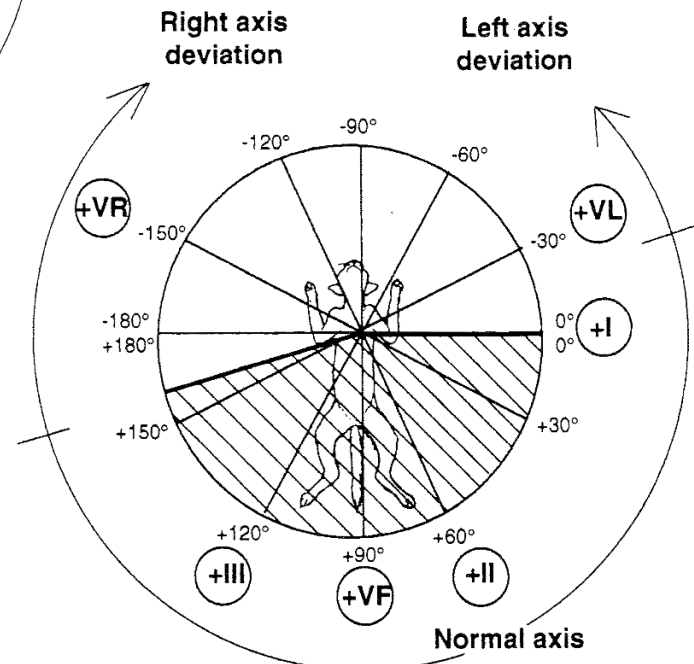
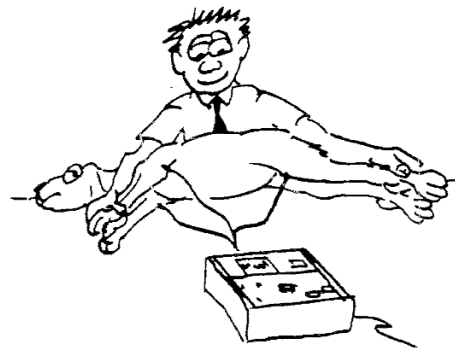
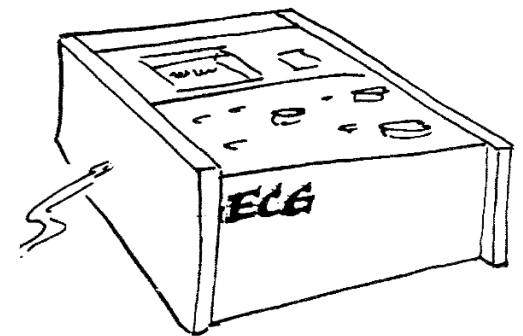
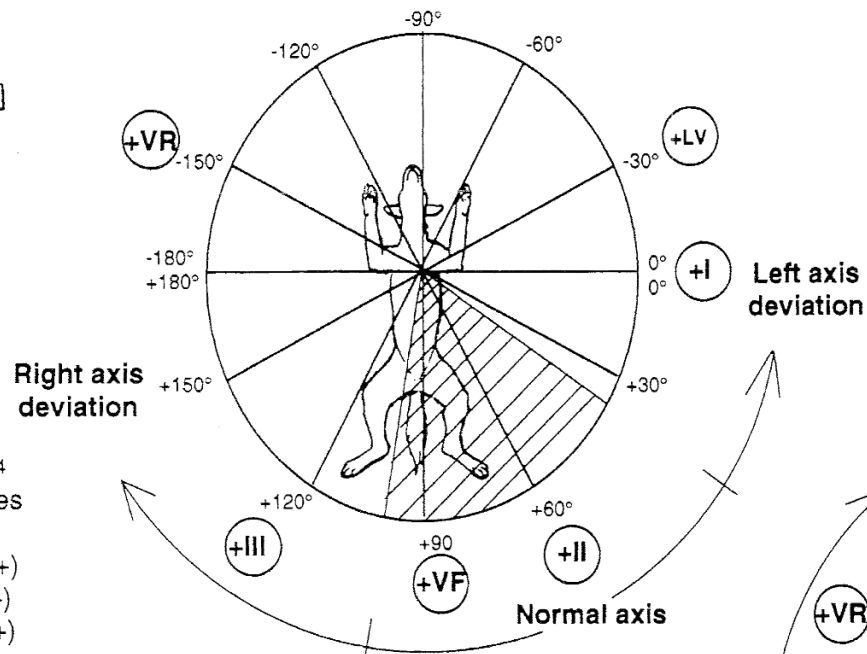
Mean Electrical Axis



Lead system H-F 46; H-T 13, 50; Pys-B 164

- Lead: different angle or pair of electrodes
- Bipolar standard leads
 - Lead I: rt arm (-) compared w/ lt arm (+)
 - Lead II: rt arm (-) compared to lt leg (+)
 - Lead III: lt arm (-) compared to lt leg (+)
- Augmented unipolar limb leads
 - Lead aVR: rt arm (+) compared w/ lt arm (-) & leg (-)
 - Lead aVL: lt arm (+) compared to rt arm & lt leg (-)
 - aVF: lt leg (+) compared w/ rt & lt arms (-)
- Chest leads
 - Lead V1: over dorsal spinous process of 7th thoracic vertebrae
 - rV2 (CV5RL): rt 5th ICS* near sternum
 - V2 (CV6LL): lt 6th ICS near sternum
 - V4 (CV6LU): lt 6th ICS at costochondral junction
- Minimum leads to be recorded for dog & cat : 3 standard leads & 3 augmented unipolar leads
- Lead selector switch to select different combinations
- Other lead systems used for specific conditions
 - Chest leads not needed for every patient
 - Useful when ECG complexes in limb leads are small & difficult to evaluate & to evaluate right heart enlargement

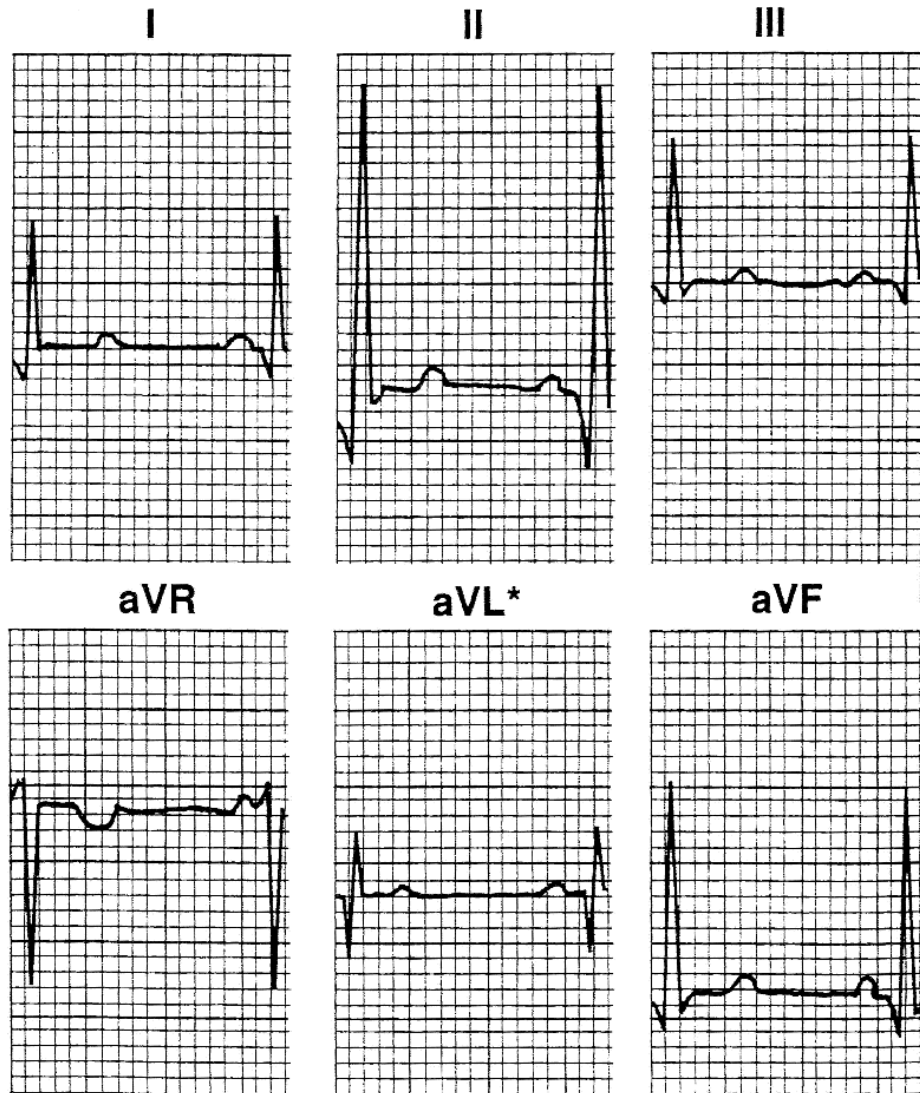
* ICS = intercostal space



Mean Electrical Axis

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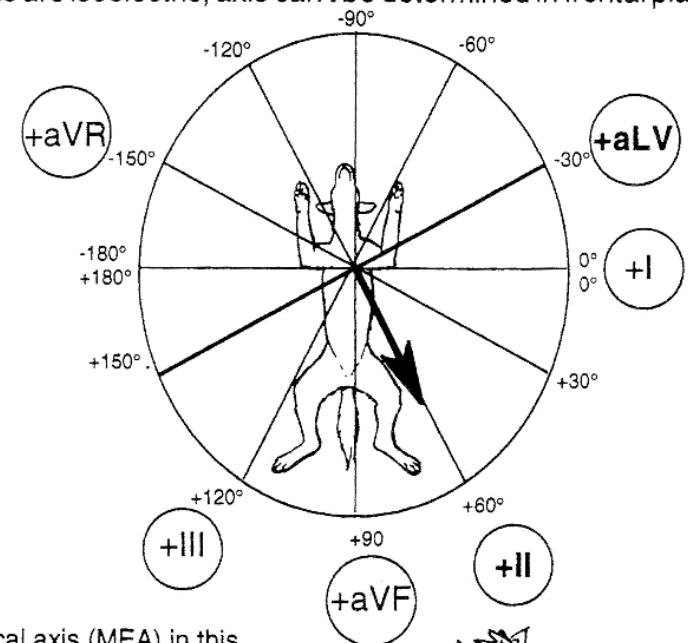
CIRCULATORY SYSTEM



Estimate the mean electrical axis, frontal plane

H-hb 22; H-F 53; T 42

- Identify the isoelectric lead (sum of positive & negative deflections of QRS complexes closest to zero)
- Identify perpendicular lead
- Axis direction of the perpendicular lead - positive or negative
- If all leads are isoelectric, axis can't be determined in frontal plane



Mean electrical axis (MEA) in this canine electrocardiogram

- aVL* is the isoelectrical lead
- II is perpendicular to aVL
- II is positive to axis
- Therefore MEA is +60 (a normal axis)



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Treatment - Heart Diz

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Treatment of heart diz - summary

M8k 66; Mk 13; E-hb 331, SAP 448; IM 148

Treatment remains largely symptomatic

- Major causes of heart failure are still largely unknown (chronic valvular diz [endocardiosis] & cardiomyopathies)
- Some congenital malformations & some pericardial dizes are medically or surgically correctable
- Most heartworm cases are managed medically
- Treatments vary with the stage of diz & the specific cause involved

Goals of heart failure management

- **Symptomatic Tx**
 1. Maintain or ↑ cardiac output
 2. Minimize myocardial oxygen demand
 3. Reduce activity & anxiety
 4. Relieve fluid accumulation (edema)
 5. Control rhythm disturbances
- **Specific Tx: See each disorder**

Desired results of successful Tx

- Comfortable with normal activity or if sedentary existence

Antiarrhythmias H-T/M 376

- **Bradycardia**
 - Sinus bradycardia, arrest or block
 - Atrial/Sinoatrial standstill
 - Sick sinus syndrome (min. schnauzer)
 - 1st degree AV block (asymptomatic)
 - 2nd degree
 - . Mobitz 1
 - . Mobitz 2 (QRS drops)
 - 3rd degree (complete block)
 - Junctional rhythm (neg P waves)
 - Branch blocks (wide QRSs)
- **Tachycardia**
 - Atrial tachycardia (≥ 4 APCs in a row)
 - Atrial fibrillation ("f" waves / no "P" waves)
 - Junctional tachycardia (neg P waves)
 - Ventricular pre-excitement
 - WPW syndrome (Delta waves)
 - Ventricular tachycardia (> 3 PVCs in a row)
 - Ventricular fibrillation (bizarre oscillations)
 - Cardiac arrest

Treatment

Glycopyrrolate (Robinul®)

0.9% NaCl fluid IV

Pacemaker

None

Propantheline (Pro-Banthine®)

Pacemaker

Pacemaker

Propantheline, Stop digitalis

None to Tx underlying cause

Digitalis

Digoxin

Digoxin

Propranolol (Inderal®) (not digoxin)

Lidocaine

Cardiopulmonary resuscitation

CPR - direct current

Robinul



Pro-Banthine



Digoxin



Inderal



Lidocaine

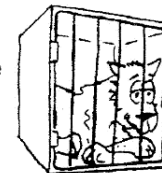


CIRCULATORY SYSTEM

Stages of Congestive Heart Failure

- **Class 1:**
- No CS of failure, ±murmur

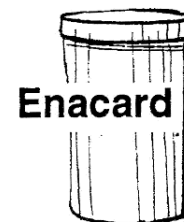
- **Class 2:**
- CS w/ exercise



- **Class 3:**
- CS w/ normal activity or at night



- **Class 4:**
- CS at rest



Treatment summary

(see below for complete)

- **None necessary**
- Consider low Na diet

- **Rest** (exercise restriction)
- **Diet:** low Na diet
- **Diuretics**
- ± (Vaso)Dilators (enalapril)

- **Rest + 3 Ds**
 - Rest (exercise restriction)
 - **Diuretics** (Lasix®)
 - (Vaso)Dilators (enalapril)
 - **Diet** - low sodium
- ± Antiarrhythmics & antitussives
- ± Bronchodilators ± Digoxin

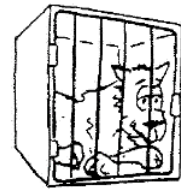
- **Rest + 3 Ds +**
- **Strict rest**
 - **Diet:** low sodium
 - **Diuretics**
 - (Vaso)Dilators: (enalapril)
- **Oxygen**
- If ↓ contractility (Echo)
 - ± Positive inotropes (**Digoxin**)
- ± Bronchodilators
- ± Antiarrhythmics

Treatment of heart diz/heart failure

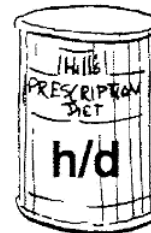
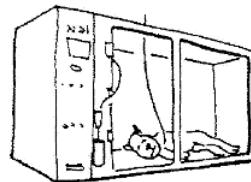
• Rest + "3 Ds", ± O₂, ± digoxin, ± antiarrhythmics

Rule of thumb (modify to specific Dx)

- **Rest & stress management:** to lower demand on heart
- **Diuretics (furosemide/Lasix®):** mainstay of heart failure Tx
 - Relieve fluid accumulation & excessive preload
 - Other diuretics: hydrochlorothiazide, spironolactone
- (Vaso)Dilators: **ACE angiotensin-converting enzyme inhibitors**
 - **Enalapril (Enacard®):** vasodilation & ↓ water & Na retention
 - Other vasodilators:
 - .. Nitroglycerine & other nitrates: acute treatment of pulmonary edema
 - .. Nitroprusside (Nipride®): emergency reduction of blood pressure
 - .. Hydralazine (Apresoline®): be careful of rebound hypotension
 - .. Prazosin (Minipress®): alpha 1 blocker (very hypotensive)
 - .. β adrenergic blockers (propranolol): used for arrhythmias
 - .. Calcium channel blockers (diltiazem) vasodilation & slows heart (↓ O₂ demand): used for hypertrophic cardiomyopathy & arrhythmias
- **Dietary restriction of salt (sodium):** Hill's h/d diet
 - Difficult: nonpalatable, gradually introduce to new diet
- ± **Oxygen therapy:** in acute severe pulmonary edema
- ± **Digoxin** (Lanoxin®, Cardoxin®/digitoxin (Crystodigin®) /positive inotropes (digitalis): improve contractility, backbone of chronic Tx of myocardial failure & most supraventricular arrhythmias
 - Only if ↓ contractility (Echo ± show CRT & weak pulse) or supraventricular tachycardia (slows rate)
 - Other positive inotrope:
 - Dobutamine (Dobutrex®), catecholamines (short term only), isoproterenol, dopamine
 - Diltiazem (Cardizem®) also a vasodilator used in arrhythmias & hypertrophic cardiomyopathy
- **Ancillary therapy:**
 - ± **Bronchodilators**
 - Theophylline (Theo-Dur®) for cough or dyspnea of pulmonary edema
 - ± **Fluid therapy:** especially if anorexic (low Na fluids with K⁺, dextrose supplementation)
 - ± **Cough suppressants (antitussive):** Dihydrocodeinone (Hycodan®)
 - ± **Sedation to minimize anxiety**
 - Morphine for dogs, ± cat (1/10 dose)



Enacard



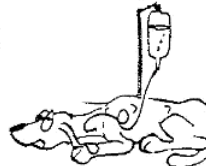
Digoxin



Morphine



Theo-Dur



Dizs requiring other Tx

- **Hypertrophic cardiomyopathy**
 - NO digoxin (not a contractile problem)
 - Diltiazem (Cardizem®) to cause relaxation (↑ ventricular filling)
- **Bacterial endocarditis (BE) & infective myocarditis** (Lyme diz, trypanosomiasis)
 - ABs (Antibiotics), months for BE
- **Nutritional dilative cardiomyopathies**
 - Taurine (cats) & carnitine (dogs) supplementation
- **Severe pulmonary edema**
 - Nitroglycerine & other nitrates: acute treatment of pulmonary edema, ointment to pinna for pulmonary edema
- **Pulmonary hypertension - cor pulmonale**
 - Nitroprusside: emergency reduction of blood pressure
 - Thromboembolic, Sx therapy for pulmonary embolism?
- **Heartworm:** Thiacetarsamide chemotherapy
- **Thromboembolism:** thromboembolectomy (surgical therapy?)
 - Aspirin, Heparin
- **Pericarditis:** pericardiocentesis, pericardiectomy
- **Thoracocentesis or abdominocentesis:** may be lifesaving in severe pleural or peritoneal effusion
- **Cardiac arrest:** Epinephrine, O₂, Cardiac massage (CPR)
- **Surgical** - stabilize patient medically first if at all possible:
 - Congenital defects with 2° heart failure:
 - PDA (patent ductus arteriosus): ligate before reversal
 - PPHD (pericardioperitoneal heart defect)
 - PS (pulmonic stenosis): balloon valvulotomy or patch graft
 - Large septal defects?
 - Persistent right aortic arch: ligate & cut



Cardizem



ABs

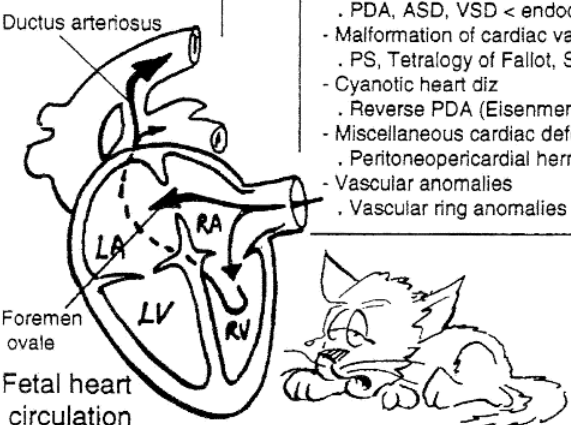
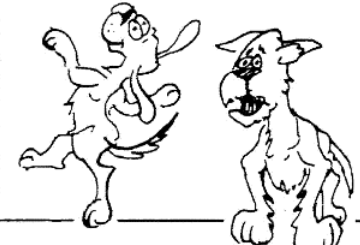

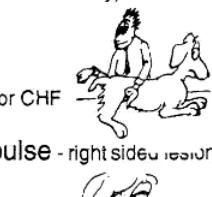
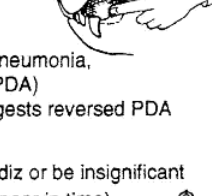
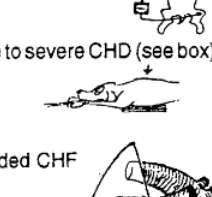
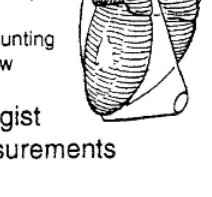



Aspirin



Congenital Heart Diz

CIRCULATORY SYSTEM

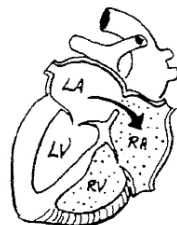
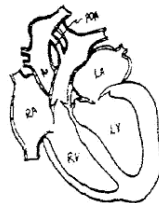
Condition	Facts/Cause	Presentation/SC	Diagnosis
Congenital heart diz, CHD M8K 67, 63; Mk 34; H-T/ M 271; SAP 500; I2M 145; IM 114; E-hb 386; IM-WW 165; F3-IM 263; H-F 136, 357, 391; E 892; Cat 859; C12T 833; C11T 647; Pys 470; S-WW 84; Sx-S 856; WB 3.29 ***  <p>Ductus arteriosus</p> <p>Foremen ovale</p> <p>Fetal heart circulation</p>	<ul style="list-style-type: none"> • Abnormality of the heart at birth which can be hereditary (genetically linked) or originate during gestation (in utero fetal diz) • Small percentage of cardiac cases (< 10%) - < 1% incidence in population - #1 cardiovascular diz in animals < 1 year old • Dogs >> cats • Cause: <ul style="list-style-type: none"> - Genetic (polygenetic) - Environmental, chromosomal, infectious, nutritional, drug related or toxicologic <div style="border: 1px solid black; padding: 5px; margin-top: 10px;"> <p>Classification (common conditions)</p> <ul style="list-style-type: none"> - Systemic to pulmonary shunting <ul style="list-style-type: none"> . PDA, ASD, VSD < endocardial cushion diz - Malformation of cardiac valves <ul style="list-style-type: none"> . PS, Tetralogy of Fallot, SAS, AV valve dysplasia - Cyanotic heart diz <ul style="list-style-type: none"> . Reverse PDA (Eisenmenger), tetralogy of Fallot - Miscellaneous cardiac defects <ul style="list-style-type: none"> . Peritoneopericardial hernia - Vascular anomalies <ul style="list-style-type: none"> . Vascular ring anomalies </div>	<ul style="list-style-type: none"> • Most asymptomatic • Stunted growth <ul style="list-style-type: none"> - Mostly associated w/ lt-to-rt shunt or CHF • Respiratory distress • Exercise intolerance • Fainting (syncope) & exertional collapse <ul style="list-style-type: none"> - Right-to-left shunts - Paroxysmal arrhythmias - Ventricular outflow obstruction (aortic or pulmonic stenosis) - Congestive heart failure 	<ul style="list-style-type: none"> • History (Hx): breeds; Clinical signs (CS) • Physical exam <ul style="list-style-type: none"> - Precordial palpation (thorax over heart) <ul style="list-style-type: none"> . Strong apical impulses suggest ventricular hypertrophy . Right-side ≥ than left suggests rt ventricular hypertrophy . Precordial thrill: vibration that identifies PMI (point of max intensity) of a loud murmur - Arterial pulse - what they suggest <ul style="list-style-type: none"> . Often normal . Weak (hypokinetic): lt ventricular outflow obstruction or CHF . Bounding (hyperkinetic) - PDA or aortic insufficiency - Distention or pulsation of jugular venous pulse - right sided congestion (PS, Rt AV dysplasia or pulmonary hypertension) - Mucous membrane <ul style="list-style-type: none"> . Normal: pink membranes . Pallor w/ long refill time: CHF or concurrent anemia . Cyanotic: pulmonary dysfunction, left-sided CHF or pneumonia, rt-to-rt shunt (tetralogy of Fallot, Reversed ASD, VSD, PDA) . Differential cyanosis: oral: pink; vulva: cyanotic - suggests reversed PDA • Auscultation <ul style="list-style-type: none"> - Murmur in puppy or kitten may indicate congenital diz or be insignificant <ul style="list-style-type: none"> . Innocent murmurs common (soft systolic which disappear in time) . Congenital diz murmur: persists & may get louder <ul style="list-style-type: none"> .. Periodically recheck for 6-12 months • Electrocardiography (ECG): good in moderate to severe CHD (see box) • Thoracic radiographs: <ul style="list-style-type: none"> - Cardiac size & shape, Specific chamber enlargement - Great vessels (pulmonary trunk, aorta) - Pulmonary vascularity, over- & under circulation, left sided CHF • Echocardiography (US) <ul style="list-style-type: none"> - Some anatomic abnormalities visualized (ASD, VSD, SAS) - Cardiac enlargement/hypertrophy - Saline ejection (contrast) into peripheral vein; rt-to-rt shunting - Doppler echocardiography: anatomical detail, blood flow information, intracardiac pressure estimates • Cardiac catheterization: refer to cardiologist <ul style="list-style-type: none"> - Outline surgical anatomy, pressure measurements     
<p>< 1% of Population: Dogs > Cats</p> <p>CS: Asymptomatic, Stunting, Fainting, Tiring</p> <p>Dx: Hx, CS, PE, ECG, Rads, Echo</p> <p>Tx: Sx, Symptomatic, CHF Tx</p>			

Common defects (% of heart dz in dogs/cats)

- **Patent ductus arteriosus (PDA)** #1 dog: 30% (cat: 10%)
- **Pulmonic stenosis (PS)** (dog: 20%, cat: 3%)
- **Subaortic stenosis (SAS)** (dog: 20%)
- **Ventricular septal defect (VSD)** #2 cat: 15% (dog: 7%)
- Persistent right aortic arch (dog: 5%)
- **AV valvular dysplasia** (#1 cat: 15%, dog: 3%)
- **Tetralogy of Fallot (TF)** (dog: 3%, cat: 6%)
- **Atrial septal defect (ASD)** (cat: 4%, dog: 1%)
- **Endocardial fibroelastosis** (cat: 10%)
- **Aortic stenosis** (cat: 6%)
- **Endocardial cushion defect** (cat)
- **Peritoneopericardial hernia**
- **Persistent left cranial vena cava** (dog)

Uncommon defects

- Vascular anomalies (dog & cat: 8%)
- Aortic interruption/hypoplasia (dog)
- Aortic stenosis (valvular) (dog)
- Aorticopulmonary window (dog)
- Anomalous pulmonary venous return (dog)
- Atrial malformation (cat)
- Arteriovenous fistula (dog)
- Coarctation of aorta
- Cor triatriatum
- Double aortic arch
- Double chambered right ventricle
- Double outlet right ventricle (dog & cat: 4%)
- Ebstein's anomaly of lt AV valve
- Endocardial cushion dz (dog)
- Endocardial fibroelastosis (dog)
- Ostium secundum atrial septal defect (dog)
- Pulmonic valve insufficiency (dog)
- Retroesophageal subclavian artery (dog)
- Sinus inversus (dog)
- Truncus arteriosus (cat)
- Taussig-Bing complex (cat)



Normal

- Innocent murmur
- Physiologic murmur
- Fever, anemia
- Mild congenital defect

Murmur



Abnormal

Systolic

Cyanotic

- Pulmonary hypertension (reversed PDA, VSD, ASD)
- Tetralogy of Fallot

Acyanotic

Lt. side

- PS
- ASD
- SAS
- Lt AV dysplasia

Rt. side

- VSD
- ECD
- Rt AV dysplasia
- PS

Systolic + diastolic

Continuous

- PDA (lt to rt shunt)

To & fro - soft

- SAS + aortic insufficiency
- VSD + aortic insufficiency



Treatment:

- **Asymptomatic** - none may be required - monitor
- **Surgical - definitive Tx, often not practical or not done**
 - **PDA** - Sx - TOC: ductus ligation, not if reversed
 - Pulmonary stenosis: patch graft
 - VSD, ASD: refer, variable success, requires bypass
 - Persistent rt aortic arch: cut ligamentum arteriosum
- **Medical:**
 - Reversed PDA: rest, phlebotomies
 - Tetralogy of Fallot: palliative (rest, beta blockers), Sx not attempted
 - AV valve dysplasia: manage heart failure - 3Ds
 - Subaortic stenosis: Sx not attempted, Inderal®

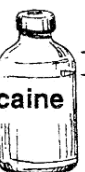
CHF (congestive heart failure) - Rest & "3 Ds"

- **Rest** (exercise restriction)
- **Diuretics** (furosemide [Lasix®])
- **Vasodilation** (enalapril [Enacard®])
 - Hydralazine + enalapril to reduce lt-to-rt shunting
 - Use w/ caution in SAS (subaortic stenosis)
- **Dietary sodium restriction**



Arrhythmias

- **Supraventricular** (atrial tachycardia, flutter, fibrillation)
 - **Digoxin**, propranolol (beta blocker), diltiazem (Cardizem®)
- **Ventricular tachycardia:** Lidocaine, Procainamide, Tocainide, Propranolol



Prognosis:

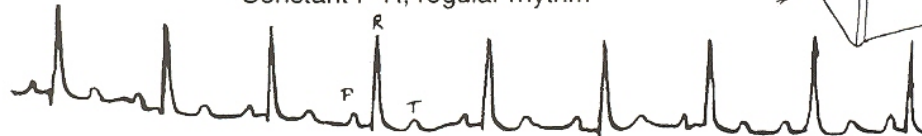
- PDA: excellent w/ surgery
- Reverse PDA: grave
- VSD & ASD, small: good; large: grave
- Pulmonic stenosis: fair to good
- Subaortic stenosis: poor to good
- AV dysplasia: good if mild
- Tetralogy of Fallot: grave - usually leads to sudden death
- Persistent rt. aortic arch: poor

Rhythms - Summary

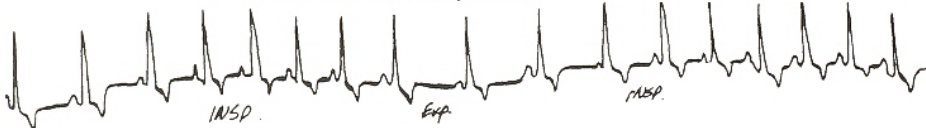
250

Normal rhythms

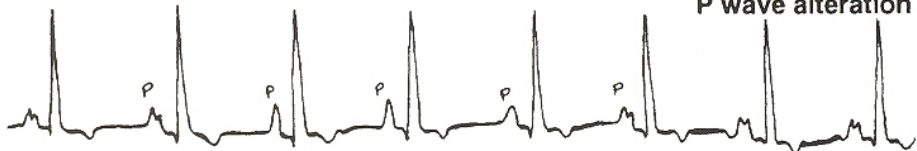
- **Normal sinus rhythm** Dog: 60-180 bpm; Cat: 120-200 bpm
Constant P-R, regular rhythm



- **Normal sinus arrhythmia:** Alters w/ respiration - Increases on inspiration, Decreases on expiration

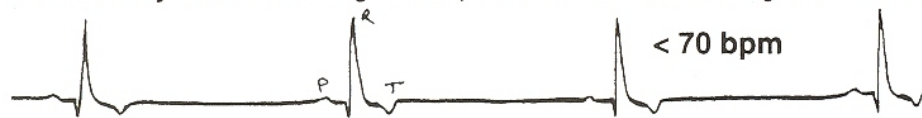


- **Wandering pacemaker:** P wave alterations - Often normal (dogs)
P wave alteration

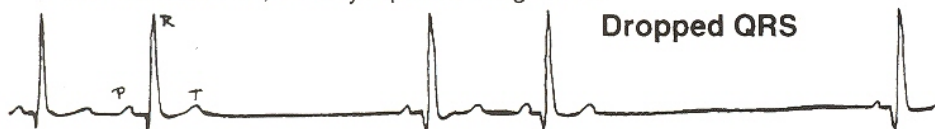


Bradyarrhythmias (too slow)

- **Sinus bradycardia:** HR: Dog: < 70 bpm, Cat: < 90; Normal, regular P-QRS-T



- **Sinoatrial block (arrest):** Pause of 2 or more R-R intervals, Clinically insignificant
Normal P-QRS-Ts, Brachycephalic - vagal tone

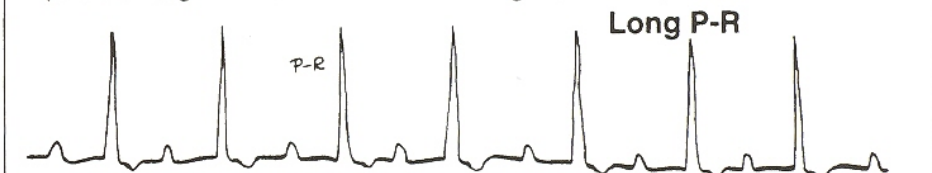


CIRCULATORY SYSTEM

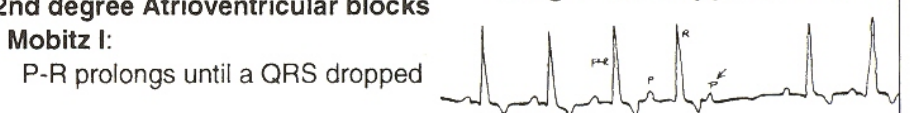
- **Atrial standstill (hyperkalemia):** HR: Dog < 60 bpm; Cat < 90 bpm
Hyperkalemia, No P waves, Junctional or Ventricular pacemaker



- **1st degree atrioventricular block:** Long P-R interval, delayed conduction of impulse through AV-node to ventricle - Dog > 0.14 sec, Cat > 0.05 sec

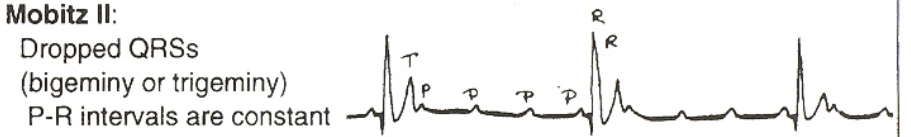


- **2nd degree Atrioventricular blocks**
Mobitz I:

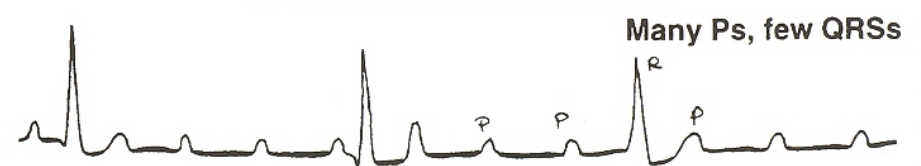


Mobitz II:

- Dropped QRSs
(bigeminy or trigeminy)
P-R intervals are constant



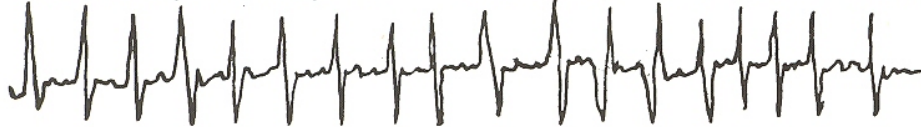
- **Complete (3rd degree) AV block:** Many Ps, few QRSs (ventricular escape)
No association between Ps & QRSs



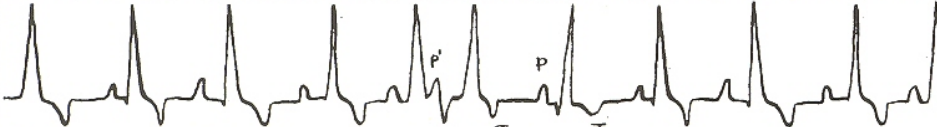


Tachyarrhythmias (too fast or irregular)

- **Sinus tachycardia:** Normal ECG, except fast rate, Normal physiologic response
QRS for every P with very short P-T intervals: Dog > 180 bpm; Cat > 240 bpm



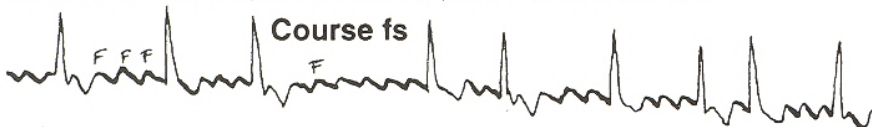
- **Atrial APCs:** Premature P-QRS-Ts w/ a pause, Isolated - clinically insignificant



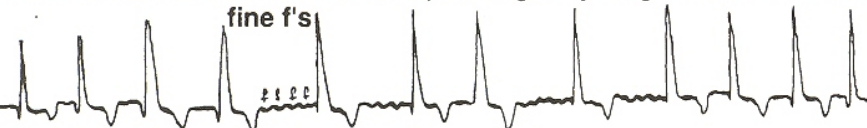
- **Paroxysmal atrial tachycardia:** Fast HR, 3 or more APCs ≥ 3 APCs (P-QRS)



- **Atrial flutter:** NO Ps, coarse f waves, Rare - often transient



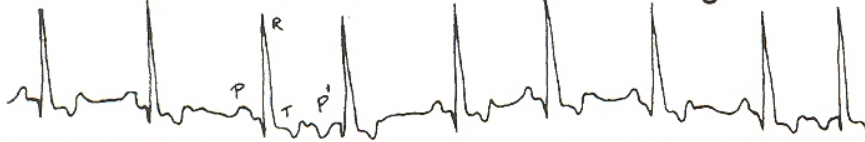
- **Atrial fibrillation:** Fine f waves, Rapid, irregularly irregular ventricular rate



- **Junctional (AV node - His Purkinje) premature contractions:**

Negative P waves, Digitalis toxicity

Negative Ps



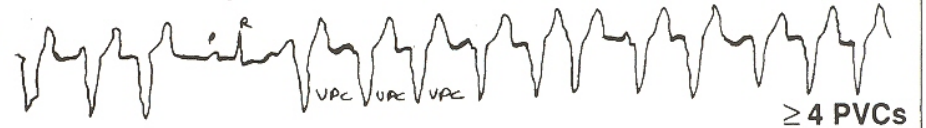
- **Junctional rhythm:** fast or slow/JPCs Negative Ps, Spontaneously reverts
Bradycardia &/or tachycardia



- **Ventricular premature contractions:** QRSs wide & bizarre



- **Ventricular tachycardia:** 4 or more VPCs in a row



- **Ventricular fibrillations:** Continuous, chaotic, bizarre positive & negative oscillations, Medical emergency - CPR

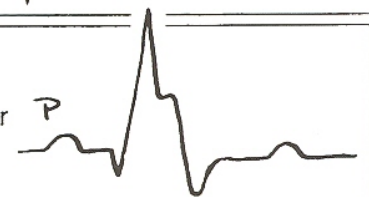


Conduction disorders

- **Intraventricular conduction blocks:** QRSs prolonged, MIMI (microscopic intraventricular myocardial infarct)



- **Pre-excitation syndromes:** QRSs widened w/ notched Rs (Delta waves), Re-entrant impulses



- **Sick sinus syndrome:** Bradycardia pattern, Female miniature schnauzer
- Weakness, syncope

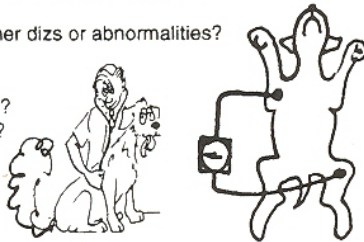


Dx - Arrhythmias

Diagnosis of arrhythmias

IM 60; Pys 152

- History (Hx)
 - **Digitalis toxicity common cause of arrhythmias**
- CS of arrhythmias: episodic weakness, fainting, CHF
- Physical exam:
 - Other signs of cardiac diz? or other ditz or abnormalities?
 - \pm Pulse deficits
- Auscultation:
 - Heart sounds of varying intensity?
 - Splitting of heart sounds (VPCs)?
- ECG (electrocardiogram):
 - HR (too fast, too slow, normal?)
 - Rhythm (regular or irregular?)
 - P waves (normal or abnormal?)
 - F waves?
 - QRS complexes (normal [sinus origin] or wide [ventricular origin])
 - Premature QRS not preceded by a P wave (atrial)
 - P-R interval (normal, short or prolonged)
 - No consistent relationship between P waves & QRS complexes (2° & 3° or complete AV block)
 - Long pauses before an abnormal complex (escape beats)?
- Further diagnostics needed?
- Decide if antiarrhythmic Tx indicated
- Monitor patient



DDx - HR & rhythm disturbances

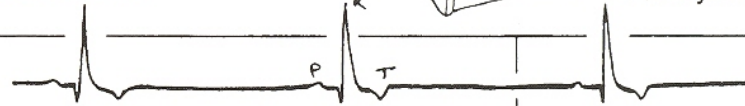
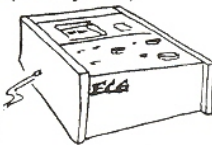
IM 60

• Slow, regular rhythms

- Sinus bradycardia
- Complete AV block (ventricular escape rhythm)
- Atrial standstill (ventricular escape rhythm)

• Slow, irregular rhythms

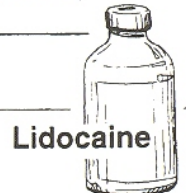
- Sinus block/arrest
- Sick sinus syndrome
- 2° AV block



CIRCULATORY SYSTEM

Antiarrhythmic Drugs


Drugs	Mechanism	Uses
Group 1 drugs		
• Lidocaine	↓ Na conduction	Ventricular arrhythmias (DOC)
• Quinidine (Quinidex®)	"	" Not given w/ digitalis
• Phenytoin (Dilantin®)	"	Digitalis toxicity
Group 2 Drugs	Beta blockers	↓ sympathetic tone
• Propranolol (Inderal®)	"	Supraven. & ventricular arrhythmias
• Atenolol (Tenormin®)	"	"
Group 3 Drugs: Bretylium, amiodarone	Expensive, not used much in vet med.	
Group 4 Drugs	Ca+ channel blockers	Supraventricular tachyarrhythmias
• Diltiazem (Cardizem®)	"	(atrial fibrillation)
		Not given w/ beta blockers ??
Miscellaneous antiarrhythmics:		
• Digitalis glycosides	Negative chronotrope	Atrial fibrillation & cardiac diz
• Anticholinergics	↑ HR (parasympathetic)	Bradycardia
- Propantheline (Pro-Banthine®)	"	"
- Glycopyrrolate (Robinul®)	"	"



Treatment of arrhythmias

H-T/M 371

- Some require no Tx; others require aggressive Tx
- Bradycardias - rest
- All arrhythmias:
 - Oxygen therapy
 - Correction of acid-base & electrolyte imbalances & fluid disorders
 - Stop drug if causes arrhythmia (Digitalis)
- Pacemaker therapy:
 - Indication: symptomatic bradyarrhythmias:
 - . Sinoatrial dysfunction (arrest & standstill)
 - . AV block (2nd [Mobitz type 2] & 3rd degree blocks)
 - Methods: pulse generator & electrode:
 - . Epicardial (thoracotomy)
 - . Transvenous or endocardial (fluoroscopy)

Arrhythmias	Facts	ECG	Treatment: Stop digitalis if cause
• Normal rhythms <ul style="list-style-type: none"> - Sinus rhythm - Sinus arrhythmia - Wandering pacemaker 	Normal Dog, normal respiration Pacemaker shift	 Dog 60-180 bpm, cat: 120-240 bpm HR increased w/ inspiration P wave alteration	Normal Normal
• Bradycardia <ul style="list-style-type: none"> - Sinus bradycardia - Sinus arrest - Sick sinus syndrome - Atrial standstill - AV blocks <ul style="list-style-type: none"> . 1st degree AV block . 2nd degree <ul style="list-style-type: none"> .. Mobitz 1 .. Mobitz 2 . 3rd degree - Junctional rhythm - Branch blocks <ul style="list-style-type: none"> . RBBB . LBBB or AFB 	Normal or pathological Usually insignificant Female min. schnauzer Hyperkalemia? breed? Asymptomatic Complete block AV junctional impulses Course fs	Dog < 70 bpm, Cat < 90 bpm R-R interval pause Bradycardia No P waves Prolonged P-R interval P-R lengthens to QRS drop Bigeminy/trigeminy - QRS drops Many Ps few QRSs Negative P waves Wide QRSs	None or glycopyrrolate (Robinul®) None Pacemaker IV NaCl None Propantheline (Pro-Banthine®) Pacemaker Pacemaker Propentheline, Stop digitalis None Tx underlying cause
• Tachycardia <ul style="list-style-type: none"> - Sinus tachycardia - Atrial tachycardia - Atrial flutter - Atrial fibrillation - Junctional tachycardia - Ventricular preexcitment <ul style="list-style-type: none"> WPW syndrome - Ventricular tachycardia - Ventricular fibrillation - Cardiac arrest 	Exercise - normal Cardiac diz Very rare Enlarged atria Accessory pathways Life threatening Precedes cardiac arrest	Dog: >160 bpm, Cat: > 240 ≥ 4 APCs in succession Fine "f" waves/ no "P" waves Irregular irregular HR Negative P waves Delta waves > 3 PVCs in a row Chaotic, bizarre oscillations	None Digitalis Digoxin Digoxin Digoxin Digoxin Propranolol (not digoxin) Lidocaine Cardiopulmonary resuscitation CPR

Robinul

Pro-Banthine

Digoxin

Lidocaine