

VENTURA COUNTY MEDICAL  
CENTER TRAUMA DEPARTMENT

TRAUMA

BOOK

2012



Ventura County Medical Center

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***This manual was written to accomplish the following goals:***

- Improve delivery of resuscitative care to the trauma patient, especially during the first few critical hours.
- Aid in the appropriate utilization of resources.
- Help orient new residents and students and rapidly acquaint them with their roles on the trauma team.
- Optimize resuscitative teamwork between the surgeons, ED staff, and residents.

This manual will be reviewed and updated bi-annually. Any suggestions for changes or adjustments should be given to Dr. Duncan or Dr. Romero personally, or via e-mail. Please feel free to contact us with any questions, concerns or comments. Our aim is to make VCMC an optimum learning environment, deliver excellent patient care, and maintain our adult level II trauma center verification by meeting the high standards set by the American College of Surgeons Committee on Trauma.

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- *Ventura County Medical Center ICU Manual 2008*
- *ATLS Manual for Doctors*, 8th Edition

Sincerely,



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## CHAPTER 1

# DEPARTMENT OF TRAUMA SERVICES

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### **IN THIS SECTION**

*Expectations of Residents*

*Obtaining Trauma Consults*

*Requirements for Trauma Patients*

*RAPS 4*

*Trauma Scoring Systems*

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## **Expectations of Residents**

- Residents are expected to know their patients well and follow-up on all ordered labs and films in a timely manner. This includes the final radiology reports which may require discussing with the radiologist early the following morning. If the resident needs to leave secondary to work hour limitations, the resident on call will take over these responsibilities and the trauma surgeon will be notified of the “pass on.”
- The resident is expected to do serial exams and follow-up on any repeat labs or films performed throughout the day or night. Any data acquired should be noted in the chart (with time and date).
- General surgery rounds begin at 7:15 a.m. Monday through Friday, in the Surgery Conference Room. Trauma rounds usually follows general surgery rounds. Bedside rounds usually begins at around 0800. These rounds involve the residents, Trauma Program Manager, Trauma Nurse Practitioners, social workers, alcohol and drug counselor, EMT students, medical students, and trauma surgeons.
- When in doubt, ASK!
- The Chief Resident will update the TPM or designee of all trauma patients admitted the night before -- the following morning at intake rounds – as well as trauma patients on the service.
- A RAPS 4 [Rapid alcohol (and drug) problems screen] form should be filled out on all patients with positive alcohol and positive U-tox lab results.
- Trauma Discharge Form and Tertiary Survey should be filled out on all trauma patients (excluding Tier III consult only).
- Mock trauma codes generally occur on each 3rd Tuesday of the month, at 0815 in the Trauma Bay.
- Morbidity and Mortality conference is held on each 3rd Thursday of the month
- All orders written on trauma patients in the Emergency room should be given to the secretary as soon as possible.
- A duplicate (yellow) copy of the H&P should be slipped under the trauma director’s office door, while the original (white) copy should remain in the chart.

## **Obtaining Trauma Consults**

### **OBJECTIVES**

- Define conditions that require consultation from the trauma surgical team.
- Define the appropriate consulting service and the type of consult needed
- During initiation of a consult, indicate whether the consulting physician needs to see the patient immediately, or if the consultation can occur at a later time.

CONSULT	INJURY	CONDITION
NEUROSURGERY	Head Injury Patients	<ul style="list-style-type: none"> <li>• CT scan abnormalities</li> <li>• GCS &lt; 12 without obvious signs of intoxication</li> <li>• Focal neurologic deficit</li> </ul>
NEUROSURGERY	Spine Injury Patients	<ul style="list-style-type: none"> <li>• Bony abnormality on X-ray</li> <li>• Ligamentous abnormality</li> <li>• Neurologic deficit</li> <li>• Suspicion of spinal cord injury</li> </ul>
PLASTICS - FACIAL	Facial Injury	<ul style="list-style-type: none"> <li>• Complex laceration</li> <li>• Facial fractures, including orbital fractures</li> </ul>
PLASTICS - HAND	Hand Injury	<ul style="list-style-type: none"> <li>• Tendon, nerve, or vascular injury distal to elbow</li> </ul>
VASCULAR SURGERY	Vascular Injury	<ul style="list-style-type: none"> <li>• If patient has exsanguinating injury, start case first</li> <li>• Vascular consult primarily for extremity, carotid, great vessel injuries</li> <li>• Abdominal or groin injuries treated by trauma team at discretion of attending</li> </ul>
ORTHOPEDICS	Bony Injury	<ul style="list-style-type: none"> <li>• For all bone fractures and major ligamentous instability</li> </ul>
PLASTICS	Superficial	<ul style="list-style-type: none"> <li>• Complex laceration requiring flap closure</li> </ul>
CARDIOTHORACIC SURGERY	Aortic Injury	<ul style="list-style-type: none"> <li>• With interventional radiology consult</li> </ul>
PSYCHIATRY		<ul style="list-style-type: none"> <li>• Suicide attempts (will need 5150)</li> <li>• Symptoms of post traumatic stress disorder</li> <li>• Signs of depression</li> <li>• Suspicion of patient sequelae</li> <li>• Loss of limb</li> <li>• Loss of friend/friend member involved in same admission</li> </ul>
PEDIATRICS		<ul style="list-style-type: none"> <li>• Any patient admitted who is 14 years of age or younger, or developmentally delayed patient that although may be older than 14, is physiologically and mentally considered to be a pediatric patient.</li> </ul>
PAIN MANAGEMENT		<ul style="list-style-type: none"> <li>• Causalgias from nerve injury</li> <li>• Other cases of chronic pain</li> </ul>

## Requirements For All Trauma Patients

### LABS

- Repeat CBC or H&H and other labs being monitored closely within 2 hours of admission labs and PRN thereafter.
- A repeat of these labs in the morning will be determined on a patient by patient basis.
- If one is doing multiple repeat CBCs or H&Hs, use pediatric tubes.

### X-RAYS

- All patients with a pneumothorax, hemothorax or chest tube will benefit from having a daily CXR until the hemo/pneumothorax has resolved and the chest tube has been removed, but this will be determined on a case by case basis.
- All patients' x-ray/CT films should be reviewed as soon as they are performed.
- During hours when the radiologist is available, all trauma patient xrays must be reviewed with the radiologist as soon as possible, after they are completed (no greater than 1 hour).
- All trauma patients admitted after hours must have their "night hawk" report reviewed as soon as it is sent. In addition, all of their x-rays (plain films and CT's) must be reviewed with our main Radiologists, or the final report reviewed by 10 a.m. the morning after admission.

### PROPHYLAXIS

- Leg squeezers or SCDs on non-injured legs.

### HEAD

- All Traumatic Brain Injury Admissions should be admitted to a monitored ward or ICU with regular neurologic exam by the nurses and notification of any deterioration. In addition, they should also have regular neuro exams performed by the resident with documentation in the chart.
- Do not over sedate or over medicate patients with potential head injury.

### WOUNDS

- All wounds (except gunshot wounds and dirty stab wounds) should be cleansed, debrided and closed as soon as the patient is stable, and the primary/secondary/tertiary survey have been completed (including CTs). Any wound(s) older than 12 hours, should not be closed.

### OTHER

- Make NPO with IVF.
- There should **not** be an automatic 2L bolus of fluids for trauma patients.
- Keep in C-collar until able to clear based on clearance protocol. Change to Aspen Collar if C-spine precautions is needed > 2 hours.
- An NGT (or OGT if intubated, infant, or risk of basilar skull fracture).

- A Foley with close monitoring of urine output ( $>30\text{ml/hr}$  /or  $\geq 0.5\text{ ml/kg/hr}$ ).
- Serial abdominal exams, or other exams documented in the chart (at least Q4 hours with date and time from admission until the next morning).
- Patients must be cleared by all services following the patient prior to ambulation, feeding and the start of any anticoagulants.
- Elevate HOB via reverse Trendelenburg.
- Incentive Spirometry.
- All IVs placed in the field or ER must be replaced within 24 hours of admission.
- Patients with injuries to extremities should have regular neuro/vascular exams with documentation in the chart including a date and time.

**ALWAYS ASK BEFORE:**

- Removing Foleys, NG tubes, JP drains (or drains in general), chest tubes, etc.
- Starting a diet.
- Starting medication which may cause bleeding (anticoagulants, aspirin, toradol, etc.)
- \*Please refer to the “Trauma Book” for specific injuries and their management/evaluation.\*

## **RAPS 4**

### **PROTOCOL FOR SUBSTANCE ABUSE SCREENING AND INTERVENTION IN TRAUMA PATIENTS**

#### ***Purpose and Background***

This protocol is intended to identify the trauma patient with alcohol and/or illicit drug abuse issues and to provide a brief intervention during the trauma-related hospitalization.

#### ***Target Population***

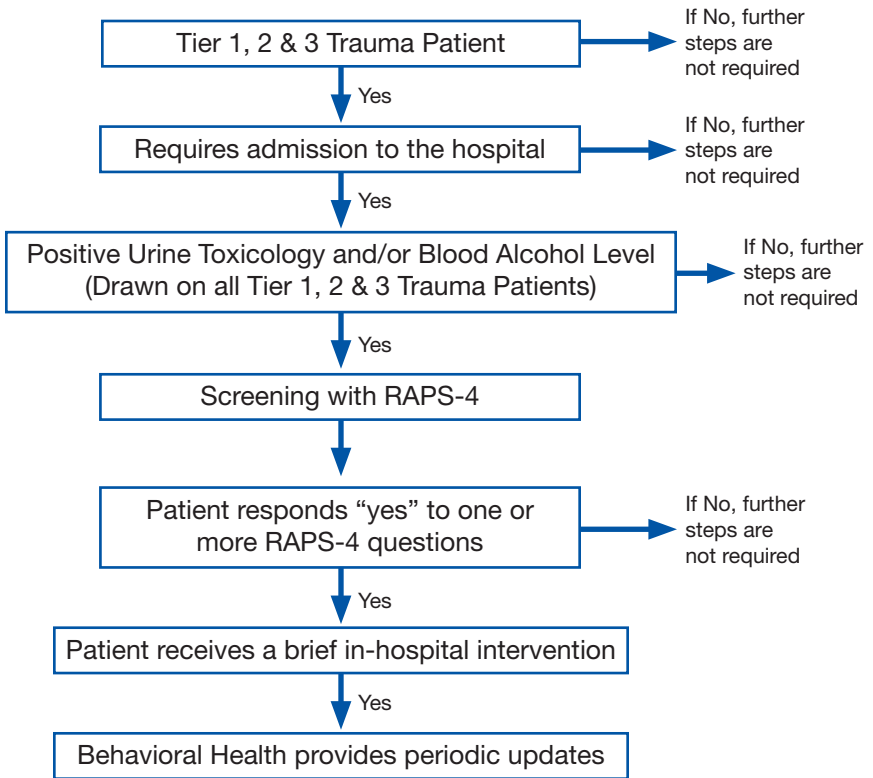
This screening and intervention protocol applies to all designated Tier I-III trauma patients admitted to the Ventura County Medical Center that are 14 years of age or older at the time of admission.

#### ***Program Collaboration***

Implementation of this protocol requires collaboration between Emergency physicians and nurses, general surgeons, medical-surgical nursing staff, a trauma nurse coordinator, social workers, mental health care providers and resident physicians. Roles and responsibilities of specific providers are outlined below. Questions and concerns regarding this protocol should be directed to the Trauma Directors or the Trauma Program Manager (TPM).

#### ***Protocol Overview***

- A. **Target Population Identification:** Trauma patients eligible for this protocol are identified by the Surgery House Officer on call, who assumes initial care of trauma patients in the VCMC Emergency Room. Patients with unintentional injuries not classified as trauma are not subject to this protocol. Residents or nurses can activate the protocol when appropriate.
- B. **Substance Abuse Screening:** All trauma patients undergo a blood alcohol level and urine toxicity screen, which are automatically included in ER trauma orders, upon admission to the Emergency Room. Trauma patients with a positive blood alcohol level and/or positive urine toxicity screen are then administered a brief screening questionnaire for alcohol dependence (RAPS4) following hospital admission and resolution of their intoxicated state. Results of the BAL and urine toxicity screen, as well as response to the screening questionnaire are documented in the patient's hospital chart.
- C. **Substance Abuse Intervention:** Patients with a positive BAL and/or urine toxicity screen who also screen positive for alcohol dependence on the RAPS4 questionnaire receive a brief substance abuse intervention from an alcohol and drug counselor, which is requested by the resident physician by contacting either the trauma office at 652-5904 or by paging the in-house alcohol and drug counselor. If appropriate, this intervention includes a referral to an appropriate substance abuse treatment program.



Sample: RASP 4 form (VCMC-331-008)

BAL Results

Utox Results

### The Rapid Alcohol (and Drug) Problems Screen (RAPS4)

- 1. During the last year, have you had a feeling of guilt or remorse after drinking or using drugs?  Yes  No
- 2. During the last year, has a friend or family member ever told you about things you said or did while you were drinking or using drugs that you could not remember?  Yes  No
- 3. During the last year, have you failed to do what was normally expected from you because of drinking or using drugs?  Yes  No
- 4. Do you sometimes drink or use drugs when you first get up in the morning?  Yes  No

If the patient answered "Yes" to one of the above, intervention\* was performed:  Yes  No

Nurse Signature \_\_\_\_\_ Date \_\_\_\_\_ Time \_\_\_\_\_

Patient Signature \_\_\_\_\_ Date \_\_\_\_\_

A positive result with this screening tool indicates alcohol or drug dependence.  
\*Please call 652-5904 to initiate intervention.

### Asesoramiento Rápido de Problemas de Alcohol y Drogas

- 1. ¿Durante el último año, ha tenido algún sentimiento de culpa o remordimiento después de beber o usar drogas?  Sí  No
- 2. ¿Durante el último año, algún miembro de su familia o un amigo le ha hablado de cosas que usted dijo o hizo cuando estaba tomando o usando drogas que usted no podía recordar?  Sí  No
- 3. ¿Durante el último año, ha dejado de hacer lo que normalmente se espera de usted a causa del consumo de alcohol o uso de drogas?  Sí  No
- 4. ¿Toma alcohol o usa drogas al levantarse en la mañana?  Sí  No

Si el paciente respondió "sí" a alguna pregunta, se llevo a cabo una intervención?  Sí  No

Firma de Enfermera \_\_\_\_\_ Fecha \_\_\_\_\_ Tiempo \_\_\_\_\_

Firma del Paciente \_\_\_\_\_ Fecha \_\_\_\_\_

Un resultado positivo de esta prueba de detección indica dependencia de alcohol o de drogas.  
\*Por favor llame al 652-5904 para iniciar intervención.



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RAPID ALCOHOL PROBLEMS  
SCREEN (RAPS4)

Patient Label  
or  
Two Patient Identifiers

VCMC-331-008 (02/2012)

## Trauma Scoring Systems

All areas of medicine and the trauma centers across the country have now embraced evidence based medicine to the point where there have been many models that have been developed for objective evaluation of trauma patients. These methods have been validated in multi-center studies, and are now standard of care in the evaluation as well as the maintenance of evolving and maturing trauma centers. These particular objective evaluations are as follows:

- A. **Anatomical Scoring System:** The first portion of the anatomical scoring system would be the abbreviated injury score (AIS). This score is from 1 (minor) or to 6 which is fatal. Over 12,000 injuries listed in the ICD-9 books are being constantly updated.
- B. **Injury Severity Scale or ISS:** The body is divided into six areas:
- Head of neck (1)
  - Face (2)
  - Chest (3)
  - Abdominal and pelvic contents (4)
  - Bony pelvis and limbs (5)
  - Body surface area (6)

The AIS for each body area estimate using the AIS booklet which is determined by the ICD-9 code. The ISS is determined by adding together the square of the three highest AIS scores from the above described body areas. An injury severity score higher than 15 is considered severe trauma.

A physiological scoring system has now been devised as well, and this physiological scoring system is done in the Emergency Room and has three major parameters. These parameters measure the degree of physiological derangement. The components are: systolic blood pressure, respiratory rate and the Glasgow coma scale. The code of value is multiplied by weighing factors in the sum of the three values given in the RTS score. Please see figure below.

GLASGOW COMA SCALE	SYSTOLIC BLOOD PRESSURE	RESPIRATORY RATE	CODED VALUE
13-15	>89	10-29	4
9-12	76-89	>29	3
6-8	50-75	6-9	2
4-5	1-49	1-5	1
3	0	0	0

$$\text{RTS} = 0.9368 \text{ GCS} + 0.7326 \text{ SBP} + 0.2908 \text{ RR}$$



The TRISS methodology, devised in the late 80s by Howard Chapman and Baker, combines the revised trauma score with the injury severity score. It uses these two types of methodology along with age to predict the death age rate or POS probabilities of survival. This is currently being done here at Ventura County Medical Center with our Lancet Trauma One software by the Department of Trauma Services. It is incredibly important to accurately describe the injuries not only in your dictations but also the operative notes, to evaluate and stratify our patients and also to continue with our patient safety improvements in the ICU as well as in the Trauma Division.

## Structure of the Trauma Program

**PURPOSE:** To define and outline the structure of the Trauma Program.

**PROCEDURE:** The Trauma Program is an administrative unit that includes the Trauma Service and coordinates all trauma related activities, including education injury prevention, research, access, acute hospital care, and rehabilitation.

**POLICY:** The Trauma Program includes the following:

- A. Trauma Medical Director, Trauma Program Manager, Trauma Registrar, Injury Prevention Coordinator, Trauma Nurse Liaison (s), Trauma Nurse Practitioner(s)
- B. Multi-disciplinary Trauma Team consisting of:
  - Trauma Surgeon
  - Trauma Program Manager
  - Trauma Nurse Practitioner(s)
  - Trauma Nurse Liaison(s)
  - ED Physician
  - Resident on Surgical Services
  - Residents on Med-Peds
  - ED and ICU Trauma Nurses
  - Ancillary Services Support to include Respiratory Therapist, Lab Technician, X-Ray Tech, and CT Tech
  - OR Team
  - Nursing Supervisor
  - Patient Advocate & Social Services
  - Pediatric Services
  - Critical Care Services
- C. Multidisciplinary Trauma Systems Committee  
Multidisciplinary Trauma Performance Improvement Patient Safety (PIPS)
- D. Committee
  1. Trauma Operational Process Performance Systems (TOPPS)
  2. Trauma Mortality & Morbidity (Peer Review)

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## CHAPTER 2

# THREE TIER CODE YELLOW TRAUMA SYSTEM

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### **IN THIS SECTION**

*Overview and Purpose of the Three  
Tier Protocol*

*Tier 1, 2, and 3 Activation Criteria*

*Code Yellow Resuscitation Procedure*

*Code Yellow Policies*

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## **Overview and Purpose of the Three Tier Protocol**

### **PURPOSE OF THREE TIER PROTOCOL**

- To facilitate care for the critically injured trauma patient, thus promoting the most favorable outcome.
- To educate residents in the management and stabilization of trauma patients.

A “CODE YELLOW” is called so personnel needed to care for critical patients respond to the ED. The trauma team response is to assure a rapid and orderly assessment of the patient with significant physiologic impairments or with a high index of suspicion for occult injury because of mechanism of injury.

Overhead page all upgrades  
No downgrades

Overhead page or "mass" alphanumeric page is made for tier I and II  
No overhead page or "mass" alphanumeric page is made for Tier III

TIER 1	TIER 2	TIER 3 (CONSULTATION)	BONY TIER 3 CRITERIA
<p><b>Traumatic injury in which there is a high probability for immediate surgical intervention.</b></p> <ol style="list-style-type: none"> <li>Hemodynamic instability (SBP &lt;80 mm Hg, pulse &gt;120 in adults &amp; age specific hypotension/tachycardia)</li> <li>Respiratory distress, intubated pre-hospital, unstable airway</li> <li>Glasgow Coma Scale (GCS) ≤ 8 or is unresponsive with a traumatic mechanism</li> <li>Penetrating wounds of the head, neck or torso (chest, abdomen, back, or buttocks)</li> <li>Major traumatic amputation</li> <li>Burns with associated trauma or respiratory distress</li> <li>Paralysis</li> <li>Transferred acute trauma patients who fulfill the above criteria or have "unstable" vital signs or require blood products to maintain "normal" vital signs</li> </ol>	<p><b>Patients at risk for significant injury based upon mechanism of injury but without the presence of any criteria for mandatory Category/Level 1 Trauma Alert.</b></p> <ol style="list-style-type: none"> <li>Ejection from automobile</li> <li>Death in same passenger compartment</li> <li>Extraction time greater than 20 minutes</li> <li>Falls &gt;10 feet</li> <li>Rollover</li> <li>High-speed auto crash</li> <li>Major passenger side intrusion (PSI)</li> <li>Auto-pedestrian/auto bicycle injury with significant (&gt;5 mph) impact</li> <li>Motorcycle crash with separation of rider from the bike</li> <li>Blunt chest trauma with suspected pneumo or hemothorax</li> <li>Blunt abdominal trauma associated with abdominal tenderness</li> <li>GCS &lt;15 due to traumatic mechanism</li> <li>Age ≥ 65</li> <li>Near drowning victims</li> <li>Transferred acute trauma patients who fulfill the above criteria.</li> </ol>	<ol style="list-style-type: none"> <li>Patients who do not meet criteria for level 1 or 2 following injury will be triaged by the Emergency Department Physician</li> <li>Consultation may be obtained on an individual case basis as per the Emergency Department Physician</li> </ol> <ol style="list-style-type: none"> <li>Dog or animal bites requiring surgical debridement.</li> <li>Burns not meeting Tier II criteria.</li> <li>Penetrating injury to extremities with intact pulses.</li> <li>Cardiac and/or respiratory diagnoses with mechanism attributed to trauma.</li> <li>DM, cirrhosis, or morbid obesity with mechanism attributed to trauma.</li> <li>Pregnancy &gt;20wks gestation with mechanism attributed to trauma.</li> <li>Patients with bleeding disorder or patients on anticoagulation with mechanism attributed to trauma.</li> <li>Patients with minor depressed skull fracture, or head/ facial trauma with associated contusions/ fracture requiring admission.</li> <li>Traumatic injury not meeting Tier II criteria work-up by E.D. physician with positive findings or potential for acute changes due to mechanism of injury and/or need for serial exams and/or admission.</li> <li>Transferred acute trauma patients who fulfill the above criteria. Patients should be upgraded according to severity.</li> </ol>	<p><b>All bony fractures with vascular compromise should have a TIER III consult</b></p> <p><b>INCLUSION:</b></p> <ul style="list-style-type: none"> <li>Humerus fractures excluding supracondylar</li> <li>Femur fractures</li> <li>Tibia/Fibula fractures with mechanism attributed to MVC/mechanically operated vehicle (skateboard/roller blades/scooter etc), or GSW</li> <li>Facial fracture requiring admission</li> </ul> <p><b>EXCLUSION:</b></p> <ul style="list-style-type: none"> <li>Supracondylar humerus fractures</li> <li>Isolated intertrochanteric hip fractures</li> <li>Radius / ulnar fractures</li> <li>Tibia/Fibula fractures w/o mechanism attributed to MVC / mechanically operated vehicle (skateboard/roller blades/scooter, etc), or GSW. i.e. fractures secondary to sport injury (w/o vascular compromise) are excluded</li> <li>Ankle fractures w/o mechanism attributed to MVC/mechanically operated vehicle (skateboard/roller blades/scooter etc), or GSW. i.e. fractures secondary to sports injury (w/o vascular compromise) are excluded.</li> </ul>
<p><b>Judgment of ED Physician/MCN</b></p>	<p><b>Judgment of ED Physician/MCN</b></p>	<p><b>Judgment of Physician</b></p>	

T1 = Trauma patient admitted to ICU

T2A = Trauma patients admitted to DOU or the floor

## Trauma Activation Criteria

TRE = Trauma patients that are seen and released from ER

TRO = Trauma patient admitted for 23 hour observation

## **Tier 1, 2, and 3 Activation Criteria**

### **TIER 1 TRAUMA ALERT**

Traumatic injury in which there is a high probability for immediate surgical intervention.

#### *CRITERIA*

- Hemodynamic instability (SBP <90 mm Hg, pulse >120 in adults and age specific hypotension/tachycardia)
- Respiratory distress, prehospital intubation, unstable airway
- Glasgow Coma Scale (GCS) < 8, or is unresponsive with a traumatic mechanism
- Penetrating wounds of the head, neck or torso
- Major traumatic amputation
- Burns with associated trauma or respiratory distress
- Paralysis
- Transferred acute trauma patients who fulfill the above criteria or have “unstable” vital signs or require blood products to maintain “normal” vital signs
- Judgment of ED Physician/MICN

#### *PROCEDURE*

- A Tier 1 code is called in to the operator with basic information (age, mechanism of injury, estimated time to arrival [ETA], and campus).
- An overhead page will state: “Tier 1 Code Yellow adult/peds/infant ETA... minutes, VCMC.”
- MICN contacts trauma surgeon on call directly from call room.
- The operator will send an alphanumeric page stating “Tier 1 Code Yellow adult/peds/infant (mechanism of injury) ETA...minutes” to all of the following people:
  - Attending Surgeon
  - ICU Resident
  - Surgical Resident
  - Med-Peds Residents
  - Nursing Supervisor
  - X-Ray Technician
  - CT Technician
  - Lab Technician
  - Respiratory Therapist
  - Security
  - Maintenance
  - Trauma Medical Director
  - Trauma Program Manager
  - Patient Advocate and Social Services, Monday – Friday from 7:00 a.m. to 5:00 p.m.
- If multiple trauma patients are being transported to the hospital, it will be paged as MCI (Multi Casualty Incident; 3-8 patients arriving at the same time).

- The nursing Supervisor will page the OR Staff (OR Tech, RN Staff).
- The following people are to arrive immediately to the Trauma Bay:
  - Physicians: Attending ED physician, ED resident, Surgery resident, ICU Resident.
  - Nurses: Two ED nurses (or more if requested), Nursing Supervisor, ICU nurses.
  - Ancillary Staff: X-Ray Technicians, Respiratory Therapists, CT Scan Technician, Security, Maintenance.
  - The Lab technician is to pick up 2 units of O negative blood and deliver it to the ER in a cooler. The Lab tech will return in approximately 30 minutes to pick up any unused blood that has been released by the surgeon and return it to the Lab.
  - Patient advocate and social services are to arrive Monday-Fridays from 8:00 a.m. to 5:00 p.m.
- The General Surgeon will receive a call on his/her cell phone from the MICN, immediately the MICN receives the call from the field.
- The General Surgeon on call is to start driving to the hospital immediately and to arrive promptly (within 15 minutes of the patient's arrival) in the ED after they are alerted.
- The OR staff on call is to start driving to the hospital immediately and arrive in the OR where an Operating Room is to be readied and remain available until released by the Surgeon on call.
- The anesthesiologist on-call will call the trauma phone once he/she receives the page. The nurse scribe will document the time the anesthesiologist called on the trauma flow sheet.

## TIER 2 TRAUMA ALERT

Patients at risk for significant injury based upon mechanism of injury but without the presence of any criteria for mandatory category/level 1 trauma alert.

### CRITERIA

- Ejection from automobile
- Death in same passenger compartment
- Extrication time greater than 20 minutes
- Falls >10 feet
- Rollover
- High-speed auto crash
- Major passenger side intrusion (PSI)
- Auto-pedestrian/auto bicycle injury with significant (>5 mph) impact
- Motorcycle crash with separation of rider from the bike
- Blunt chest trauma with suspected pneumo or hemothorax
- Blunt abdominal trauma associated with abdominal tenderness
- GCS <15 due to traumatic mechanism
- Age >65
- Transferred acute trauma patients who fulfill the above criteria
- Judgment of ED Physician/MICN
- All near drowning victims



**PROCEDURE**

- A Tier 2 code is called in to the operator with basic information (age, mechanism of injury, estimated time to arrival [ETA], and campus).
- An overhead page will state: “Tier 2 Code Yellow adult/peds/infant ETA... minutes, VCMC.”
- The operator will send an alphanumeric page stating “Tier 2 Code Yellow adult/peds/infant (mechanism of injury) ETA...minutes” to all of the following people:
  - Attending Surgeon
  - ICU Resident
  - Surgical Resident
  - Med-Peds Residents
  - Nursing Supervisor
  - X-Ray Technician
  - CT Technician
  - Lab Technician
  - Respiratory Therapist
  - Security
  - Maintenance
  - Trauma Program Manager
  - Trauma Medical Director
  - Patient Advocate & Social Services Monday-Friday from 7:00 a.m. to 5:00 p.m.
- An MCI will be called if multiple trauma patients are being transported to the hospital (3-9 patients at the same time).
- The following people are to arrive immediately to the Trauma Bay:
  - Physicians: Attending ED physician, ED resident, Surgery resident.
  - Nurses: Two ED nurses (or more if requested), Nursing Supervisor.
  - Ancillary Staff: X-Ray Technicians, Respiratory Therapists, CT Scan Technician.
  - Security, Maintenance
  - Lab technician
  - Patient advocate and social services are to arrive Monday-Friday from 8:00 a.m. to 5:00 p.m.
- The General Surgeon will call to inquire of the patient’s injuries/status, soon after receiving the page.
- The General Surgeon will discuss the case with the resident or ED physician, and has 1 hour to evaluate the patient.
- A Tier 2 Trauma can be upgraded to a Tier 1 Trauma at any time based on the patient’s condition. In this situation, the MICN will notify the page operator who will both overhead page and alphanumeric page the above noted personnel with the message “Upgrade Tier 1 Trauma.” The trauma protocol will then proceed as a Tier 1.
- \* It is our goal ***not*** to downgrade a code.

### TIER 3 TRAUMA ALERT (CONSULTATION)

- Patients who do not meet criteria for level 1 or 2 following injury will be triaged by the Emergency Department Physician.
- Consultation may be obtained on an individual case basis as per the Emergency Physicians.
- No overhead page or “mass” alphanumeric page is made.

#### CRITERIA

- Dog or animal bites requiring surgical debridement.
- Burns not meeting Tier 2 criteria.
- Penetrating injury to extremities with intact pulses.
- Cardiac and/or respiratory diagnosis with mechanism attributed to trauma.
- DM, cirrhosis, or morbid obesity with mechanism attributed to trauma.
- Pregnancy >20 wks gestation with mechanism attributed to trauma.
- Patients with bleeding disorder or patients on anticoagulation with mechanism attributed to trauma.
- Patients with minor depressed skull fracture, or head/facial trauma with associated contusions/fracture requiring admission.
- Traumatic injury not meeting Tier 2 criteria work-up by ED physician with positive findings or potential for acute changes due to mechanism of injury and/or need for serial exams and/or admission.
- Transferred acute trauma patients who fulfill the above criteria. Patients should be upgraded according to severity.

### BONY TIER 3 CRITERIA

(Note: All bony fractures with vascular compromise should have a Tier 3 consult)

#### INCLUSION:

- Humerus
- Femur fx
- Tib/Fib fx w/ mechanism attributed to MVC/mechanically operated vehicle (skate board/roller blades/scooter etc), or GSW
- Facial fx requiring admission

#### EXCLUSION:

- Supracondylar humerus fx
- Isolated intertrochanteric hip fx
- Radius/ulnar fx
- Tib/Fib fx w/o mechanism attributed to MVC/mechanically operated vehicle (skate board/roller blades/scooters/motorcycles etc), or GSW. i.e. fx secondary to sports injury (w/o vascular compromise) are excluded
- Ankle fx w/o mechanism attributed to MVC/mechanically operated vehicle (skate board/roller blades/scooters/motorcycles etc), or GSW. i.e. fx secondary to sports injury (w/o vascular compromise) are excluded

## ADMISSIONS AND TRANSFERS

All trauma patients who are being admitted will be admitted to the Trauma Service (TRA if floor, TRI if ICU, or TRO if for observation) for the first 23 hours with other specialty services as consults. The patient can then be transferred to a specialty service if they are found to only have an isolated injury which is managed by that specialty service and the Trauma Service is no longer needed.

All Tier 1 patients must be assessed within 15 minutes of the patient's arrival. At any time, a Tier 2 or 3 trauma can be elevated to Tier 1 status. In addition, the trauma surgeon will respond immediately to assess the patient at any time the ICU, ED, Floor, or residents deem necessary.

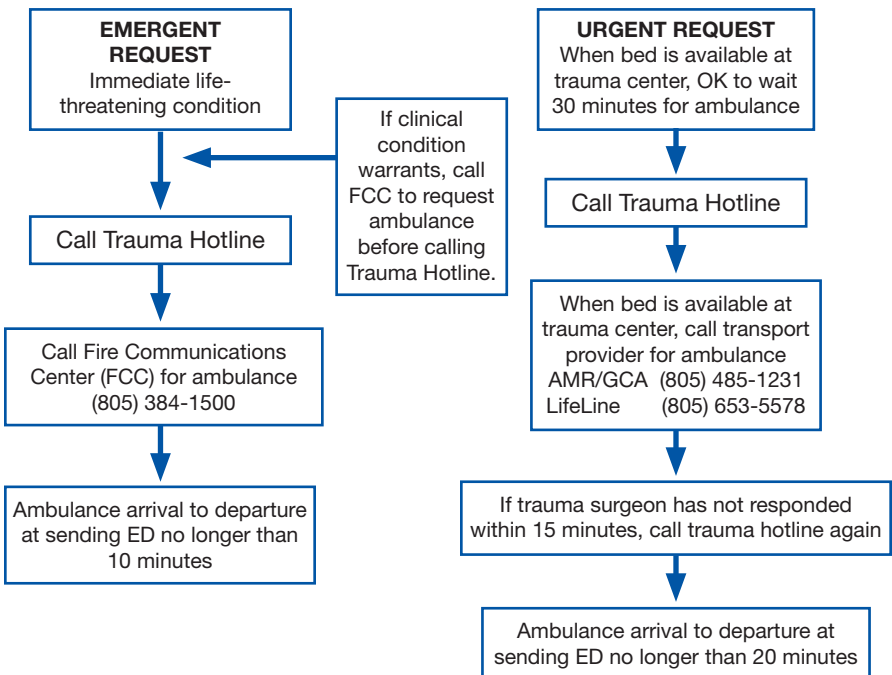
All acutely injured trauma patients (within 23 hours) who are being transferred to VCMC should be managed in the same manner as described in this protocol.

The ER must notify the trauma surgeon on call, as well as any other specialty service (including the ICU) that may be required prior to the transfer. The Trauma Service should then be notified via the Tier System guidelines once the patient is en route (Tier level, age, mechanism and ETA).

## VENTURA COUNTY TRAUMA CENTERS - TRAUMA HOTLINES

LRHMC...(805) 370-5901

VCMC...(805) 652-6777



## **Code Yellow Resuscitation Procedure**

### **TRAUMA BAY CONFIGURATION**

#### **Head of Bed**

- Intubation equipment (ambu bag and mask, cuffed tubes), suction, RSI medications
- NG tube, KY lubricant, 60 ml syringe, tape, tincture of benzoin
- Medications: Ordered by physician
- Age appropriate Crash Cart with monitor and defibrillator
- End Tidal CO<sub>2</sub> detector
- Manual blood pressure cuff

#### **Right Side of Bed**

- Blood drawing equipment
- ABG equipment
- Central venous access device
- Foley catheter tray with urimeter
- KY Jelly, gloves
- Central Line Cart
- Portable ultrasound

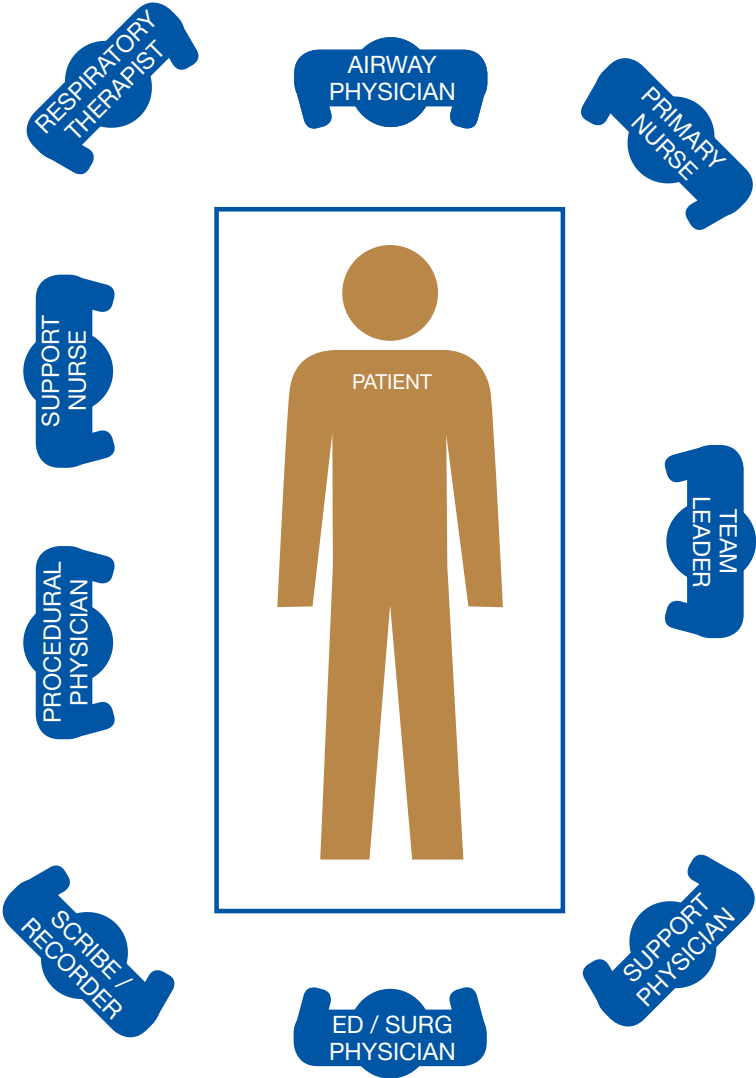
#### **Foot of Bed**

- Auto transfusion equipment as needed (should be attached to pleurovac for all trauma patients receiving a chest tube)
- Chest tube cart with thoracostomy tray
- Airway cart
- Thoracotomy and Cricothyroidotomy tray
- Level 1 Transfuser (will be set up prior to patient's arrival for Tier 1 traumas)

#### **Have Available**

- Chest cart, Central Line Cart, Airway Cart
- Breslow Tape
- Pressure bags
- Prepared IV lines, warm Normal saline, or Lactated ringer's with blood tubing as necessary
- 2 units O-negative to be brought in cooler by Lab Technician for Tier 1 traumas
- Lead vests, hanging on wall behind door
- Restraints as needed
- Universal precaution supplies - gown, gloves, masks, goggles, plastic aprons
- Scissors
- ED record/Trauma record/CPR record/ER Trauma Order Sheet
- Splint and casting cart

**PERSONNEL POSITIONING:**



## RESUSCITATION PROCEDURE

### **Prehospital Report**

Upon arrival of the patient QUIET by all team members should be observed so that everyone can hear report from prehospital personnel.

### **Duties of assigned nurses**

#### **ED Primary nurse (left head of bed)**

- Set up the Trauma room to include:
  - Additional IVs and equipment to establish IVs
  - Age appropriate Crash Cart with defibrillator
  - Airway cart
  - Chest tube cart open if indicated, including auto-transfuser
  - Venous access cart
  - Foley catheter with urimeter
  - NG tube, KY and 60 ml syringe
- Monitor on, with HR/resp., O<sub>2</sub> sat, BP modules
- Call out initial vital signs including temperature (if SBP < 100 check manually)
- Assist with airway management, apply in line cervical immobilization as directed
- Place patient on O<sub>2</sub>
- Assure patient's clothing is removed. Remove head and neck jewelry
- Do a complete physical assessment in conjunction with the code leader
- Place and replace monitoring equipment on patient (HR, O<sub>2</sub> sat, BP)
- Gastric tube is inserted, placement verified and stomach decompressed
- Apply ID band to patient
- Administer medications as ordered
- Accompany patient to CT or other diagnostic areas for all Tier 1 and Tier 2 trauma patients deemed necessary

#### **ED Nurse #2 and ICN / ICU nurse - Support Nurses (right side of bed)**

- Set up Level I transfuser
- Assess IV patency (est. additional IV(s) as necessary, with large bore IV)
- Assist in removing patient clothing
- Assist with equipment and procedures
- Foley catheter with urimeter is inserted, if ordered (after rectal exam). Urine dipped for blood. Empty first urine returned from urimeter. Note time
- Notify documentation nurse (scribe) of all procedures, meds, etc.
- ICN /ICU nurse assist ED#2 nurse and helps run the level I transfuser as needed

**ED nurse #3 - Scribe/Recorder nurse (right foot of bed)** - Start trauma clock when patient enters room.

- Note field report
- Document all information, procedures, treatments, outcomes and progress on trauma sheet
- Collect and retain all records
- Carry the trauma phone
- Chart on ED record all procedures performed
- Send formal code record to Medical Staff office for review
- Secure and document valuables

### **ED Charge nurse**

- May assist with initiation of Code Yellow
- Coordinate activities of ED
- Assists in crowd control
- Should not become actively involved in Code if he/she is only MICN (Mobile Intensive Care Nurse)
- Is authorized to call back up if necessary

### **Nursing Supervisor**

- Notify family, if Law Enforcement has not, and provide emotional support
- Obtain additional information from Law Enforcement, as necessary
- Contact OR staff (to come in, be ready and prepare OR), and other specialist as needed
- Should not become actively involved in Code unless asked to assist

### **Duties of Physicians**

**Physician (1) - Code Yellow Team leader** (ATLS certified resident on surgery rotation, or R2 or R3 resident on Medicine-Peds rotation under the supervision of the ER attending and Surgical attending) (Left head of bed). The Code Yellow Leader in charge of the resuscitation should be the **ONLY** physician giving orders to the Trauma Team members. Orders from other physicians should be suggested to the Code Yellow Leader, if OK'd then carried out.

- Code leader's role:
  - Assure all team members are present and knowledgeable of duties
  - Receive prehospital report
  - Directs movement of patient (slowly and deliberately), maintaining pre-established airway, IV and C-spine precautions

#### **Primary Survey:**

- **Airway** (C-spine precautions) delegate to maintain
- **Breathing** - moving air – oxygen, intubation
- **Circulation** - carotid pulse, control external bleeding, s/s of shock, IV's
- **Deficit/Disability** – GCS, pupils, moving extremities?
- **Expose** - remove clothing, place warm blanket, core temperature
- **Foley** - after perineum, pelvis examined
- **G-tube** - NGT if no facial trauma, not intubated, or infant. Otherwise OGT
- **Hertz** – F.A.S.T.

#### **Resuscitation Phase simultaneous with primary & secondary survey**

- Order Trauma Lab panel, T&S and additional labs/studies as needed; remind nursing of u-tox
- Assure 2 large bore IVs are established if possible and indicated
- O<sub>2</sub>, monitor, Foley, NG/OG tube
- Secondary Survey Head to Toe physical exam, including posterior/back
- Responsible for contacting attending physicians as necessary
- Responsible for having a physician talk to family members
- Responsible for care of the patient until turned over to OR, ICU Resident or admitted to the floor

- Vocalize all findings from primary and secondary survey
- Releases unneeded staff of their duties when deemed appropriate
- Accompany Tier 1 patients (and Tier 2 patients deemed necessary) during transport and while in radiology department for studies

**Physician (2) - Airway physician** - (head of the bed) (ICU R2 or above signed off for intubation - under ER physician's supervision)

- Manage Airway, intubation, and assist with other procedures as directed by the code leader
- Assist with gastric tube insertion
- Assess Pupils, examine head (scalp, TM, teeth, tongue, face, etc)

**Physician (3) - Procedural physician** - (right side of Bed) (R2 Med-Peds)

- Assist in managing airway by applying in line cervical immobilization for intubation and during patient movement
- Insert central line as directed by code leader
- Femoral blood draw and/or ABGs as needed
- Assist with/perform other procedures as requested
- Assist team leader with documentation, telephone calls
- Performs F.A.S.T. with ED physician

**Physician (4) – Support physician** - (left foot of Bed) (R1 Med-Peds)

- Assist with removal of clothing and head/neck jewelry prior to C-Spine X-ray
- Assist with/perform procedures as directed by code leader (If ED resident unavailable)
- Perform CPR as needed
- Examine back and perform rectal exam per code leaders direction
- Assist team leader with documentation, telephone calls
- Record H & P after A – E (above) performed

### **ED Attending**

- Assist code leader in managing the code throughout entire evaluation and ED resuscitation
- Assist with airway management and intubation
- Assume any resident physician role when deemed necessary
- Teach and assist invasive procedures
- Become the code leader if necessary
- Assist Support physician with FAST and other procedures as needed
- Assist Airway physician with intubation
- ED attending will be the primary attending until deemed appropriate to transfer care to the surgery attending. At that time, the ED physician will continue to assist with the evaluation and ED resuscitation of the patient

### **Surgery Attending**

- Assist code leader in managing the code
- Assume any resident physician role when deemed necessary
- Teach and assist invasive procedures
- Become the code leader if necessary
- The Surgery attending will be the primary attending upon their arrival
- Releases the operating room from being on "Trauma Hold" when deemed appropriate



### ***Duties of Respiratory Therapy***

- (Only 2 therapists to be in the Trauma Bay at one time unless it is absolutely necessary to have more)
- Assist with intubation by applying cricoid pressure
- Assist with endotracheal tube stabilization
- Set up and maintain ventilator settings
- Other duties as requested/needed

### ***Laboratory personnel***

- Bring 2 units of O-negative blood in cooler for all tier 1 traumas
- Return unused O-negative blood to blood bank within 30 minutes
- Draw ordered labs

### ***Observers***

Those individuals who do not have a designated position or job in the trauma bay or those who are not “actively involved” with the code may observe outside the trauma room, behind the yellow line. Specific observers may be asked to assist in certain situations.

### ***Miscellaneous***

All Tier 1 patients going to the CT scanner will be monitored continuously and will be accompanied by a resident and the Trauma Surgeon. Tier 2 patients going to the CT scanner will require a monitor and accompaniment by a resident per the ED physician’s discretion.

### **GOALS:**

#### ***Tier 1 Trauma patients:***

- Time from door to CT Scanner < 30 minutes (goal: single digit).
- Time from door to OR in patients with immediately life threatening issues and requiring operative management < 30 minutes (goal: single digit).
- Trauma Attending to arrive within 15 minutes of patient’s arrival.
- At least 5 minutes notification by prehospital personnel prior to patient’s arrival.
- Improved morbidity and mortality.
- Organized, rapid, efficient care.

Sample: Trauma Flow Sheet (VCMC-388-003) - page 1 of 3

Trauma Resuscitation Record

		Admit Date: _____	
		Arrival Time: _____	
		Arrival Time: _____	
		Level: <input type="checkbox"/> I <input type="checkbox"/> II <input type="checkbox"/>	
<b>Arrived via:</b>	<b>Pre-hospital Interventions</b>	<b>Pt. Medications</b>	<b>Past History</b>
<input type="checkbox"/> Ambulance <input type="checkbox"/> Helicopter <input type="checkbox"/> Police <input type="checkbox"/> Private Vehicle <input type="checkbox"/> Transfer from: _____	<b>Airway:</b> <input type="checkbox"/> Oral <input type="checkbox"/> Nasal <input type="checkbox"/> Intubated <input type="checkbox"/> O <sub>2</sub> <input type="checkbox"/> IV size _____ site _____ <input type="checkbox"/> IV #2 size _____ site _____ <input type="checkbox"/> Blood sugar _____ mg/dl <input type="checkbox"/> CPR <input type="checkbox"/> Splint type _____ location _____ <input type="checkbox"/> Meds _____ <input type="checkbox"/> IV Fluids total _____	<input type="checkbox"/> Unknown	<input type="checkbox"/> DM <input type="checkbox"/> COPD <input type="checkbox"/> Cardiac <input type="checkbox"/> Seizure <input type="checkbox"/> Unknown Est. Weight: _____ last tetanus _____ last P.O. _____
<b>Mechanism of Injury</b>			
<b>Motor Vehicle</b>		<b>Fall/Jump</b>	<b>Burn</b>
<b>Involved:</b>	<b>Patient was:</b>	<b>Approx. height:</b>	<b>Penetrating</b>
<input type="checkbox"/> Auto <input type="checkbox"/> Light truck <input type="checkbox"/> Heavy truck <input type="checkbox"/> Motorcycle <input type="checkbox"/> ATV <input type="checkbox"/> Bicycle <input type="checkbox"/> Pedestrian <input type="checkbox"/> Watercraft <input type="checkbox"/> Sporting _____ <input type="checkbox"/> Unknown	<input type="checkbox"/> Driver <input type="checkbox"/> Passenger-front <input type="checkbox"/> Passenger-back <input type="checkbox"/> Pedestrian struck by auto <input type="checkbox"/> Bicyclist struck by auto <input type="checkbox"/> Unknown	<input type="checkbox"/> Seatbelt <input type="checkbox"/> Airbag <input type="checkbox"/> Child Seat <input type="checkbox"/> Helmet <input type="checkbox"/> Ejected <input type="checkbox"/> Extrication <input type="checkbox"/> Death of another occupant	<input type="checkbox"/> GSW caliber _____ distance _____ <input type="checkbox"/> Stab blade length _____ <input type="checkbox"/> Self inflicted <input type="checkbox"/> Impalement Other: _____
		Impact: <input type="checkbox"/> Front <input type="checkbox"/> Side <input type="checkbox"/> Rear <input type="checkbox"/> Rollover <input type="checkbox"/> T-bone	<input type="checkbox"/> Flame <input type="checkbox"/> Steam <input type="checkbox"/> Chemical <input type="checkbox"/> Radiation <input type="checkbox"/> Inhalation <input type="checkbox"/> Electrical voltage: _____
		<input type="checkbox"/> Grass/Dirt/Earth <input type="checkbox"/> Stone <input type="checkbox"/> Concrete/Brick <input type="checkbox"/> Tile/Wood <input type="checkbox"/> Carpet <input type="checkbox"/> Water <input type="checkbox"/> Found Down	<input type="checkbox"/> Confirmed by: _____ <input type="checkbox"/> End tidal CO <sub>2</sub> <input type="checkbox"/> CXR
<b>Primary Survey and Preliminary Interventions</b>			
<b>Airway</b>	<b>Breathing</b>		<b>Circulation</b>
<input type="checkbox"/> Patent/Talking <input type="checkbox"/> Clear <input type="checkbox"/> Partially obstructed	<input type="checkbox"/> Completely obstructed <input type="checkbox"/> Intubated <input type="checkbox"/> EOA/Combitube	<input type="checkbox"/> Jaw thrust <input type="checkbox"/> Suction <input type="checkbox"/> Foreign object removal/laryngoscopy	RSI _____ time _____ tube size _____ # attempts: _____
	<input type="checkbox"/> Spontaneous <input type="checkbox"/> Labored <input type="checkbox"/> Agonal <input type="checkbox"/> No effort	Trachea: <input type="checkbox"/> Midline <input type="checkbox"/> Deviated <input type="checkbox"/> R <input type="checkbox"/> L Chest wall symmetry: <input type="checkbox"/> Symmetrical <input type="checkbox"/> Asymmetrical	Assisted: <input type="checkbox"/> BVM <input type="checkbox"/> Ventilator Vent. Rate _____
	Lung sounds: R L Present <input type="checkbox"/> <input type="checkbox"/> Rales <input type="checkbox"/> R L Clear <input type="checkbox"/> <input type="checkbox"/> Rhonchi <input type="checkbox"/> R L Diminished <input type="checkbox"/> <input type="checkbox"/> Wheezes <input type="checkbox"/> R L Absent <input type="checkbox"/> <input type="checkbox"/>	Time _____ IVs: Site _____ Size _____ _____ _____ _____ <input type="checkbox"/> Warm IV fluids	<input type="checkbox"/> Warm blankets <input type="checkbox"/> Warming lights <input type="checkbox"/> Direct pressure bleeding control: _____ site _____
<b>Disability</b>	<b>Glasgow Coma Scale (GCS)</b>		<b>Pupils</b>
Eye Opening <input type="checkbox"/> 4 Spontaneous <input type="checkbox"/> 3 To Verbal <input type="checkbox"/> 2 To Pain <input type="checkbox"/> 1 None	Verbal <input type="checkbox"/> 5 Oriented <input type="checkbox"/> 4 Confused <input type="checkbox"/> 3 Inappropriate response <input type="checkbox"/> 2 Incomprehensible <input type="checkbox"/> 1 None/Intubated	Motor <input type="checkbox"/> 6 Obeys <input type="checkbox"/> 5 Localizes pain <input type="checkbox"/> 4 Withdraws from pain <input type="checkbox"/> 3 Flexor posturing <input type="checkbox"/> 2 Extensor posturing <input type="checkbox"/> 1 None/chemically paralyzed	R L <input type="checkbox"/> Brisk <input type="checkbox"/> Sluggish <input type="checkbox"/> Non-reactive R _____ L _____ mm



VENTURA COUNTY MEDICAL CENTER  
SANTA PAULA HOSPITAL  
**TRAUMA RESUSCITATION  
RECORD**

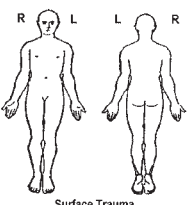

PATIENT LABEL

Page 1

VCMC-388-003 (09/2010)

Distribution: White - Chart    Canary - Trauma Office    Pink - Billing / Medical Record

Sample: Trauma Flow Sheet (VCMC-388-003) - page 2 of 3

Secondary Survey																					
Head	<input type="checkbox"/> Pain/tenderness <input type="checkbox"/> Drainage from: <input type="checkbox"/> ears <input type="checkbox"/> nose <input type="checkbox"/> mouth <input type="checkbox"/> Normal																				
Neck	<input type="checkbox"/> Pain/tenderness <input type="checkbox"/> JVD <input type="checkbox"/> Normal Findings																				
Chest	<input type="checkbox"/> Pain/tenderness <input type="checkbox"/> Dyspnea <input type="checkbox"/> Normal <input type="checkbox"/> Deformity <input type="checkbox"/> Paradoxical expansion <input type="checkbox"/> Bowel sounds present																				
Abdomen	<input type="checkbox"/> Pain <input type="checkbox"/> tender <input type="checkbox"/> Rigid <input type="checkbox"/> Bowel sounds present <input type="checkbox"/> Soft <input type="checkbox"/> Guarded <input type="checkbox"/> Distended <input type="checkbox"/> Bowel sounds absent Erisias/gastrocut: <input type="checkbox"/> + <input type="checkbox"/> - <input type="checkbox"/> Normal																				
Pelvis/Genital	<input type="checkbox"/> Pain/tenderness Pelvis: <input type="checkbox"/> stable <input type="checkbox"/> unstable <input type="checkbox"/> Blood at the meatus Rectal tone: <input type="checkbox"/> present <input type="checkbox"/> absent Hemocult: <input type="checkbox"/> + <input type="checkbox"/> - <input type="checkbox"/> Normal																				
Extremities	<input type="checkbox"/> Pain/tenderness <input type="checkbox"/> CMS intact x4 <input type="checkbox"/> Normal <input type="checkbox"/> Moves all extremities <input type="checkbox"/> Extremities warm and pink <input type="checkbox"/> Normal																				
Back	<input type="checkbox"/> Pain/tenderness <input type="checkbox"/> Normal <input type="checkbox"/> Deformity <input type="checkbox"/> Normal																				
First Set of Vitals												Ongoing Monitoring (Document every 5 minutes)									
Time																					
BP	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
Pulse																					
Resp.																					
SaO2	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
O <sub>2</sub> Supplemental	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y
GCS	E	V	M																		
Temp.	°F	°F	°F	°F	°F	°F	°F	°F	°F	°F	°F	°F	°F	°F	°F	°F	°F	°F	°F	°F	°F
Pain scale	/10	/10	/10	/10	/10	/10	/10	/10	/10	/10	/10	/10	/10	/10	/10	/10	/10	/10	/10	/10	/10
Medications	Dose	Route	Time	By:	Response Effective	Solution/Blood Product	Time hung	Blood unit #	Amount infused												
					Y N				mL												
					Y N				mL												
					Y N				mL												
					Y N				mL												
					Y N				mL												
					Y N				mL												
					Y N				mL												
<input type="checkbox"/> Other: _____ Time <input type="checkbox"/> ABG _____ Time <input type="checkbox"/> Trauma Panel _____ Time												LAB		<input type="checkbox"/> HCG _____ Time <input type="checkbox"/> U/A / Urin Tox. _____ Time		PROCEDURE		TIME		By:	
RADIOLOGY STUDIES												<input type="checkbox"/> Chest Tube R <input type="checkbox"/> Chest Tube L <input type="checkbox"/> CPR <input type="checkbox"/> Central Line <input type="checkbox"/> Back Board Removed <input type="checkbox"/> Thoracotomy <input type="checkbox"/> Suture									
Plain	Time	CT	Time	Time																	
Chest		Abdomen		CT Angio																	
Pelvis		Chest																			
Spine		Head		MRI																	
Extremities		Neck																			
		Pelvis		Fast Scan (+ / -)	/																
		Spine																			
Patient Disposition																					
INTAKE		OUTPUT						DISPOSITION													
Crystalloids		Est. Blood Loss						Admitted to:		Time Transferred:											
Blood		Urine						Expired:		Time Coroner Notified:											
Other Colloids PO		Chest Tube						Body sent to:		Morgue Coroner's Office Mortuary Other											
		NG/OG Emesis						Transported Via:		<input type="checkbox"/> Wheelchair <input type="checkbox"/> Stretcher <input type="checkbox"/> Monitor <input type="checkbox"/> Alert/Oriented <input type="checkbox"/> Unchanged <input type="checkbox"/> Improved <input type="checkbox"/> Asymptomatic <input type="checkbox"/> Stable <input type="checkbox"/> Guarded											
Total IN		Total OUT						<input type="checkbox"/> ID Bands <input type="checkbox"/> Clothing List		Report Called to:											
 VENTURA COUNTY MEDICAL CENTER SANTA PAULA HOSPITAL TRAUMA RESUSCITATION RECORD										PATIENT LABEL						Page 2					
VCMC-388-003 (09/2010)																					

Sample: Trauma Flow Sheet (VCMC-388-003) - page 3 of 3

Progress Notes:

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**TRAUMA TEAM SIGN-IN ROSTER:**

DEPARTMENT	NAME (Print)	TIME OF ARRIVAL
Scribe:		
Attending Surgeon		
ED Physician		
Anesthesia	TIME CALLED: _____	
CT - Technologist		
X - Ray Technologist		
Phlebotomist		
Respiratory Therapist		
Social Worker		
Resident: ICU		
Resident: Surgical		
Resident: Med / Ped		
DOU / ICU RN		
Trauma RN		
Primary RN		



VENTURA COUNTY MEDICAL CENTER  
 SANTA PAULA HOSPITAL  
**TRAUMA RESUSCITATION  
 RECORD**

PATIENT LABEL

Page 3

VCMC-388-003 (09/2010)

## Code Yellow Policies by Department

### ANESTHESIA AND SURGERY DEPARTMENT

- In an effort to provide better care to the severely injured patient and reduced morbidity and mortality, an operating room, OR staff and Anesthesia personnel will be rapidly available to perform operative procedures.
- An Operating Room will automatically be placed on hold for all Tier 1 traumas until released by the trauma surgeon. The decision to release the room will be made by the trauma surgeon as soon as possible, but not before the primary and secondary survey have been completed.
- The Operating Room staff (OR Tech & RN staff) are to be paged by the Nursing Supervisor for all Tier 1 traumas. They will start driving to the hospital immediately and arrive in the OR, where they will ready the OR, and keep it available until it is released by the surgeon on call.
- Anesthesia will be paged by the nurse or nursing supervisor once the trauma surgeon has decided an Urgent/Emergent operative management is indicated, or if their assistance is needed for a difficult airway. The only information that needs to be conveyed is the patient's age, sex, mechanism of injury, known past medical history, known injuries and planned surgery/need for airway. The anesthesiologist is to proceed immediately and present to the operating room/trauma room within 10 minutes of notification.
- In the event the anesthesiologist and OR staff on call are currently assisting with an operation, the trauma surgeon and anesthesiologist will discuss and decide whether the second team should be called, or if the trauma case should follow the current case (no more than 30 minutes if urgent and no more than 15 minutes if emergent).
- A Trauma Cart with basic instruments and supplies as well as a defibrillator with internal paddles will be stored \*at a designated place\* at all times. This tray will be utilized while awaiting the arrival of the OR staff and anesthesiologist. This way, a patient requiring emergent, lifesaving surgery can proceed to the OR, be prepped and draped and surgery started before all members of the team have arrived. During this time, Respiratory Therapy will maintain Ventilator management with a basic ventilator, and the ER /ICU nurse will work as circulators until all personnel have arrived. This EMERGENCY TRAUMA use of the OR will only be performed for lifesaving surgery. Indications include:
  - Hemodynamic Instability
  - Exsanguination
  - Return of cardiac activity after traumatic arrest
  - Impending herniation following blunt head injury
  - Cardiac Injury
  - Evisceration following penetrating trauma
  - Suspected vascular injury with active bleeding or expanding hematoma

### BLOOD BANK

- When a Tier 1 Code Yellow is called, the Lab Tech will deliver 2 units of O-negative blood to the ED in an ice chest. The ice chest will be delivered to the charge nurse (who will sign for the blood).

- The Blood Bank will inquire concerning any unused blood after approximately 30 minutes. Blood not used and released by the trauma surgeon will be returned to the Blood Bank by the Lab Tech.

## RADIOLOGY

- A radiology tech will arrive to the trauma bay immediately upon notification of a Tier 1 or 2 trauma activation.
- CT tech will arrive immediately to the trauma bay immediately upon notification of a Tier 1 or 2 trauma activation.
- A 64 Channel (or better) CT scan will be utilized on all trauma patients having a CT scan performed.
- A verbal report will be given to the Attending Trauma Surgeon on call for all radiographs with significant findings or discrepancies from the preliminary report.

## PAGING

- For all Tier 1 & 2 Code Yellows, the Page Operator will send an alphanumeric page stating: “Tier [1 or 2] Code Yellow [Adult/Peds/Infant] [mechanism of injury] ETA .... minutes, VCMC” to the following people on call:
  - Attending Surgeon
  - Surgical Resident
  - ICU Resident
  - Med-Peds Residents
  - Nursing Supervisor
  - X-Ray Technician
  - CT Technician
  - Lab Technician
  - Respiratory Therapist
  - Security
  - Maintenance
  - Trauma Program Manager
  - Trauma Medical Director
- The on-call Pediatric Intensivist will be paged for tier I and II pediatric trauma activation.
- In addition, they will also page the Patient Advocate and Social Services during Monday – Friday 7 a.m. – 5 p.m.
- For all Tier 1 & 2 Code Yellows, The Page Operator will make an overhead page stating “Tier [1 or 2] Code Yellow [Adult/Peds/Infant] ETA [...] minutes, VCMC.”
- If a trauma has been upgraded to a Tier 1, the operator will both overhead and alphanumeric page the above noted personnel with the message “Upgrade Tier 1 Trauma.” \* It is our goal **not** to downgrade a code.
- If multiple trauma patients are being transported to the hospital, an MCI will be called (3-9 patients arriving at the same time).
- A-3333 can be added to the alphanumeric pages to identify patients being transported by helicopter.
- Determination of calling in the back-up surgeon will be made by the on-call surgeon.

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## CHAPTER 3

# INITIAL TRAUMA EVALUATION

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### **IN THIS SECTION**

*Primary Survey*

*Airway*

*Surgical Airway Management*

*Lab Studies*

*X-rays*

*Guidelines for Procedural Sedation*

*Trauma Orders*

TRAUMA  
BOOK **2012**



## Primary Survey

The assessment and resuscitation of the trauma patient is performed simultaneously with the priority to rapidly detect and treat fatal conditions. Only after all life threatening problems have been dealt with should one proceed with the secondary survey and deal with injuries of secondary importance.

Primary survey:

- Airway
- Breathing
- Circulation
- Disability/Neurological status
- Exposure/Environmental control
- Foley catheter
- Gastric tube
- Hertz (FAST)

### A - AIRWAY

- Open the airway
  - Clear oropharynx of blood, mucus and foreign bodies.
  - Lift angle of the jaw to prevent the tongue from obstructing the airway while maintaining C-spine precautions.
  - Use of oropharyngeal tubes in patients with gag reflexes may induce vomiting and aspiration. Very limited use!!
  - If above measures are not sufficient or if the patient is unconscious, intubation is necessary.
- Endotracheal tube size
  - 7.5-8 for adult males.
  - 7-7.5 for adult females, or recommendations based on Breslow tape for peds patients (the size of the patient's small finger, regardless of age).
- Apply cricoid pressure
  - Until cuff is inflated and during intubation to prevent aspiration.
- Verify placement
  - Check CO<sub>2</sub> by using End Tidal CO<sub>2</sub> monitor
  - Listen for bilateral breath sounds AND
  - Obtain chest x-ray
- If one is unable to intubate
  - A cricothyroidotomy should be performed. There is no place for tracheostomy in an emergency situation.
  - A transverse or vertical incision is made over the cricothyroid space and a tube is inserted
  - In desperate cases, a large-bore needle (14-16 gauge angiocath) may be placed in the cricothyroid space (needle cricothyroidotomy)
- Monitor oxygen saturation
  - Perform an ABG on all severely injured or intubated patients. See trauma order for Tier levels.

- Maintain high index of suspicion for spine injury
  - C-spine precautions until cleared clinically or radiographically. See protocol. Avoid manipulation of head and neck.
  - Use sand bags or hard collar to immobilize the neck.
  - Obtain adequate radiography (performed after patient stabilized) if patient cannot be cleared clinically.
  - Continue C-Spine precautions if the patient is unconscious or intoxicated despite normal x-rays or CT scan, especially if not observed moving all extremities (see C-spine clearance algorithm).
  - Radiological evaluation should be done only after the patient has been stabilized, if necessary after an emergency operation.

## B - BREATHING

- Look, Listen, & Feel
- Inspect for symmetrical chest movements.
- Auscultate for breath sounds bilaterally.
- Palpate trachea for deviation and the chest wall for fractures or emphysema.
- Life-threatening problems to be identified during primary survey:
  - Flail chest: Monitor pulse oximetry and blood gases, intubate and ventilate if hypoxia or respiratory distress. Consider early intubation.
  - Open, “sucking/blowing” wound in the chest wall: place chest tube prior to closing or dressing wound secondary to potential risk of tension pneumothorax.
  - Tension pneumothorax: Initial decompression with needle insertion 14-16 gauge through 2nd or 3rd intercostal space anteriorly, mid-clavicular line followed by thoracostomy tube.
  - If unable to place chest tube immediately, apply occlusive dressing, but tape only 3 sides.

## C - CIRCULATION

- Assess level of consciousness, skin color, pulse, BP, capillary refill.
- Control any external bleeding by direct pressure (do not clamp blindly).
- In penetrating injuries of the neck with suspected venous injuries, place patient in trendelenburg position (head down) to prevent air embolism.
- Insert two large (14-16 gauge) intravenous lines and start fluid resuscitation.

### **Shock**

The cardiovascular system consists of a pump system, and circulating blood volume. Failure of either of the two may result in shock. In addition, a high spinal cord injury may result in interruption of the sympathetic chain leading to neurogenic shock. The following section describes the three types of shock that one may encounter when dealing with the acutely injured patient.

- **Cardiogenic Shock:** This should be suspected in trauma patients with shock in the absence of blood loss. The blood pressure is low and the neck and peripheral veins are distended. The following conditions may be associated with cardiogenic shock: cardiac tamponade, myocardial contusion, tension pneumothorax, air embolism, and myocardial infarction.
  - *Cardiac Tamponade:* Injury to heart or proximal great vessels leading to bleeding into the pericardium. Eventually the pressure within the pericardium surrounding the heart can prevent atrial filling thus leading to cardiac failure. Symptoms include: restlessness, shock, tachycardia, weak peripheral pulses. Signs: Beck's triad. (shock/hypotension, distended neck veins, distant cardiac sounds) present in ~90% of patients. Pulsus paradoxus is present in only 10% of the cases. Every penetrating injury to the chest is a cardiac injury until proved otherwise.
  - *Air Embolism:* May follow injuries to major veins (including internal jugular), lungs, or the low pressure cardiac chambers. (May occur during insertion of a central venous line). Sometimes a "sloshing" sounds may be heard over the heart. Treatment consists of positioning the patient in the Trendelenburg position (head down), and left lateral decubitus position with right side up performing a thoracotomy and the direct aspiration of air from the heart. In lung injuries, cross-clamp the hilum to control the source of air embolism.
  - *Myocardial infarction* should be suspected in older patient presenting in cardiogenic shock.
- **Hypovolemic Shock:** This could be due to external or internal blood loss or loss of vascular tone (e.g., neurogenic shock in spinal injuries – see below). With hypovolemic shock, vascular access with two or more large bore IV lines (14-16 angiocaths) and volume replacement are of critical importance. In addition, access to central veins can be achieved by means of subclavian or jugular or femoral vein catheterization. In patients with neck or arm injuries, the intravenous line should be inserted on the opposite uninjured side to avoid extravasation of the infused fluid from a proximal venous injury. In children younger than 6 years, consider intraosseous infusion. Give a fluid challenge of 2 liters of warm Ringer's Lactate/NS solve (or 20 ml/kg for children). If more fluids are required, consider blood transfusion and possible surgical intervention.
- **Neurogenic Shock:** Due to injury of the sympathetic chain therefore causing vasodilatation (high cardiac output and low SVR on swan). These patients differ from hypovolemic and Cardiogenic shock in that you will notice hypotension with warm extremities and neurologic deficits (paraplegia or quadriplegia). These patients are treated differently than the above mentioned patients in that they will require vasopressors in addition to fluid resuscitation.

### **Blood Transfusion**

- O-negative. No need for typing or cross-matching. For life-threatening blood loss only.
- For male patients, there is no need to utilize O-negative. O-positive can be used instead.
- Type-specific blood. Typed but not cross-matched. Ready in about 10 minutes. Fully typed and cross matched. Ready in about 30 minutes.
- Always use a micro-filter to prevent micro-embolization to the lungs.
- Use blood warmers. Hypothermia may worsen acidosis, shift the oxyhemoglobin dissociation curve to the left impairing oxygenation, induce arrhythmias and impair platelet function leading to coagulopathy.
- In severe hypovolemia use level I rapid infusion blood warmers.
  - Trigger the Massive Transfusion Protocol (MTP) on all patients who are in severe shock.

### **D - DISABILITY (NEUROLOGICAL EVALUATION AND MANAGEMENT)**

- Assess level of consciousness (Glasgow Coma Scale).
- Assess pupils (size, reactivity).
- Assess if patient is moving extremities and rectal tone.
- Correct any hypotension or hypoxia to minimize secondary brain damage.

### **E - EXPOSURE/ENVIRONMENTAL CONTROL**

- Undress the patient completely for thorough examination.
- Look in the axilla, perineum and between the buttock checking for penetrating injuries.
- An obvious injury should not distract from another less obvious but perhaps more dangerous injury.
- Keep the patient warm with blankets and warm IV fluids to prevent hypothermia (which may lead to acidosis, hypotension and coagulopathy).
- Obtain/document core temperature.

### **F - FOLEY CATHETER**

- Be sure to rule out urethral injury prior to placement (perineal/scrotal ecchymosis, blood at the meatus, high riding prostate).

### **G - NASOGASTRIC TUBE/OROGASTRIC TUBE**

- NG/OG tubes can help reduce the risk of aspiration. Children commonly swallow air when crying, thus increasing gastric dilatation leading to a potential decrease in tidal volume as well as an increased risk of emesis/aspiration. An orogastric tube should be used in infants and patients with massive facial or basilar skull fractures in place of NG tubes.

## H - HERTZ (TRAUMA ULTRASOUND)

**FAST SCAN** - Focused abdominal Sonography for Trauma

**E-FAST Scan** - Extended Fast Scan (include lungs)

- For diagnosis of intra-abdominal bleeding or pericardial blood.
- 4 locations: Hepatorenal, Splenorenal, Suprapubic and Subxiphoid

### **Secondary Survey**

- The secondary survey is done only after the primary survey is completed and resuscitation is initiated.

### **Complete examination from head to toe!**

### **Tertiary Survey (see form)**

Trauma patients can offer a unique set of challenges as they may present unresponsive, unable to provide vital information, uncooperative, intoxicated or have distracting or life threatening injuries that prevent the detection of all injuries in the primary and secondary surveys.

The primary and secondary surveys are part of the systematic approach developed to recognize and treat immediate life threatening problems upon arrival. The initial head-to-toe examination is intended to identify all injuries; however, multiple studies demonstrate that not all injuries are identified at the time of presentation.

The purpose of the tertiary trauma survey (TTS) is to minimize injuries that are overlooked on initial presentation. It is defined as a patient evaluation that identifies and catalogues all injuries after the initial resuscitation and operative intervention. The TTS is a comprehensive review which includes repetition of the primary and secondary surveys, a review of the mechanism, co-morbid conditions, examination of lab and final imaging studies and complete head to toe physical exam. Any new physical exam findings may require further workup to rule out any missed injuries and re-evaluation of known injuries.

**The TTS has been implemented to avoid missed injuries and is to be performed:**

- On all trauma patients, including those seen and released from the E.D.
- Within 24° for admissions to the ICU and repeated prior to discharge.
- Prior to discharge, for patients admitted to the floors.
- May be used as the progress note for the day.

## Airway

### BACKGROUND

Managing the airway in a trauma patient is the cornerstone to a successful resuscitation. The initial management entails a rapid overview, determining if the patient is stable, unstable, or dying. The primary survey is an evaluation of the ABC's and neurologic function. The patient's evaluation, along with any relevant history, will determine the best means to manage the airway. The unstable or dying patient needs their airway immediately secured. The stable patient may have impending respiratory failure, and may need prophylactic endotracheal intubation. There are many variables that influence the best means to safely secure a patient's airway. One of the most important decisions to make is whether or not to use neuromuscular blockers, i.e., succinylcholine or a non depolarizing muscle relaxant such as rocuronium. By definition, the trauma patient has a full stomach. The safest way to secure the airway in a patient with a full stomach, assuming relatively normal anatomy and a lack of special circumstances, is by rapid sequence induction (RSI). Below are the steps of a rapid sequence induction in a trauma patient. The difficult airway and special situations will be discussed following the RSI.

### RAPID SEQUENCE INDUCTION

Why the big deal over a rapid sequence induction? Mortality has been estimated to approach 30-50% in trauma patients with a significant aspiration. A significant aspiration is defined as gastric contents with a pH less than 2.5, and the volume greater than 0.4 ml/kg. The rapid sequence induction has two goals. Secure the airway without significant desaturation and secure the airway without pulmonary aspiration.

#### ***Preoxygenation:***

4 vital capacity breaths are sufficient to denitrogenate normal lungs. If the patient is unable to take maximal breaths, then 3-5 minutes is required to obtain the same degree of preoxygenation. This luxury is obviously not always available.

#### ***Cricoid Pressure:***

An assistant applies firm pressure over the cricoid cartilage prior to any IV sedation. Pressure on the cricoid cartilage is transmitted to the underlying tissue, which compresses the esophagus, limiting the amount of passive regurgitation that will reach the hypopharynx. The amount of pressure is controversial; however, the pressure should not be uncomfortable to a conscious patient. The risks of too much pressure include esophageal rupture, laryngeal fracture, and cervical spine fracture in an unstable C-spine.

### **Sedation/Muscle Relaxants**

Sedation is dependent on the patient's level of consciousness and hemodynamic stability. Hypotensive unconscious patients will probably not require any sedation. Conscious hypotensive patients will need a decreased dose of a hemodynamic stable induction agent such as etomidate or ketamine. The important decision is to decide on your IV induction agent and stick to it. The IV induction agent is immediately followed by the muscle relaxant, either 1.5 mg/Kg of Succinylcholine or 1 mg/kg of Rocuronium or other suitable non-depolarizing muscle relaxant.

### **Direct Laryngoscopy**

The classic RSI does not include ventilating the patient prior to securing the airway with an endotracheal tube. The goal is to avoid filling the stomach with gas and increasing the risk of emesis. If ventilation is required prior to securing the airway, cricoid pressure is maintained and ventilation is accomplished by keeping the peak airway pressures less than 20-25cmH<sub>2</sub>O. Prior to direct laryngoscopy, the airway is suctioned, if necessary. Direct laryngoscopy is accomplished with the operator's blade of choice. MAC blades and Miller blades should both be readily available, no matter what the situation. MAC blades are generally more effective at controlling large tongues that can obscure the hypopharynx, and Miller blades are generally more successful at exposing the vocal cords in patients with anterior airways or large epiglottis.

### **Confirmation of Tracheal Intubation**

A CO<sub>2</sub> detection device should immediately be attached to the endotracheal tube to confirm correct placement. This is the most accurate and definitive means to ensure tracheal intubation; however, in the severely hemodynamically compromised trauma patient CO<sub>2</sub> may not be detected. Listen for bilateral breath sounds, watch for bilateral chest rise, and rule out gastric distension as well as "gastric breath sounds."

## **DIFFICULT AIRWAY**

There is no "correct" way to manage the difficult airway; however there are textbooks dedicated to helpful suggestions. If the patient is unconscious, in respiratory or cardiac arrest, then RSI must proceed. In these situations back up plans must be readily available. The conscious, hemodynamically stable patient with a difficult airway and impending respiratory failure should have their airway secured awake. Rendering a patient with a difficult airway apneic can lead to a fatal outcome. Recognition of a difficult airway is relatively subjective, yet there are some objective criteria that can be valuable in this situation (see table 1).

## **EMERGENT DIFFICULT AIRWAY**

If the patient presents in respiratory or cardiac arrest or with a depressed level of consciousness with an inability to protect his/her airway, then RSI must follow. The problem arises if a difficult airway is encountered after a neuromuscular

blocker has been given. Succinylcholine is the neuromuscular blocker of choice with the emergent RSI in a difficult airway. The majority of patients will return to spontaneous ventilation within 5-10 minutes after IV succinylcholine, as opposed to a nondepolarizer, which may take up to 20-30 minutes to return to spontaneous breathing. The undesirable effects of succinylcholine must be considered in context to the particular trauma patient, particularly increased potassium release in patients with burns and neurologic diseases, increased intracranial pressure, bradycardia and dysrhythmias. The first step in the failed airway is to mask the patient and maintain oxygenation. The next step is to have a "second look" with another blade, i.e., Miller blade. If the second look is unsuccessful, help should be called, specifically an airway expert and a surgeon for a possible cricothyroidotomy. The next step is controversial, as there are a multitude of techniques that can be used to manage the difficult airway, including retrograde wires, lighted stylets, airway bougies, and many more. Recently, the intubating LMA, or the fastrach has become very popular and been shown to be very successful in this situation. In '97 Basket et al. performed a study on 500 patients, and was able to ventilate 99% of these patients with the intubating LMA. He was able to achieve blind intubation through the fastrach in 96% of these patients. These numbers have improved since the study with the refinement of the fastrach and better techniques. If the intubating LMA is unsuccessful, the next step is a surgical airway. It is important to note that the LMA alone is not a secure airway. Significant aspiration can still occur with an LMA, which is why intubating through the LMA is important to secure the airway. If unable to intubate through the LMA, keep airway pressures less than 20cmH<sub>2</sub>O and the risk of aspiration will be significantly less.

## GLIDE SCOPE

The Glide Scope belongs to an evolving class of airway devices referred to as video-assisted laryngoscopes. The glide scope has a protected miniature camera with anti-fogging technology. The blade has the advantage of a 60-degree midblade angle, which allows for better exposure of the anterior airway. The use of the glide scope is widespread, and has been useful in the following situations.

- First use intubations:
  - This is particularly useful in inexperienced hands. A recent study in Anesthesiology (Laryngoscopy via Mac Blade versus GlideScope, Nouruzi-Sedeh, et al) demonstrated a 93% first attempt intubation success rate in caregivers who previously only had glide scope training on a manikin. This is compared to a 51% first attempt success rate in caregivers using direct laryngoscopy who previously only had direct laryngoscopy training on a manikin. It has been estimated that a clinician needs over 50 direct laryngoscopy attempts to achieve a great than 90% intubation success rate. The glide scope significantly accelerates intubating performance in inexperienced hands.



- Challenging airways:
  - The angle of the scope and the location of the camera allows for greater visualization of the anterior airway.
- Teaching the anatomy of the airway.
- Cervical spine immobilization:
  - The glide scope does not require moving the neck to visualize the larynx.
- Traumatic airways:
  - The glide scope is less likely to be affected by blood and secretions. The location of the camera and the anti-fogging technology allow greater visualization in these situations.

## **NON-EMERGENT DIFFICULT AIRWAY WITH IMPENDING RESPIRATORY FAILURE**

The safest management in this situation is to perform an awake fiberoptic intubation. There are many other potential means to secure the airway in this situation; however, the safest means is to keep the patient spontaneously breathing while placing a definitive airway. Below is an example of an awake fiberoptic intubation.

- Premedication:
  - 0.2 mg robinol to decrease oral secretions. Avoid sedation in the trauma patient, which can increase the risk of aspiration.
- Anesthetize the airway:
  - There are several means to anesthetizing the airway. If full anesthesia of the airway is obtained, the patient will lose his/her ability to protect his/her airway. It is not advised to provide full airway anesthesia of a trauma patient. 3 ml of 4% lidocaine nebulized breathing treatment is a starting point for anesthesia. Cetacaine spray to the back of the throat is helpful.
- Fiber optic intubation:
  - The fiberoptic is inserted through the endotracheal tube and taped into position. The fiberoptic is attached to an oxygen source. The patient is instructed to stick out his/her tongue, or an oral ovassapian tube is placed. The fiberoptic is inserted into the oropharynx. 4% lidocaine is injected along the way at key targets, including the epiglottis and vocal cords (1.5 ml at each location). The vocal cords are identified, the fiberoptic is placed through the vocal cords, and the tube is advanced over the fiberoptic. Confirm placement with a CO<sub>2</sub> detector.

## **SPECIAL SITUATIONS:**

### ***Head Trauma***

It is essential to ensure adequate oxygenation and ventilation. The primary objective in these patients is to prevent the secondary injury process that can occur following a decrease in the oxygen supply to the brain. This is

accomplished by avoiding hypotension, hypoxemia, anemia, raised ICP, acidosis, and hyperglycemia. From an airway standpoint, this leads to specific management techniques. These patients require deep anesthesia and profound muscle relaxation before airway manipulation. This will prevent hypertension, coughing, and bucking which will minimize intracranial pressure. The induction agents used are controversial; however, the need for profound muscle relaxation and adequate anesthesia is not controversial. Muscle relaxation can accurately and predictably be obtained with succinylcholine. Succinylcholine will increase ICP by approximately 5mmHg, however this increase is negligible compared to the increase after inadequate muscle relaxation and subsequent coughing, which can be greater than 20mmHg. Non depolarizing muscle relaxants can be used without any increase in ICP, however the doses needed for a reliable rapid sequence induction are substantially higher, and the block can last up to 2 hours. For anesthesia, too much can drop blood pressure, decreasing cerebral perfusion pressure, and too little can increase blood pressure, which will increase intracranial pressure. Recommended induction agents include etomidate (hemodynamically stable) 0.2-0.3mg/kg, thiopental 2-5mg/kg, and propofol 2-2.5mg/kg. Pressure agents should be readily available to treat hypotension after induction, specifically when thiopental and propofol are used. Ketamine is contraindicated because it may increase intracranial pressure. Once the airway is secured, oxygenation can be optimized, and if necessary hyperventilation can be utilized to decrease intracranial pressure (along with other measures discussed in the neuro chapter).

### ***Cervical Spine Precautions***

Immobilization of the neck in a neutral position is required in all unconscious patients, and conscious patients with cervical pain or tenderness. Direct laryngoscopy requires in-line stabilization, with an assistant holding the head and torso in the neutral position. The incidence of inadequate exposure of the larynx increases from 3% to approximately 10% with in-line stabilization, so back up airway devices should be available.

### ***Open Eye***

The management is similar to above. The main objective is to ensure adequate anesthesia and muscle relaxation prior to intubating the patient. This will avoid the potential of extrusion of eye contents.

### ***Maxillofacial Injuries***

Soft tissue edema of the pharynx, peripharyngeal hematoma, blood in the oropharyngeal cavity may be responsible for partial or complete airway obstruction. A hematoma or edema in the head or neck may expand during the first 6-12 hours and ultimately occlude the airway. This may be aggravated by the liberal administration of IV fluids. These patients may benefit from prophylactic intubation.

## **Burns**

Respiratory distress in the initial phases of a burn requires immediate intubation. Patients without marked respiratory distress may require prophylactic intubation. Patients with singed facial hairs, facial burns, dysphonia or hoarseness, swallowing difficulties without respiratory distress most likely have upper airway injury. These patients may require intubation. Burn patients require massive fluid resuscitation, and this will add to potential airway obstruction. An awake fiberoptic intubation is the safest way to secure the airway in a burn patient. The anatomy can be markedly distorted in the burn patient, and marked edema can lead to an inability to mask ventilate after induction. Succinylcholine is contraindicated in burn patients after 24 hours secondary to the massive hyperkalemia that occurs with denervated muscle membrane. This hypersensitivity can last up to 6 months after a burn injury. Hemodynamically stable induction agents are required, such as etomidate or ketamine, because of the profound hypovolemia found in burn patients.

## **Pediatric Patients:**

Pediatric trauma patients have unique airway challenges. Before negotiating the pediatric airway, resuscitative drugs, particularly succinylcholine and atropine in IV and IM doses should be drawn up. The pediatric airway differs from the adult airway anatomically. The narrowest part of the infant airway is the cricoid cartilage vs. the glottic opening in the adult. Infants have relatively larger tongues, tonsils, adenoids and epiglottis. Infants have a narrower and more anterior glottis. Physiologically, infants have an increase MV(minute ventilation)/FRC (function residual capacity). All together, this means that the pediatric airway is more difficult to intubate, and they have little reserve, which means they will desaturate very quickly. Because the pediatric patient has a smaller airway, there is an increased chance of developing subglottic edema if the tube is too large. It is recommended that an air leak is detected at less than 25cmH<sub>2</sub>O, or the tube is too large. Below are generalized recommendations for tube sizes in the pediatric patient, but again, physical exam, by detecting an air leak is the only true means to determine the appropriate sized tube.

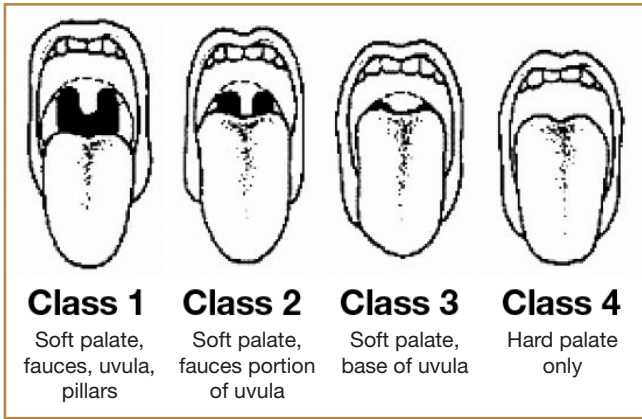
**TABLE: ENDOTRACHEAL TUBE SIZE AND POSITION BASED ON PATIENT AGE**

AGE	INTERNAL DIAMETER (MM)	EXTERNAL DIAMETER (MM)*	FRENCH UNIT	DISTANCE INSERTED FROM LIPS FOR TIP PLACEMENT IN THE MIDTRACHEA (CM) ±
Premature	2.5	3.3	10	10
Term Newborn	3.0	4.0-4.2	12	11
1-6 MO	3.5	4.7-4.8	14	11
6-12 MO	4.0	5.3-5.6	16	12
2 YR	4.5	6.0-6.3	18	13
4YR	5.0	6.7-7.0	20	14
6 YR	5.5	7.3-7.6	22	15-16
8 YR	6.0	8.0-8.2	24	16-17
10 YR	6.5	8.7-9.3	26	17-18
12 YR	7.0	9.3-10	28-30	18-22
≥14 YR Females	7.0	9.3-10	28-30	20-24
≥14 YR Males	8.0	10.7-11.3	32-34	20-24

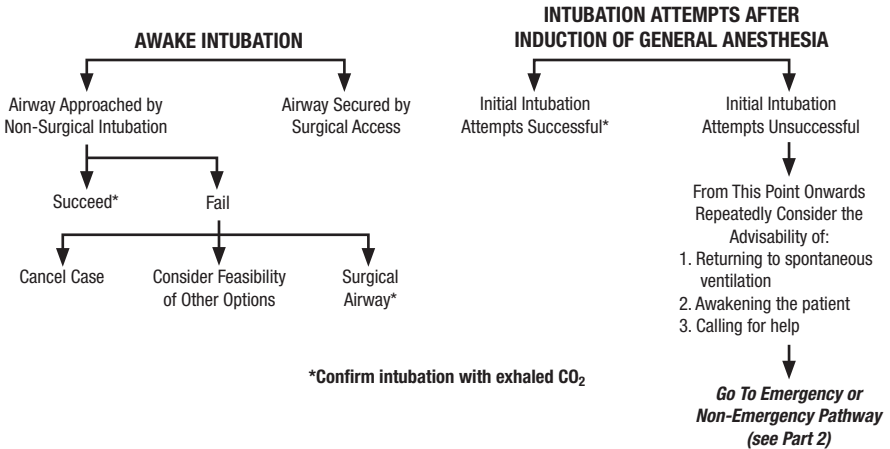
**MALLAMPATI CLASSIFICATION**

The amount of the posterior pharynx you can visualize is important and correlates with the difficulty of intubation.

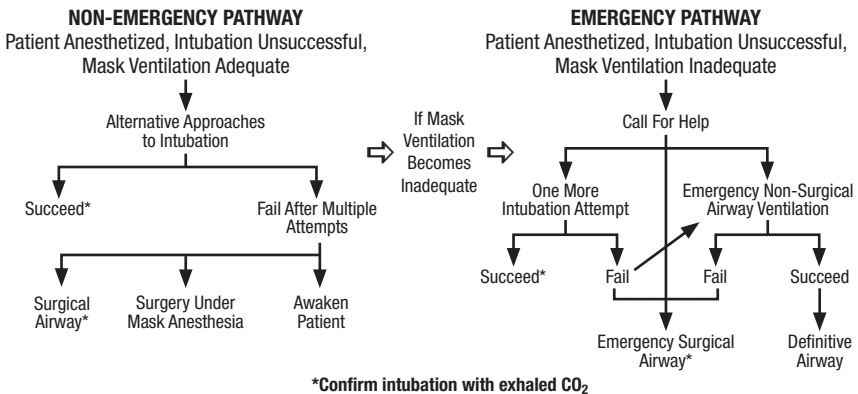
Visualization of the pharynx is obscured by a large tongue (relative to the size of the mouth), which also interferes with visualization of the larynx on laryngoscopy. The Mallampati Classification is based on the structures visualized with maximal mouth opening and tongue protrusion in the sitting position (originally described without phonation, but others have suggested minimum Mallampati Classification with or without phonation best correlates with intubation difficulty).



**ASA ALGORITHM PART 1**



**ASA ALGORITHM PART 2**



## Surgical Airway Management

### BACKGROUND

We have all learned the ABC's in medical school and CPR classes: Airway, Breathing, Circulation. The order is critical, and thus the airway is of paramount importance in the initial evaluation of any patient, critical or otherwise. Many trauma patients arrive to the emergency department with an artificial airway, i.e., endotracheal tube. Even then, it is necessary to make sure the tube is indeed in the airway. Other patients may initially present with stable airway assessments, but then rapidly deteriorate. It is for these situations, which require prompt, instinct-like attention to appropriate airway management, that we must be prepared.

### EVALUATION

Observation is the cornerstone in the initial patient assessment. A quick gestalt would include the following:

- Is the patient alert? Level of consciousness.
- Obviously breathing/not breathing?
- Skin/mucous membrane color; cyanotic?
- Work of breathing; audible stridor, sternal retractions, paradoxical breathing?
- Positioning; crouched over
- Tone; limp, rigid?
- The answers to these observations will guide subsequent patient triage. Obviously, the patient who is awake, talking, pink, quiet, and upright will not need urgent attention and is not the subject of this chapter.
- The other extreme is the patient who is unconscious, not perceptibly breathing, blue, limp, and down.

The first step involves attempting to see if this patient may be alerted or awakened by a shout or physical jolt. The next steps involve placement of an artificial airway. How this is accomplished depends in part on the environment one is in. In the emergency department, there is ready access to an airway cart with all the necessary equipment. Then, depending on training and experience, securing the airway will typically proceed with an attempt at oral intubation. The different algorithms are outlined in the airway chapter.

The surgical management begins when non-operative techniques have failed, or the resources for carrying them out are unavailable. It is also the procedure of choice if personnel are comfortable with the procedures, and/or fast action is needed. Any airway is better than no airway. So, who should be considered for a surgical airway? Anyone who is considered for intubation yet cannot be intubated for some reason. The old adage, "If you think about doing a trach, do it" summarizes this point.

One special trauma situation arises from severe maxillofacial trauma. In such cases, the anatomical distortion may be such that oral intubation techniques may not be feasible or advisable, and a surgical airway is necessary.

In summary, evaluation of the critical airway patient requires close observation of the patient, but also keen observation of the environment one is in and what resources are available, including nurses, staff, and equipment.

## MANAGEMENT

Knowing how to manage the surgical airway requires some knowledge of neck and airway anatomy. The key is knowing where the cricoid is. This ring of cartilage is directly below the thyroid cartilage, and forms the first (and only complete) tracheal ring. It is easier to palpate neck structures if the neck is hyperextended, although this is rarely possible in the trauma situation because of concern about the cervical spine. The easiest way to find this is to actually first feel for the Adam's apple, which is the jut of inferior thyroid cartilage anteriorly, more prominent in men and thin individuals. Run your fingers from this point to a depression or indentation, which should be the cricothyroid membrane. The cricoid will be the first ring inferior to this. It is usually more prominent (anterior) than the remaining tracheal "rings".

The cricoid is key because it defines the subglottis, or the area beneath the glottis, or vocal folds. Knowing where it is will avoid injury to the larynx. One would not want to separate the vocal folds, or place a tube through them if at all possible because of the long-term stenosis, hoarseness, and airway difficulty that would ensue long term. Of course, this is tempered by the fact that if it saves the patient, they will be around at least to have these secondary problems addressed.

It may be useful to palpate this in your own neck. If you are unsure, another quick check could be to run your fingers up the thyroid cartilage to find a firm, bony structure, the hyoid bone. This should reassure you of having the correct anatomy down. All the procedures are also done in the midline, so be sure the head is not turned. There is an avascular plane that exists which will make performance of these maneuvers much more manageable.

Lateral to the midline run the anterior jugular veins, and more deeply, cricothyroid vessels, the superior laryngeal nerve and branches including the external branch to the cricothyroid, and the recurrent laryngeal nerve in the groove between the trachea and esophagus (which lies posterior to the trachea). This should be abundant reason to stay in the middle.

Cricothyroidotomy is the classically taught technique for establishing a rapid, safe airway in the adult patient. Once the cricoid is defined, make a vertical incision in the midline down to it. You will go through skin, subcutaneous tissue, intervening fascia, and then the cricoid itself. You may be able to see the cricothyroid muscle, which attaches onto either side of the cartilage. This is another confirmatory sign. Feel for the cricothyroid membrane (the indentation just superior to the cricoid). Make a horizontal incision through this gaining entrance into the airway. Sometimes it is possible to see the vocal folds' inferior surfaces. Place an endotracheal tube through the opening you have created.

Another technique is needle cricothyroidotomy. To do this, feel for the cricothyroid membrane and insert a large bore needle (14 or 16 gauge) through it. This can be done rapidly and usually safely. However, it does require that you have an adapter to hook up to the needle to utilize jet ventilation through the needle. This again mandates special equipment being available and the appropriate connectors, adapters, and tubing. Thus, it is essential to have knowledge beforehand what equipment there is and where it is.

Lastly, if you have done enough and are comfortable enough, an emergent or “slash” tracheotomy may be performed. This requires more skill and knowledge and will therefore not be presented as a practicable alternative. For instance, the thyroid cartilage typically drapes over tracheal rings 2 to 4, and must be avoided or large blood loss will ensue, and the strap muscles need to be divided in the midline. This technique should only be attempted by an attending surgeon (General/Trauma or ENT) who has experience in performing this procedure in an emergent setting.

Percutaneous tracheostomy as yet has no role in the emergent surgical airway. It requires special equipment and time (for the serial dilation).

Final note - The emergent airway you have achieved by cricothyroidotomy must be taken back to the operating room, typically, to be “formalized” into a tracheotomy. This is done after the patient has been stabilized (usually days later). The reason is that the tube currently runs right through the subglottis and the resultant scarring over time could be devastating.

## **PITFALLS**

### ***Bleeding***

Invariably, there is some bleeding, no matter if you stay midline or not. The skin and tissues will bleed. Hopefully, this will not be enough to prevent continuation of the procedure. Usually, bovie equipment is not available. Then blind techniques may be needed. Feel with your fingers where the cricothyroid membrane is, perhaps making a “V” with your non-dominant ring and middle fingers. Then incise through it with a knife.

### ***Equipment***

Get help; make sure different sized endotracheal and tracheostomy tubes are available. Or that the right adapters/connectors/tubing are available for the needle cricothyrotomy. In addition, be sure to have the tracheostomy instrument tray available. Have suction and 4x4's available for the bleeding. Ideally, a headlight would be very helpful, or at least an area with good lighting. Make sure a ventilator is ready.



### **C-spine**

Take care to avoid hyperextending the neck or undue neck manipulation. Sandbags could be placed on either side of the head, or someone might hold the head steady from above. Keeping the posterior neck collar in place is also usually possible.

### **Movement**

There may be excess motion with bag valve mask ventilation, typically in progress as you work. You may ask that these ventilations and other maneuvers on the patient stop until the airway is obtained.

### **INCISION SIZE AND SHAPE**

Don't linger on these points! No one will fault you for a 5 cm cut versus a 1 cm micro-incision. This is not the time for delicate surgery; you need to establish an airway, fast. Don't fret about horizontal vs. vertical incisions; do what you need to get in safely.

### **INCISION PART 2**

The above notwithstanding, you also want to avoid making machete style cuts through the airway. Severing the airway, esophagus, carotid artery or internal jugular vein will not make things easier.

### **ESOPHAGUS**

If already done, an NG tube that is usually placed previously may serve as a guide that you are not in the esophagus. One may palpate it in the back of the membranous trachea. Also, the esophageal lumen is collapsible, not like the tracheal lumen which is supported by cartilage.

### **PEDIATRIC AIRWAY**

A cricothyrotomy is not advocated in the initial surgical management of very young or small children. Anatomy is harder to appreciate, and there is the real danger of incisions going awry into major vascular structures. A head and neck surgeon must usually do bronchoscopy in an OR setting for these patients.

### **BLUNT NECK TRAUMA**

Clothesline-type injuries and situations involving massive neck hematomas or cervical emphysema require special caution. There may be existing laryngotracheal or esophageal disruption and/or separation. There is real danger of placing the airway into a false tract. One may consider having a bronchoscope available.

Always make sure back-up is on the way, usually an experienced surgeon or ED staff. Try to remain calm, because everyone else around you will be paralyzed by fear or shock. Just remember, if you don't succeed, the patient may die.

## Lab Studies

At VCMC, the trauma team has standard labs that are drawn on all patients according to injury status. Further blood studies should be individualized to the patient and the injuries that are being treated.

### TIER 1 ADULT TRAUMAS (AGE > 14 YRS):

- CBC with diff
- CMP
- Type and cross
- Urinalysis
- Urine for U-HCG for women older than 10 and younger than 55 years.
- Serum lactate
- ABG plus and VBG (venous Blood Gas)
- PT/PTT
- Urine toxicology
- Blood alcohol
- For Tier 1 pediatric patients (<14), include the above labs except for urine toxicology, and blood alcohol level, which may be ordered PRN.

### TIER 2 ADULT TRAUMAS (AGE > 14 YRS):

- CBC with differential
- CMP
- Urinalysis
- Urine for U-HCG for women older than 10 and younger than 55 years
- Type and screen
- Urine toxicology
- Blood alcohol
- A lactate, PT/PTT, and ABG / VBG can be ordered based on a clinically deteriorating patient.
- For Tier 2 pediatric patients (<14), include the above labs except for urine toxicology, and blood alcohol level, which may be ordered PRN.

### TIER 3 ADULT TRAUMAS (AGE > 14 YRS) - CONSULTS:

- CBC with differential
- CMP
- Urinalysis
- Urine for U-HCG for women older than 10 and younger than 55 years.
- Urine toxicology
- Blood alcohol
- A lactate, PT/PTT, and ABG / VBG can be ordered based on a clinically deteriorating patient.
- For Tier 3 pediatric patients (<14), include the above labs except for urine toxicology, and blood alcohol level, which may be ordered PRN.

## **ADDITIONAL INJURY-SPECIFIC LABS**

### **Clotting studies (PT/PTT/platelet count):**

- All trauma patients with suspected coagulation problems or who are taking anticoagulants.
- All trauma patients requiring massive transfusions (>4 units).
- All severely head injured patients (GCS <8 or with cerebral pathology on CT scan), and taking Coumadin should have 2 U FFP immediately thawed

### **Urinalysis**

- All trauma patients with hematuria.
- All trauma patients with abdominal, flank, or pelvic trauma.

### **Lactate:**

- Patient with evidence of tissue hypoperfusion

### **Repeat ABG/VBG**

- Patients in shock or who may potentially be in shock (to assess the degree of metabolic acidosis).
- Patients with severe head injury (to assess the carbon dioxide level).
- Patients with anticipated rapid weaning from the ventilator (to assess the partial pressure of oxygen).
- Patients with SaO<sub>2</sub> <90% on pulse oximetry.

### **EKG:**

- All patients with serious chest trauma.
- All patients with arrhythmias on cardiac monitor.
- All patients underlying cardiac disease.
- All patients with sternal tenderness or fractures.
- All patients over age 50.

### **Serum troponin:**

- Patients who may have had a myocardial infarction.

### **Serum CPK:**

- Patients with substantial crush injury.
- Patients with suspected rhabdomyolysis.
- Dark maple syrup colored urine positive for blood and negative for RBCs.
- Urine positive for blood and negative for RBCs in patients at risk for muscle necrosis or compartment syndrome.

### **Transthoracic echo:**

- Patients with findings suggestive of myocardial contusion with cardiac dysfunction.
- See Blunt Cardiac Injury protocol.

## X-Rays

### OBJECTIVE

To provide guidelines for the proper ordering of X-rays on multiple trauma patients.

### GUIDELINES

#### *Usual order of Trauma Room X-rays:*

##### 1. C-spine (cross table lateral)

- Refer to C-spine clearance protocol. The awake, alert patient without neck pain does not need a C-spine film!
- In all patients with an altered level of consciousness, and patients with a mechanism or pain suggestive of a possible C-spine injury.
- Pull shoulders down to visualize C7.
- If unable to clinically clear c-spine, a CT scan is obtained

##### 2. Trauma Room supine chest X-ray

- In general, almost all multiple injured patients require a supine chest x-ray. Unless, the lung portion of the E-FAST scan is negative and the patient needs to be urgently taken to CT.
- On all patients with suggestion of chest injury.
- On all patients transferred from another hospital, especially if intubated.
- Obtain as soon as possible in intubated patients.
- Following subclavian or jugular line placements or attempts.
- Upright chest X-ray preferred if patient's spine is cleared.
- On all patients with penetrating wounds to neck, chest, or abdomen.

##### 3. Trauma Room A-P pelvis

- In general, almost all multiply injured patients require an AP pelvis X-ray, but may be omitted if a CT scan of the abdomen/pelvis is planned.
- Obtain when there are signs and symptoms of pelvic injury.

##### 4. Other Trauma Room films

- Should be obtained only if the information from them is urgently needed (e.g., foreign body identification in GSW, etc.) OR
- If the patient is unstable – remember portable films are expensive and may be of poorer quality.
- Do not perform non-urgent films (i.e., extremities) prior to CT or emergent OR, unless there is down time – awaiting on CT availability or OR room.
- Other X-rays: Will be obtained in the main X-ray ED facility. In general, spine and extremity X-rays are obtained in areas that an injury is suspected on the basis of physical signs or symptoms.

#### *Extremity CT angiogram or angiogram:*

- Any fracture with evidence of poor arterial perfusion (e.g., ankle-brachial index [ABI] <0.9).

- Posterior knee dislocations (even if spontaneously relocated) with any evidence of intimal occlusion (ABI < 0.9).
- Penetrating wounds where course of injury is near an artery and there are signs of bleeding, expanding hematoma or diminished distal circulation.
- Remember that the presence of distal pulses does not necessarily mean that an arterial injury has not occurred. Doppler occlusion pressures may be helpful (ankle brachial index <0.9 is considered significant and is an indication for an arteriogram).

#### **Vessel CT angiogram neck**

- Obtain on patients with lateralizing neurologic deficit unexplained by findings on head CT (i.e., to evaluate for carotid occlusion/dissection or vertebral artery injury).
- Obtain on patients with penetrating wounds to neck who are stable and do not require emergent surgery.
- Obtain on patients with suspicion of blunt carotid injury (i.e., hematoma, seatbelt sign). See *blunt carotid injury guidelines*.

#### **Wound paperclip or radiographic arrow markers**

- Use for identification of point of injury on X-rays:
- On all penetrating stab or gunshot wounds.
- Do not mark abrasions or scratches.

#### **Intravenous pyelogram: (rare)**

- Abdominal CT with IV contrast should be obtained if perirenal bleeding is likely.
- IVP is indicated for all cases of gross and microscopic (>50 RBC/hpf) hematuria in which an abdominal CT scan has not, or cannot be obtained -- this would be an **unusual** x-ray to obtain.
- Clamp Foley for "free" cystogram.
- Obtain IVP by injecting one ml/kg (usually 100 ml) of contrast intravenously. Obtain a film between 5 and 10 minutes.
- Occasionally necessary to obtain an IVP in the OR to document contralateral renal function if nephrectomy is anticipated.

#### **Retrograde cystogram:**

- Should be considered for all cases of gross hematuria, penetrating abdominal trauma and pelvic fractures where bladder disruption is suspected.
- Allow 300 ml of contrast agent to flow into Foley catheter and then clamp.
- X-ray the pelvis- AP, lateral, and oblique views
- Obtain repeat x-ray after emptying bladder, post-void film.
- Other option is a true CT cystogram where 300 ml of contrast is injected while fine cuts made through pelvis, and a delayed, post-void scan is performed.

#### **Retrograde urethrogram:**

- Should be considered for all cases of gross hematuria, penetrating abdominal trauma and pelvic fractures where disruption of the urethra is suspected.
- Blood at the urethral meatus.

- Displaced or non-palpable prostate.
- Obvious perineal injury (perineal hematoma or open perineal injury or scrotal hematoma).
- Position patient in right anterior oblique (45°) in “bicycling” position with right hip flexed and penis placed on medial aspect of right thigh. Insert small (12 Fr.) Foley catheter into the meatus for a distance of 2-3 cm. Inject 10-20 ml of contrast gently.
- X-ray tube centered over pubic tubercle.
- If Foley catheter has been previously placed, may be performed alongside the catheter by inserting 18 gauge angiocath next to Foley.

## **CT SCANS**

### ***Head – mechanism for head injury***

- GCS < 14
- Loss of consciousness
- Focal neuro deficits

### ***C-spine – mechanism for C-spine injury***

- Unconscious patient who is not anticipated to regain consciousness within 24 hours.
- Focal posterior C-spine tenderness.
- See C-spine clearance guidelines for further information.

### ***Chest***

- Evaluation of widened mediastinum to rule out aortic injury.
- Evaluation of patient with mechanism worrisome for aortic injury.

### ***Abdomen / Pelvis – Mechanism for abdominal / pelvic injury***

- Abdominal or pelvic pain.
- Substantial mechanism for abdominal injury in the comatose or unresponsive patient.
- Pelvic fracture on plain film.
- Fluid in the abdomen on FAST exam in the hemodynamically stable patient.
- Abdominal ecchymosis or “seat belt sign.”

### ***Spine (thoracic and lumbar) – limit to area of interest.***

- Confirm or further diagnose fractures either seen on plain films, or suspected on clinical exam.
- Evaluate severe point tenderness over midline spine.

### ***Cystogram***

- 300 mL of contrast placed into Foley catheter, then the catheter is clamped.
- Should be done on all patients with possible hematuria, penetrating abdominal trauma and/or pelvic fractures when a CT scan is being performed.

## **Guidelines for Procedural Sedation**

### **PROCEDURAL SEDATION AND ANALGESIA**

Procedural sedation and analgesia (PSA) is the clinical practice of utilizing pharmacologic agents in order to achieve a measurable level of sedation, while performing typically painful or anxiety-provoking procedures.

The term “conscious sedation” is no longer used because it describes neither the intent nor the outcome of the process. PSA allows the non-anesthesiologist to perform selected procedures in a safe and controlled setting.

The Joint Commission on Accreditation of Healthcare Organization (JCAHO) has produced sedation guidelines in order to describe and define the spectrum of PSA. More importantly, the American Society of Anesthesiologists (ASA) and the American College of Emergency Physicians (ACEP) have published guidelines for PSA by non-anesthesiologists and emergency physicians, respectively. As defined by the ASA, PSA is a continuum from minimal sedation/analgesia to general anesthesia.

Minimal sedation occurs when the patient continues to respond normally to verbal commands without affecting cardiopulmonary functions. Moderate sedation is a state of depressed consciousness where the patient responds appropriately to verbal command with or without light tactile stimuli. Dissociative sedation should be considered a form of moderate sedation which occurs when a dissociative pharmacologic agent produces a trance-like state. The result is analgesia and amnesia while protective airway reflexes and cardiovascular stability are maintained. Deep sedation causes a depression of consciousness and the patient is not easily arousable but responds purposefully with repeated or painful stimuli. At this level, the patient may require assistance in maintaining airway and ventilation. General anesthesia is at the end of the spectrum; consciousness is lost and the patient is unarousable to any stimuli. The patient requires ventilatory assistance, and cardiovascular function may be affected or impaired.

For coding purposes, the AMA CPT coding manual describes “moderate (conscious) sedation” as a drug induced depression of consciousness during which patients respond purposefully to verbal commands, either alone or accompanied by light tactile stimulation. No interventions are required to maintain a patent airway, and spontaneous ventilation is adequate. Cardiovascular function is maintained. It does not include minimal sedation (anxiolysis), deep sedation or monitored anesthesia care (Table 2-1; page 66).

There are three components which comprise PSA. First there is the process of sedation which requires a thorough knowledge of the agents being administered. Next is the intended procedure to be performed. Finally, there are the unpredictable side effects and untoward reactions to the sedating medications, which can occur during or in the recovery phase of the procedure.

The physician should be familiar with all of the appropriate monitoring and rescue equipment. A suitably trained provider should assist with the sedation. All individuals who participate in the care of the patient undergoing PSA must be privileged for the procedure and demonstrate ongoing clinical competency.

## INDICATIONS

As non-anesthesiologist physicians become more comfortable with PSA, the roster of appropriate procedures using these agents continues to expand. The list includes but is not limited to the following:

- Biopsy procedures
- Bone marrow aspiration or biopsy
- Bronchoscopy
- Cardioversion (electrical or chemical)
- Dental/oral surgical procedures
- Endometrial biopsy
- ESSURE Contraceptive placement
- GI endoscopy
- Hysterosalpingogram
- Lumbar puncture
- MRI/CT scans/invasive radiographic procedures
- Orthopedic procedures
- Phlebectomy
- Plastic/cosmetic procedures
- Wound repair/care, including burns

PSA can be used in conjunction with and as a supplement to digital, hematoma or regional nerve blocks as well as topical anesthetic agents. These modalities may obviate the need for deeper levels of sedation. Other distractions for the patient such as music or videos are useful adjuncts.

## CONTRAINDICATIONS

Elective procedures on pregnant patients should be deferred until after delivery. Patients with severe unstable systemic disease and patients with potentially unstable airways should be directed to a higher level of care. The ASA classification of systemic disease is designed to guide the physician as to which patients are appropriate candidates for PSA (Table 2-2; page 67).

**Class 1 patients** are considered to be normal and healthy. Little or no risk.

**Class 2 patients** include those with well-controlled hypertension, controlled noninsulin-dependent diabetes, and minimal cardiac or respiratory disease.

**Class 3 patients** include those with insulin-dependent diabetes mellitus, poorly controlled hypertension, significant cardiac or respiratory disease, and significant renal or hepatic disease. Based on individual experience and skill in administering conscious sedation, practitioners may decide to limit the amount of patient risk they are willing to accept, using the ASA guidelines.



In general, the non-anesthesiologist physician who provides PSA in the private office setting should do so on patients with Class II status or less. For hospital-based procedures outside of the operating room, PSA may be performed on patients up to and including Class III status.

The ASA has set forth preprocedure fasting guidelines for scheduled elective cases. However, in separate recommendations for PSA, the ASA states, “The literature does not provide sufficient evidence to test the hypothesis that preprocedure fasting results in a decreased incidence of adverse outcomes in patients undergoing either moderate or deep sedation.” The current guidelines are the result of consensus, rather than evidence-based, with respect to the risk of aspiration. The recommendations are 6 hours for solids, cow’s milk, and infant formula; 4 hours for breast milk; and 2 hours for clear liquids. The American College of Emergency Physicians recognizes that there are certain emergent situations in which the benefits of PSA at any sedation depth outweigh the potential risks. In all other circumstances, it would be best to strictly adhere to the fasting guidelines.

## EQUIPMENT

A single unit with blood pressure and ECG measurements, variable-pitch beep pulse oximeter and recording device is the ideal monitor for PSA. Individual units are acceptable but require repeated manual recordings of the readings on the patient’s chart.

- Angiocatheter for IV (at least 20 gauge), IV solution, and stand
- Oxygen source
- Medications for sedation and analgesia
- Reversal medications
- Diphenhydramine and epinephrine to be used in the event of severe allergic reactions
- Crash cart or Banyan kit with equipment and medications for basic and advanced cardiac life support (ACLS)
- Suction device
- Defibrillator (Figure 2-1)

While it is not a requirement for Class I patients, the application of oxygen by nasal cannula should be used on every patient undergoing PSA because each patient has a unique and unpredictable response to the medications. Capnometry is another more sensitive measurement of ventilatory status and is being used as part of PSA monitoring. As a measure of exhaled carbon dioxide, end tidal CO<sub>2</sub> may detect hypoventilation prior to the development of oxygen desaturation.

## PERSONNEL

At least two providers must be involved in PSA. The physician who is performing the procedure is also ordering the medications. The assistant is typically a

registered nurse who has fulfilled all of the requirements to administer PSA drugs, monitor the patient during the procedure and recovery phase, and participate in any needed resuscitations.

There should be a well-defined response for any cardiopulmonary emergency that results from PSA. Most hospitals have organized a “code team” to respond to such situations. In the non-hospital setting, the physician should be able to manage the emergency until EMS/paramedics arrive for transport to a hospital.

### **PRE-PROCEDURE PATIENT ASSESSMENT**

Every patient who undergoes PSA should have a complete history and physical examination prior to the procedure. Included in the documentation are pertinent medical history, current medications, allergies (problems with sedative or analgesics), and review of systems (snoring or obstructive sleep apnea). The physical examination should focus on assessment of airway and cardiovascular system. Anatomic variants (macroglossia, micrognathia), presence of a beard, dentures, or a short, arthritic neck should be noted.

Direct evaluation of the patient’s open mouth using the Mallampati classification measures how much the tongue obscures the uvula and soft palate (pages 45 & 46. Table 2-3; page 67).

Obtain and document an informed consent from the patient for both PSA and the procedure. Explain the sedation process, potential for failure, adverse effects, as well as alternatives and consequences of not providing sedation.

### **PRE-PROCEDURE PATIENT PREPARATION**

Prior to beginning the procedure, reconfirm the initial assessment and the patient’s ASA classification.

Document the fasting time and check a pregnancy test on age-appropriate women. Make certain there is an adult to escort the patient home.

Ask the patient to void, dress into a gown and recline on the procedure bed.

The IV line should be secured and functioning. Blood pressure cuff, cardiac monitor, and pulse oximeter should be applied and baseline vitals including room air SaO<sub>2</sub> documented. Emergency resuscitation equipment and medications should be functional and at the ready.

A PSA monitoring flow sheet is used to record pre-, intra-, and post- procedure data. Document start and completion times, medications and dosages administered, as well as the level of sedation achieved throughout the procedure.

The practice of premedicating the patient with H<sub>2</sub> blockers or PPI’s is no longer recommended because of the lack of evidence with regard to the efficacy of these drugs to diminish gastric acid secretion and subsequent risk of aspiration.

Prior to sedating the patient, physician and assistant must take a “time out” to once again identify the patient, the intended procedure, and the site. Once the procedure has started, the patient should be encouraged to tell the operator about any unusual discomfort, shortness of breath, chest pressure or itching.

## TECHNIQUE

During the procedure:

Position the patient as comfortably as possible for the procedure, using warm blankets and placing pillows under the head and/or knees.

Use the single dose of medication that will provide a maximum level of sedation required to perform the procedure. Multiple small doses create discomfort for the patient and may culminate in over-sedation. For painful procedures, begin IV administrations with a short acting narcotic. For painless but anxiety-producing procedures, there should be more emphasis on anxiolysis. Maintain verbal contact with the patient. Observe the patient for slurred speech, droopy eyelids, and calm affect. The patient should stir to verbal commands and be able to follow them. Remember that the effects should start within several minutes but may not peak for up to 7 minutes.

Begin the procedure once the patient has achieved the desired depth of sedation.

If the patient is not sedated adequately after a modest dose of narcotic, administer a small dose of a shortacting benzodiazepine and continue to observe for effects. Recall the synergistic efforts of these drugs.

Record vital signs every 5 minutes. The assistant should remain at the patient's bedside throughout the procedure to observe the response to sedation and to respond to any monitor alarms. The patient must be monitored continually for head position, level of consciousness, airway patency, and adequacy of respiration and oxygenation. Observation of ventilation is essential, especially when using supplemental oxygen, which will delay the detection of apnea by pulse oximetry. Naloxone and flumazenil should be at the bedside in the event any reversal is required.

The depth of sedation should be assessed at frequent intervals during the procedure. If the sedation is too light, the patient may express displeasure or experience discomfort, as well as develop tachycardia or hypertension. If sedation is too deep, the patient may develop periods of apnea, the oxygen saturation will decrease and trigger the monitor alarm. Also, if side stream ET CO<sub>2</sub> is used, the earliest sign of respiratory compromise would be a steady rise of the ET CO<sub>2</sub> above 40 mm Hg. Finally, the patient's Adrete score will decrease if sedation is too deep. If at any time during the procedure there is a change or deterioration of the patient's condition, either suspend or abort the procedure, assess the patient, and commence any resuscitation.

There are several medications within the armamentarium of PSA. The physician must understand the pharmacology of these drugs and the appropriate settings in which to use them.

A short acting analgesic should be used at the onset. Fentanyl has a very good safety profile with a rapid onset and short duration of action. It does not cause the extent of cardiorespiratory depression that is typical of other opioids. However, its side effects are magnified with benzodiazepines (Table 2-4; page 68).

If anxiolysis is the goal of PSA, fentanyl combined with midazolam provides a minimal level of sedation which is ideal for such procedures as cardioversion, endoscopy, lumbar puncture, and certain wound repairs.

When moderate sedation is desired for particularly painful procedures, fentanyl can be used with etomidate to create relaxation for closed reductions of joint dislocations or fractures. Propofol can be used for moderate or deep sedation. It has no analgesic properties and should be used with fentanyl. It is safest to deliver propofol as a continuous infusion which can be discontinued if any adverse reaction occurs. At low doses, methohexital produces a state of unconsciousness while preserving protective airway reflexes. It is purely an amnestic agent, and careful use with opioids is advised. Hypotension and histamine release are significant side effects.

## COMPLICATIONS

Several factors are associated with adverse outcomes during PSA. In addition to the known effects of the drugs themselves, there are patient factors, inadequate preprocedural evaluation, drug-drug interactions, drug dosing errors and inconsistent monitoring and observation.

Respiratory depression is the most common and profound adverse effect. All of the drugs employed inhibit respiratory drive to some degree. The synergistic effects which occur when the drugs are combined can magnify the inhibition of the respiratory system. Should the  $SaO_2$  fall below 90%, the procedure should be suspended and the patient evaluated. Additionally, chest wall and glottic rigidity are catastrophic side effects of fentanyl and can occur when a high dose of the drug is injected rapidly. Under these circumstances the patient may require paralysis and mechanical ventilation until the symptoms resolve.

Sympathetic output from the CNS is similarly suppressed by all of the PSA drugs and can result in bradycardia and hypotension. Furthermore, there is a preponderance of patients who take beta-blockers and calcium channel blockers, which increases the risk for dysrhythmias and cardiovascular collapse during PSA. Atropine 0.4 mg IVP is used to treat symptomatic bradycardia; that is bradycardia associated with hypotension or heart block.

Nausea and vomiting are usually due to opioids. Preventing unwanted gastrointestinal side effects is important when the patient's sensorium is depressed, as emesis could lead to aspiration. Noxious gastrointestinal symptoms also make for an unpleasant experience for the patient. Zofran 4-8 mg IV is an excellent antiemetic.

Should the patient experience any itching or if urticaria becomes apparent (allergic reactions), diphenhydramine 25 mg IV should be administered. Auscultate the lungs for wheezing and check vital signs. Inhaled bronchodilators, IV corticosteroids, and subcutaneous epinephrine are appropriate for the management of allergic reactions and anaphylaxis.

In rare instances, paradoxical reactions can occur to benzodiazepine. Malignant hyperthermia must also be kept in mind as a potential complication.

### **POST-PROCEDURE RECOVERY AND PATIENT EDUCATION**

Recovery should occur in a place where there is adequate cardiopulmonary monitoring and trained personnel for direct observation because the patient continues to be at risk for developing drug related complications. If reversal agents are administered, continuous observation is required until sufficient time for the last dose to wear off, thus avoiding re-sedation. The Aldrete score uses five criteria to determine a level at which it is safe to discharge the patient. The parameters include a measure of blood pressure and SaO<sub>2</sub> and an evaluation of the patient's mental status, airway patency, and motor function.

The patient's escort should be given both verbal and written instructions which include post procedure activities, diet and medications. Advise the patient:

- Do not drive a car or operate hazardous equipment until the next day.
- Do not make important decisions or sign legal documents for 24 hours.
- Do not take medications unless your physician has prescribed them specifically for the next 24 hours.
- Avoid alcohol, sedatives, and other depressant drugs for 24 hours.
- Notify your health care provider of pain, severe nausea, difficulty breathing, difficulty voiding, bleeding, or other new symptoms.

## CPT/BILLING CODES

See the CPT definition for moderate sedation discussed earlier

90774 IV injection (use in conjunction with J codes for drugs)

90760 IV therapy 1 hour

99144 Sedation services provided by the same physician performing the diagnostic or therapeutic service that the sedation supports requiring the presence of an independent observer including monitoring of cardio-respiratory function (pulse oximetry, ECG, and blood pressure), age 5 years or older, first 30 minutes. When providing moderate sedation, the following services are included, and NOT reported separately:

- Assessment of the patient (not included in intraservice time;
- Establishment of IV access and fluids to maintain patency, when performed;
- Administration of agent(s);
- Maintenance of sedation;
- Monitoring of oxygen saturation, heart rate and blood pressure; and
- Recovery (not included in intraservice time).

Intraservice time starts with the administration of the sedation agent(s), requires continuous face-to-face attendance, and ends at the conclusion of personal contact by the physician providing the sedation.

99145 Each additional 15 minutes of intra-service time

99147 Moderate sedation services provided by a physician other than professional performing the procedure, first 30 minutes, age 5 years or older

99150 Each additional 15 minutes

94760 Non-invasive ear or pulse oximetry for oxygen saturation

94761 Non-invasive single interpretation

97761 Non-invasive, multiple interpretations

36000 Introduction of needle or intracatheter, vein

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**TABLE 2.1: OPERATIONAL DEFINITIONS AND CHARACTERIZATIONS OF LEVELS OF SEDATION-ANALGESIA**

Sedation Score	0	1	2	3	4
Level of Sedation	None	“Light”	“Moderate	Deep	General Anesthesia
Level of Consciousness	Fully aware of self & surroundings	Mostly aware of self & surroundings, but sedate	Slightly aware of self & surroundings, usually somnolent, arouses easily with stimuli	Not aware of self or surroundings, little arousal with stimuli	Unconscious, no arousal with painful stimuli
Response Verbal	P	P-L	L-A	A	A
Response Tactile	P	P	P-L	L (to pain)	A (to pain)
Response Patency	P	P	P-L**	L-A	L-A
Ventilation, Oxygenation	P	P	P-L*	L	L-A

**Legend:** P = Present, adequate, or normal; L = Limited, partial, mildly abnormal;

A = Absent, inadequate\* = May need to supplement oxygen to keep SaO<sub>2</sub>

**Notes:** Deep sedation may be indistinguishable from general anesthesia and carries all the same risk.



**TABLE 2.2: ASA SEDATION RISK**

ASA Physical Status Classification	Sedation Risk
Class I: Normal healthy patient	Minimal
Class II: Mild systemic disease without physical limitation	Low
Class III: Severe systemic disease with functional limitations	Intermediate
Class IV: Severe systemic disease which is a constant threat to life	High
Class V: Moribund patient who may not survive without procedure	Extremely High

**TABLE 2-3: MALLAMPATI CLASSIFICATION**

Class I	Soft palate, fauces, uvula, pillars
Class II	Soft palate, fauces, portion of uvula
Class III	Soft palate, base of uvula
Class IV	Hard palate only

**TABLE 2-4: COMMONLY USED MEDICATIONS FOR PSA**

Medication	Class	Description	Initial IV Dose	Repeat Dose	Minimum Interval
Etomidate (Amidate)	Sedative Hypnotic	Rapid Onset Short Duration	0.1 mg/kg	0.1 mg/kg	5 min
Fentanyl (Sublimaze)	Opiate	Short Acting	1 mcg/kg up to 100 mcg	25-50 mcg	5 min
Flumazenil (Romazicon)	Benzodiazepine antagonist	Reversal Agent for Benzodiazepine	0.2 mg	0.2 mg up to 1 mg total	1 min
Midazolam (Versed)	Benzodiazepine	Benzodiazepine Short Acting Sedation/Amnesia	1-2 mg	0.5-1 mg up to 5 mg	5 min
Methohexital (Brevital)	Ultra-short acting Barbiturate	Non-analgesic Amnesia	0.75-1 mg/kg	0.5 mg/kg	2 min
Naloxone (Narcan)	Opiate Antagonist	Reversal Agent For Opiate	0.2-0.4 mg	0.2 mg	2-3 min
Propofol (Diprivan)	Sedative hypnotic	Rapid Onset	1 mg/kg	0.5 mg/kg	3-5 min
Atropine	Anticholinergic Antiarrhythmic	Treatment of symptomatic bradycardia; decrease secretions	0.4 mg	0.4 mg 3 mg max	3-5 min
Diphenhydramine (Benadryl)	Antihistamine Anticholinergic	Treats anaphylaxis; sedative; antiemetic	25 mg	25 mg	5-10 min
Metoclopramide (Reglan)	Central & peripheral dopamine antagonist	Antiemetic	10 mg		
Ondansetron (Zofran)	Serotonin 5-HT <sub>3</sub> Receptor antagonist	Antiemetic	4 mg	4 mg 16 mg max	5-10 min

## COMPLICATIONS

- Several factors are associated with adverse outcomes during PSA. In addition to the known effects of the drugs themselves, there are patient factors, inadequate pre-procedural evaluation, drug-drug interactions, drug dosing errors, and inconsistent monitoring and observation.
- Respiratory depression is the most common and profound adverse effect. All of the drugs employed inhibit respiratory drive to some degree. The synergistic effects which occur when the drugs are combined can magnify the embarrassment to the respiratory system. Should the SaO<sub>2</sub> fall below 90%, the procedure should be suspended and the patient evaluated. Additionally, chest wall and glottis rigidity are catastrophic side effects of fentanyl and can occur when a high dose of the drug is injected rapidly. Under these circumstances the patient may require paralysis and mechanical ventilation until the symptoms resolve.
- Sympathetic output from the CNS is similarly suppressed by all of the PSA drugs and can result in bradycardia and hypotension. Furthermore, there is a preponderance of patients who take betablockers and calcium channel blockers, which increases the risk for dysrhythmias and cardiovascular collapse during PSA. Atropine 0.4 mg IVP is used to treat symptomatic bradycardia.
- Nausea and vomiting are usually due to opioids. Preventing unwanted opioid induced side effects is important when the patient's sensorium is depressed as emesis could lead to aspiration. Noxious opioid induced symptoms also make for an unpleasant experience for the patient. Zofran 4-8 mg IV is an excellent antiemetic.
- Should the patient experience any itching or if urticaria becomes apparent, diphenhydramine 25 mg IV should be administered. Auscultate the lungs for wheezing and check vital signs.

Inhaled bronchodilators, N-corticosteroids, and SQ epinephrine are appropriate for the management of allergic reactions and anaphylaxis.

## POST PROCEDURE RECOVERY AND PATIENT EDUCATION

Recovery should occur in a place where there is adequate cardiopulmonary monitoring and trained personnel for direct observation because the patient continues to be at risk for developing drug related complications. If reversal agents are administered, continuous observation is required until sufficient time for the last dose to wear off, thus avoiding re-sedation. The Aldrete score uses five criteria to determine a level at which it is safe to discharge the patient. The parameters include a measure of BP and SaO<sub>2</sub> and an evaluation of the patient's mental status, airway patency, and motor function.

The patient's escort should be given both verbal and written instructions which include post procedure activities, diet and medications. Advise the patient to refrain from operating motorized vehicles, consuming alcohol, and signing any legal documents in the 24 hours following PSA. A 24-hour contact phone number is provided in the event of any complications such as pain, bleeding, severe nausea, or difficulty breathing.

## Trauma Orders

Currently, there are three preprinted order sets (which can be found in the ER) for trauma: ER Trauma orders, ICU Trauma orders, and basic floor Trauma order set. Basic considerations when writing orders are shown below.

### **ER Trauma Orders**

- For use in the ER to get specific labs, radiographs, fluids etc. while the patient is in the ER.

### **ICU Trauma Order Set (TRI)**

- For use when admitting trauma patients to the ICU.
- **All trauma patients (including patients transferred from other hospitals directly to the ICU) should be admitted to the on-call trauma attending, rather than the ICU attending, unless indicated otherwise by the trauma attending.**

### **Basic floor trauma order set (TRA).**

- For use when admitting patients to the floor.
- The final form is the Trauma Summary (Yellow) Sheet
- This is filled out to keep track of what studies have been ordered, the dates performed, and their results. In addition there is an area to record date and mechanism of injury, injuries sustained, and procedures performed including their dates.
- **All facial fracture patients should be admitted to the trauma attending, rather than the OMFS attending, unless it is an elective fracture that requires fixation.**

## **ALWAYS REMEMBER ADCVANDIMLE/ADCVANDISSEL FOR ALL PATIENTS**

- Admit to Trauma Service
- Attending Dr. --
- Resident Dr. --
- Diagnosis: give useful information
- Condition
- Vitals
- Think about this one. Do you need continuous pulse oximetry? How often do you need vitals? Are they in the DOU or ICU
- Activity:
- In theory, all trauma patients should be at bed rest initially.
- In addition, if their spine is not cleared, you should state “maintain CTLS spinal precautions. Maintain hard cervical collar.”
- Elevate bed by 30 degrees via reverse Trendelenburg. Do not bend bed until thoracic spine is clear!!!
- Sequential Compression Devices – bilaterally unless injured extremity... then only on non-injured extremity.

- Nursing:
- Foley to gravity, NGT/OGT to low continuous suction.
- JP drains? Wounds? Oral care? Suctioning?
- Diet: NPO
- IVF: LR or 1/2 NS with 20 meq kcl/L if no head injury. If head injury then NS versus hypertonic saline (per neurosurgeon choice).
- As far as rate goes...remember...Resuscitate, don't flood.
- If the patient is stable and going to the floor, administer maintenance fluids.
- If you are giving liters of fluid to maintain urine output or blood pressure... that patient should be in the OR
- A corollary to this is no trauma patient should require pressors unless they have a cardiac contusion with resultant heart failure or they have a high spine injury resulting in neurogenic shock.
- Medications:
- GI prophylaxis. Sucralfate, H2 blockade (can cause confusion and thrombocytopenia), or Proton pump inhibitors. Given on a case by case basis (e.g. If patient has a known peptic ulcer, or gastritis history).
- DVT prophylaxis: Do not start on injury day #1. Use SCD's for the 1st day and then reassess on the second day based on all injuries and operations.
- Antibiotics
  - 1 dose of ancef for lacerations, wounds or chest tubes
  - Perioperative antibiotics (24 hours) for operative procedures including bowel injury
  - Antibiotics per Ortho for open fractures
  - No antibiotics for CSF leaks
- Sedation/Analgesia:
  - On the floor, administer pain meds if there is a fracture, contusions, or if an operation was performed. It is not advisable to give sedation or anxiolytics on the floor unless a monitor is available, and the patient has 1:1 watch with nursing and a physician.
  - In the ICU, fentanyl is preferable for pain starting at 50 mcg/hr. and titrating to effect (less hypotension). Use versed prn for agitation, and rarely use propofol for sedation (do not use past 72 hours).
- Labs: See Labs chapter
- Exams: See specific injury chapters and Radiograph chapter.

SNAPSHOTS OF TRAUMA FORMS

Sample: Trauma Admission Orders (VCMC-388-004) - page 1 of 2

TRAUMA ADMISSION ORDERS
DOU / FLOOR

- 1. [ ] TRA: admit to trauma service Location:
[ ] TRO: 23 hours observation, assign to trauma service Location:
Trauma Attending: Resident:
Consults:
Dx: Weight Kg
Allergies: Reaction, if any

- 2. Vital Signs:
[ ] Neuro Check(s) Q : call physician with changes
[ ] Continuous telemetry & pulse oximetry
[ ] Document Vitals Q
CVP Q
Neurovascular check of extremity Q : call physician with changes

- 3. Activity:
[ ] Bed Rest [ ] TLSO Brace
[ ] Out of bed to chair (describe) [ ] Elevate HOB 30 degrees (check spine precautions)
[ ] Cervical Spine precautions [ ] Elevate HOB via Reverse Trendelenburg (with uncleared spine)
[ ] Cervical Collar (circle: Philadelphia / Miami J) [ ] Physical Therapy Consult Indication:
[ ] Thoracolumbar Spine precautions [ ] Other

- 4. Nursing:
[ ] Foley to gravity with strict I & O's & document [ ] RAPS 4
[ ] JP drain(s) to bulb suction. Describe quantity and [ ] Trendelenburg (with uncleared spine)
locations: [ ] Replace all peripheral IVs placed in field or ER
[ ] Chest tube to side [ ] Incentive Spirometry 10 times per hr while awake
[ ] 20 cm H2O suction [ ] Dressing changes: (Type)
[ ] H2O seal to (area) every
[ ] NGT [ ] OGT to low continuous suction [ ] Social Service Consult Indication:
[ ] Sequential compression devices

- 5. Diet:
[ ] NPO [ ] Enteral Feeds at mL/hr via
[ ] Clear Liquids Hold tube feeds for (check all that apply):
[ ] Advance diet as tolerated [ ] Residual >500 mL [ ] Residual > mL
[ ] Dietician Consult Indication: [ ] Signs of intolerance (vomiting, abdominal pain or distention)

- 6. Fluid Management:
[ ] Maintenance IV: with meq KCl/L to maintain total IV fluids rate of mL/hr
[ ] Other:

- 7. Labs:
[ ] Upon arrival: [ ] Hematocrit Q 6 hrs X
[ ] CBC, CMP Daily [ ] Additional labs
[ ] Amylase Daily X days [ ] Urine Drug Toxicology
[ ] PT, PTT Daily X days [ ] BG Q 6 hrs, notify Physician if BG <70mg/dL x 1, BG >180mg/dL x 2
[ ] Phenytoin level Daily X days [ ] Other:

Physician Signature ID# Date Time
RN Noted Date Time



VENTURA COUNTY MEDICAL CENTER
SANTA PAULA HOSPITAL
TRAUMA ADMISSION ORDERS
DOU / FLOOR

Patient Label
or
Two Patient Identifiers

Sample: Trauma Admission Orders (VCMC-388-004) - page 2 of 2

8. **Imaging studies and other tests:**

- Head CT without contrast Indication: \_\_\_\_\_
- Chest X-Ray Indication: \_\_\_\_\_
- Extremities Indication: \_\_\_\_\_

9. **Medications:**

- Phenytoin Load 20 mg/kg IV Once. Dose not to exceed 1500 mg. Rate not to exceed 50 mg per minute
- Phenytoin Maintenance 100 mg IV Push Q8 hrs
- Levetiracetam 500 mg IV Q12 hrs
- Levetiracetam \_\_\_\_\_mg IV Q12 hrs (Max: 1500 mg/dose)
- Levetiracetam 500 mg PO Q12 hrs
- Levetiracetam \_\_\_\_\_mg PO Q12 hrs (Max: 1500 mg/dose)
- NS 1000 mL once daily X 3 days IV at 125 mL/hr add:
  - Adult Multivitamins 10 mL Injectable
  - Thiamine 100 mg Injectable
  - Folic Acid 1 mg Injectable
  - Pyridoxine 100 mg Injectable
  - Magnesium Sulfate 2 gm injectable
- Esomeprazole (Nexium) 40 mg IV Daily
- VTE Prophylactic:
  - Enoxaparin 40 mg SQ Daily, or
  - Enoxaparin 30 mg SQ Daily for CrCl 15-30 mL/min, or
  - Heparin 5000 units SQ Q8 hrs
- Piperacillin/tazobactam (Zosyn):
  - 4.5 gm IVPB Q6 hrs, for normal renal funtion
  - 2.25 gm IVPB Q6 hrs for CrCl 40 - 20 mL/min
  - 2.25 gm IVPB Q8 hrs for CrCl < 20 mL/min
- ceFAZolin (Ancef) \_\_\_\_\_gm IV Q \_\_\_\_\_ hrs
- Hydrocodone 5 mg / Acetaminophen 500mg (Vicodin) 1 tab PO Q4 hrs PRN mild pain  
**(Maximum 4000 mg Acetaminophen per 24 hrs)**
- Hydrocodone 10 mg / Acetaminophen 325 mg (Norco) 1 tab PO Q4 hrs PRN moderate pain
- Morphine 2 mg IV Q4 hrs PRN severe pain
- Ondansetron (Zofran) 4 mg IV Q4 hrs PRN N/V
- Other \_\_\_\_\_

10. **Blood Products:**

- Type & Screen
- Type & Cross for \_\_\_\_\_ units of PRBC & keep \_\_\_\_\_ units available X 24 hrs
- Transfuse \_\_\_\_\_ units of \_\_\_\_\_ with each unit over \_\_\_\_\_ hrs IV
- Recheck serum \_\_\_\_\_ after transfusion and call House Officer with results
- Other: \_\_\_\_\_

11. **Respiratory:**

- O<sub>2</sub> via (nasal canula / mask) at \_\_\_\_\_ L/min. Titrate to maintain SaO<sub>2</sub> at \_\_\_\_\_%, SaO<sub>2</sub> Q4 hrs
- Albuterol \_\_\_\_\_mg INH via nebulizer Q \_\_\_\_\_ hrs SCH, and Q \_\_\_\_\_ hrs PRN SOB/Wheezing
- Ipratropium \_\_\_\_\_mg INH via nebulizer Q \_\_\_\_\_ hrs SCH, and Q \_\_\_\_\_ hrs PRN SOB/Wheezing
- EZPAP with Albuterol 2.5 mg nebulized Q \_\_\_\_\_ hrs
- ABG X 1 now
- Other: \_\_\_\_\_

12. **Notification:** Call House Officer

- Change in Neuro status, seizure
- Temp  $\geq$  38.5°C
- SBP > 180 or < 90, DBP > 100 or < 70 mm/Hg
- HR < 50 or > 110 BPM
- UO < 0.5 mL/hr/kg
- Hemoglobin < \_\_\_\_\_
- Oxygen Saturation < \_\_\_\_\_
- Serum Na > 150 or < 130 mmol/L
- Call resident on call with all lab results
- IF MAP \_\_\_\_\_ < mm/Hg
- Contact Attending Surgeon if pressors started
- Contact Attending Surgeon if \_\_\_\_\_

13. **Other:**

- \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_

Physician Signature \_\_\_\_\_ ID# \_\_\_\_\_ Date \_\_\_\_\_ Time \_\_\_\_\_

RN Noted \_\_\_\_\_ Date \_\_\_\_\_ Time \_\_\_\_\_



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TRAUMA ADMISSION ORDERS  
DOU / FLOOR

Patient Label  
or  
Two Patient Identifiers



Sample: Trauma ICU Orders (VCMC-388-005) - page 1 of 2

**TRAUMA ICU ORDERS**

1.  TRI: Admit to trauma service  
 TRO: 23 hours observation, assign to trauma service  
 Trauma Attending: \_\_\_\_\_ Resident: \_\_\_\_\_  
 Consults: \_\_\_\_\_  
 Diagnosis: \_\_\_\_\_  
 Allergies: \_\_\_\_\_
  
2. **Vital Signs:** Strict I&O's, continuous telemetry and pulse oximetry, vitals documented Q 1 hour (BP, P, Temp, Sat, etc.)  
 Neuro Check Q 1 hour: call physician with changes       Mixed venous oxygen saturation monitoring Q 1 hour  
 CVP Q 1 hour  
 Neurovascular check of \_\_\_\_\_ extremity Q \_\_\_\_\_. Call physician with changes.
  
3. **Activity:**  
 Bed Rest  
 OOB to chair TID  
 C-Spine precautions and Hard Collar  
 TL Spine Precautions  
 TLSO Brace \_\_\_\_\_  
 HOB  $\uparrow$  30 degrees (check spine precautions)  
 Elevate HOB via Reverse Trendelenburg (with uncleared spine)  
 Physical Therapy Consult Indication: \_\_\_\_\_  
 Occupational Therapy Consult Indication: \_\_\_\_\_  
 Other: \_\_\_\_\_
  
4. **Nursing:**  
 Foley to gravity  
 JP drain(s) to bulb suction  
 Chest tube to \_\_\_\_\_ side,  
      20cm H<sub>2</sub>O suction  
      H<sub>2</sub>O seal  
 Chest tube to \_\_\_\_\_ side,  
      20cm H<sub>2</sub>O suction  
      H<sub>2</sub>O seal  
 Sequential compression devices  
 External ventricular drain monitor output Q 1 hour  
 Monitor ICP Q 1 hour, drain for 5 minutes for ICP >20mmHg  
 Replace all peripheral IVs placed in field or ER  
 Neutral Head Position  
 CPT Q \_\_\_\_\_ hours (no CPT if unstable spine)  
 Reposition Q 2 hours  
 Incentive Spirometry 10 times per hour while awake  
 Podus Boots  
 Dressing changes: (Type) \_\_\_\_\_ to (area) \_\_\_\_\_ Q \_\_\_\_\_  
 RAPS 4
  
5. **Diet:**  
 NPO  
 NGT    OGT to low continuous suction  
 Clear Liquids  
 Advance diet as tolerated \_\_\_\_\_  
 Enteral Feeds: \_\_\_\_\_ at \_\_\_\_\_ mL/hour via \_\_\_\_\_  
 Hold tube feeds for (check all that apply):  
 Residual >500 mL    Residual > \_\_\_\_\_ mL  
 Signs of intolerance (vomiting, abdominal pain or distention)
  
6. **Fluid Management:**  
 Maintenance IV: \_\_\_\_\_ with \_\_\_\_\_ mEq KCl/L to maintain total IV fluid rate of \_\_\_\_\_ mL/hour  
 Hypertonic Saline: 3% NS at 50 mL/hour x 5 hours, check serum Na after infusion completed  
 Other: \_\_\_\_\_
  
7. **Labs:**  
 Upon arrival: ABG, CBC, Lactate, CK, Amylase, CMP, PT/PTT, Fibrinogen  
 CBC, CMP Daily  
 Amylase Daily x 2 days  
 PT, PTT Daily x 3 days  
 Phenytoin level daily x 3 days  
 hct Q 6 hours x 72 hours  
 Lactate level at \_\_\_\_\_  
 ABG at \_\_\_\_\_  
 Additional labs: \_\_\_\_\_  
 Urine Drug Toxicology \_\_\_\_\_  
 BG Q 6 hr, notify Physician if BG <70mg/dL x 1, BG > 180mg/dL x 2  
 \_\_\_\_\_  
 \_\_\_\_\_

Physician Signature \_\_\_\_\_ ID# \_\_\_\_\_ Date \_\_\_\_\_ Time \_\_\_\_\_

RN Noted \_\_\_\_\_ Date \_\_\_\_\_ Time \_\_\_\_\_



VENTURA COUNTY MEDICAL CENTER  
 SANTA PAULA HOSPITAL  
**TRAUMA ICU ORDERS**

Patient Label  
 or  
 Two Patient Identifiers

Sample: Trauma ICU Orders (VCMC-388-005) - page 2 of 2

8. **Imaging studies and other tests:**

- Head CT without contrast Indication: \_\_\_\_\_
- Chest X-Ray Indication: \_\_\_\_\_
- Other: Indication: \_\_\_\_\_

9. **Consults:**

- Social work consult Indication: \_\_\_\_\_
- Nutrition consult Indication: \_\_\_\_\_

10. **Medications: (Dosing adjustments may be needed for renal impairment)**

- Phenytoin 20 mg/kg IV Load, not to exceed 1500 mg and infused no faster than 50 mg per minute
- Phenytoin maintenance, 100 mg IVP Q 8 hours
- Levetiracetam (Keppra) \_\_\_\_\_ mg IVPB Q 12 hours (MAX of 1500 mg/dose)
- IV Fluids:
  - NS 1000 mL once daily x 3 days IV at 125 mL/hour add:
    - Multivitamins 10 mL  Pyridoxine 100 mg
    - Thiamine 100 mg  Magnesium Sulfate 2 GM
    - Folic Acid 1 mg
- VTE/DVT Prophylaxis:
  - Enoxaparin (Lovenox) 40 mg SQ daily
  - Enoxaparin (Lovenox) 30 mg SQ BID
  - Heparin sodium 5000 units SQ Q 8 hours
- G) Protectant:
  - Esomeprazole (Nexium) 40 mg IV daily

- Antibiotics:
  - Piperacillin/Tazobactam (Zosyn) \_\_\_\_\_ GM IVPB Q 6 hours
  - CeFAZolin (Ancef) \_\_\_\_\_ GM IVPB Q 8 hours
  - Oral care: Chlorhexidine mouth rinse (Peridex) 15 mL oral rinse BID
  - Eye care: Lacrilube Oph Oint 1 cm to both eyes Q 4 hours PRN dry eyes
  - Neomycin 230 mg/Amphotericin 2 mg/Bacitracin 2080 units per 10 mL, compounded oral sol'n 10 mL per OGT Q 6 hrs x 96 hours
  - For all IV Titratable drips; for physician orders refer to Adult IV Titratable Medication Order Form
  - Insulin Drip and monitoring, see Physician Order Form (Adult Intravenous Insulin Infusion Orders)
  - Blood Glucose Monitoring: Accuchecks Q 6 hrs if not on insulin drip. Call Physician for BG < 70 x 1, or BG >180 x 2
  - Other: \_\_\_\_\_

11. **Blood Products:**

- Type & Screen
- Type & Cross for \_\_\_\_\_ units of PRBC & Keep \_\_\_\_\_ units available at all times
- Transfuse \_\_\_\_\_ units of \_\_\_\_\_ with each unit over \_\_\_\_\_ hours IV
- Recheck \_\_\_\_\_ after transfusion and call House Officer with results
- Other: \_\_\_\_\_

12. **Respiratory:**

- O<sub>2</sub> via (nasal canula/mask) at \_\_\_\_\_ L/min Titrate to maintain SaO<sub>2</sub> at \_\_\_\_\_%
- Albuterol \_\_\_\_\_ mg NEBS INH every \_\_\_\_\_ hours
  - Scheduled
  - PRN SOB/Wheezing
- Albuterol \_\_\_\_\_ mg NEBS INH every \_\_\_\_\_ hours
  - Scheduled
  - PRN SOB/Wheezing
- Ipratropium Bromide \_\_\_\_\_ mg NEBS INH every \_\_\_\_\_ hours
  - Scheduled
  - PRN SOB/Wheezing
- Ipratropium Bromide \_\_\_\_\_ mg NEBS INH every \_\_\_\_\_ hours
  - Scheduled
  - PRN SOB/Wheezing
- Other: \_\_\_\_\_

13. **Notification:** Call House Officer

- Change in Neuro status, seizure
- Temp ≥ 38.5°C (101.3°F)
- SBP > 180 or < 90, DBP > 100 or < 70 mm/Hg
- HR < 50 or > 110 BPM
- UO < 0.5 mL/hour/kg
- Hemoglobin < \_\_\_\_\_
- Oxygen Saturation < \_\_\_\_\_
- Serum Na > 150 or < 130 mmol/L
- Call resident on call with all lab results
- IF MAP \_\_\_\_\_ < mm/Hg
- Contact Attending Surgeon if pressors started
- Contact Attending Surgeon if \_\_\_\_\_

14. **Other:**

- \_\_\_\_\_
- \_\_\_\_\_

Physician Signature \_\_\_\_\_ ID# \_\_\_\_\_ Date \_\_\_\_\_ Time \_\_\_\_\_

RN Noted \_\_\_\_\_ Date \_\_\_\_\_ Time \_\_\_\_\_



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**TRAUMA ICU ORDERS**

Patient Label  
or  
Two Patient Identifiers

Sample: Trauma Patient Summary (VCMC-388-011) - page 1 of 4

<b>TRANSFER?</b> ( Y or N ) from: _____ <b>MECHANISM:</b> _____ <b>DATE INJURY:</b> _____ <b>ADMIT DATE:</b> _____	<b>TRAUMA SURGEON:</b> _____ <b>ICU RESIDENT:</b> _____ <b>SURGERY RESIDENT:</b> _____ <b>DISCHARGE DATE:</b> _____
<b>INJURIES (Primary/Final Diagnosis):</b>	
<b>COMORBIDITIES (Secondary Diagnosis):</b>	
<b>PROCEDURES / IMMUNIZATIONS:</b>	<b>SURGEON / SERVICE</b>
	<b>DATE</b>
<b>DISPOSITION:</b> <input type="checkbox"/> Home <input type="checkbox"/> SNF <input type="checkbox"/> Acute Rehab Facility <input type="checkbox"/> Transfer _____ <input type="checkbox"/> Death	
<b>SEE MEDICATION RECONCILIATION FORM FOR DISCHARGE MEDICATIONS</b>	
<b>FOLLOW-UP APPOINTMENTS:</b>	
<input type="checkbox"/> Anacapa Trauma Clinic 3291 Loma Vista Rd., Suite 401 Ventura, CA 93003 (805) 652-6201 Date: _____ Time: _____	<input type="checkbox"/> Traumatic Brain Injury Clinic 3170 Loma Vista Rd. Ventura, CA 93003 (805) 648-9830 Date: _____ Time: _____
<input type="checkbox"/> Other: _____ _____ _____ Date: _____ Time: _____	
<b>DIET:</b>	
<b>ACTIVITY:</b>	
Patient Signature/Date	Resident Signature/ID/Date/Time
RN Signature/Date	Attending Signature/ID/Date/Time



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**TRAUMA PATIENT SUMMARY**

Patient Label  
 or  
 Two Patient Identifiers

Sample: Trauma Patient Summary (VCMC-388-011) - page 2 of 4

**EDUCATION MATERIALS PROVIDED:**

<input type="checkbox"/> TBI	<input type="checkbox"/> Fracture	<input type="checkbox"/> Other: _____
<input type="checkbox"/> Wound Care	<input type="checkbox"/> Chest Tube Removal	_____
<input type="checkbox"/> TLSO Brace	<input type="checkbox"/> Cast Precautions	_____
<input type="checkbox"/> Return to ER	<input type="checkbox"/> Splenectomy	_____
<input type="checkbox"/> IVC Filter	<input type="checkbox"/> Self Inject Guide	_____
<input type="checkbox"/> Non-Operative Spleen Injury	<input type="checkbox"/> Clavicle Fracture	_____

**OTHER INSTRUCTIONS:**

**CONSULTS: DATE & TIME**

Neuro Surgery	_____ / _____	Name: _____
Orthopedics	_____ / _____	Name: _____
Plastics	_____ / _____	Name: _____
OMFS	_____ / _____	Name: _____
Other	_____ / _____	Name: _____

**DRUG / ALCOHOL SCREENING & BRIEF INTERVENTION**

Urine Tox: \_\_\_\_\_ Etoh: \_\_\_\_\_  RAPS4 +  Brief Intervention

**ALLERGIES:** \_\_\_\_\_ **EMERGENCY CONTACT:** \_\_\_\_\_

**C-SPINE CLEARANCE:**  Yes (Date: \_\_\_\_\_ ) **THORACOLUMBAR SPINE:**  Yes (Date: \_\_\_\_\_ )

**ED DISPOSITION:**  OR  ICU  DOU  MED/SURG  TRANSFER  HOME  DEATH

**DRS for: TBI, SCI, Pelvic & Long Bone Fractures (To be completed by Physical Therapist)**

Disability Rating Scale	Eye Opening	Communication	Motor Response	Feeding	Toileting	Grooming	Level of Functioning	Employability	Total Score	Safety Evaluation
	0-3	0-4	0-5	0-3	0-3	0-3	0-5	0-3	<b>0-29</b>	Y
<b>Score</b>										N
<b>Staff Signature</b>										



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**TRAUMA PATIENT SUMMARY**

Patient Label  
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 Two Patient Identifiers

DISTRIBUTION: White - Medical Record Yellow - Patient Page 2 of 4  
 VCMC-388-011 (09/2011)

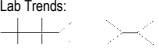
Sample: Trauma Patient Summary (VCMC-388-011) - page 3 of 4

**Tertiary Trauma Survey (TTS)**

Date & Time of TTS: _____ Admission Date: _____		Tier: I II III		Patient Location: _____	
Subjective:		PMHx: <input type="checkbox"/>			
		PSHx: <input type="checkbox"/>			
		Social Hx: <input type="checkbox"/>			
<b>PHYSICAL EXAM:</b>		<input type="checkbox"/> Intubated	<input type="checkbox"/> Sedated	<input type="checkbox"/> Intubated/alert	<input type="checkbox"/> Alert/confused
VS =	BP	HR	RR	O2 Sat	Temp
Neuro	<input type="checkbox"/> WNL	E _____ V _____ M _____			
HEENT	<input type="checkbox"/> WNL	Motor/Sensory:		Nose/mouth:	
Neck	<input type="checkbox"/> WNL	Midline tenderness		<input type="checkbox"/> Yes	<input type="checkbox"/> No
		Clinically cleared		<input type="checkbox"/> Yes	<input type="checkbox"/> No
		Radiographically cleared		<input type="checkbox"/> Yes	<input type="checkbox"/> No
Cardiac	<input type="checkbox"/> WNL				
Chest	<input type="checkbox"/> WNL				
Abdomen/Pelvis	<input type="checkbox"/> WNL				
Back	<input type="checkbox"/> WNL				
Extremities	<input type="checkbox"/> WNL				
Other	<input type="checkbox"/> WNL				

Evaluating Provider MD/NP/DO: \_\_\_\_\_ Date Completed: \_\_\_\_\_ Time \_\_\_\_\_

Attending Physician Name: \_\_\_\_\_

RADIOLOGICAL FINDINGS REVIEW:		Date Completed	Date / Repeated
CXR: <input type="checkbox"/> WNL			
Pelvis A/P: <input type="checkbox"/> WNL			
C-Spine: <input type="checkbox"/> WNL			
T/L/S Spine: <input type="checkbox"/> WNL			
Extremity: <input type="checkbox"/> WNL			
HEAD CT: <input type="checkbox"/> WNL			
CERVICAL CT: <input type="checkbox"/> WNL			
CHEST CT: <input type="checkbox"/> WNL			
ABD/PELVIS CT: <input type="checkbox"/> WNL			
FACIAL CT: <input type="checkbox"/> WNL			
OTHER: <input type="checkbox"/> WNL			
Lab Trends: 		PT: INR: LACTATE:	



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## SNAPSHOT OF TRAUMA HISTORY AND PHYSICAL

Sample: Trauma History & Physical (VCMC-388-015) - page 1 of 3

Name of scribe / service: \_\_\_\_\_ Injury Date: \_\_\_\_/\_\_\_\_/\_\_\_\_ Injury Time: \_\_\_\_\_  
Trauma Tier **I** **II** **III** Referring Hospital (if any): \_\_\_\_\_ Pre-hospital IV access: \_\_\_\_\_  
Current Date: \_\_\_\_/\_\_\_\_/\_\_\_\_ Current Time: \_\_\_\_\_ Pre-hospital Fluids/type: \_\_\_\_\_

Vitals en route: T \_\_\_\_ BP \_\_\_\_/\_\_\_\_ P \_\_\_\_ O2Sa \_\_\_\_%/\_\_\_\_ RR \_\_\_\_ IV access/fluids \_\_\_\_\_  
**HPI/ Mechanism of Injury:** \_\_\_\_ year-old ♀ / ♂ arrived by \_\_\_\_\_  
**LOC:**  No  Yes (duration \_\_\_\_\_); **Amnestic to Event:**  No  Yes; **Witnessed Event:**  No  Yes  
**Safety:** helmet, airbags deployed, seat belt, other \_\_\_\_\_  
**MVC:** single or multiple vehicles, driver / front-seat passenger / backseat passenger, ejection, rollover, trapped

**Staff Present**

ER attg: \_\_\_\_\_  
Surg : \_\_\_\_\_  
MP2 : \_\_\_\_\_  
MP1 : \_\_\_\_\_  
ICU : \_\_\_\_\_  
Surg attg : \_\_\_\_\_  
Anesth : \_\_\_\_\_

**-PRIMARY SURVEY-:** Airway:  Patent  Obstructed  
Breathing:  Normal  Labored  Assisted  None  
Breath Sounds Left:  Normal  Diminished  Absent  
Right:  Normal  Diminished  Absent  
Circulation: Skin Temperature  Warm  Cool  
Distal Pulses  2+  1+  absent  
Capillary Refill  <2 sec  Prolonged  Level I transfuser  
Disability: GCS \_\_\_\_ (E = \_\_ V = \_\_ M = \_\_) time: \_\_\_\_\_  
Moves all extremities:  Yes  No \_\_\_\_\_  
Pupils:  PERRLA \_\_\_\_ mm \_\_\_\_\_  
Exposure: \_\_\_\_\_

**Review of Systems**

HEENT:  Neg; \_\_\_\_\_  
Cardiovascular:  Neg; \_\_\_\_\_  
Respiratory:  Neg; \_\_\_\_\_  
GI:  Neg; \_\_\_\_\_  
GU:  Neg; \_\_\_\_\_  
Skin:  Neg; \_\_\_\_\_  
Neuro/Psych:  Neg; \_\_\_\_\_  
Endocrine:  Neg; \_\_\_\_\_  
Heme/Lymph:  Neg; \_\_\_\_\_  
Other:  Neg; \_\_\_\_\_  
*last tetanus:* \_\_\_\_\_

**PROCEDURES**

(A)  Intubated (in Field/in ED)  
intubation type: \_\_\_\_\_  
(A)  Other Airway: \_\_\_\_\_  
(B)  Needle thoracostomy R / L  
(B)  Tube Thoracostomy R / L  
(B)  Thoracotomy R / L  
(C)  Femoral R / L  
(C)  Subclavian R / L  
(C)  Internal Jugular R / L  
(C)  Intraosseous (Site: \_\_\_\_\_)

**-SECONDARY SURVEY: MEDICAL HISTORY-**

**Medical Problems:** \_\_\_\_\_  
**Medications:** anticoagulation  yes  no  
**Surgical History:** \_\_\_\_\_  
**Medical Allergies:** \_\_\_\_\_  
**Social History:**  non-smoker  non-drinker  no illicit drugs  
**Family History:**  noncontributory  
**Last meal:** \_\_\_\_\_

**Glasgow Coma Scale**

<b>Eyes</b>	
Spontaneous	4
React to Speech	3
React to Pain	2
No response	1
<b>Best Motor</b>	
Obeys/Spontaneous	6
Localizes to pain	5
Withdraws to pain	4
Decorticate	3
Decerebrate	2
No response	1

**-SECONDARY SURVEY: PHYSICAL EXAM-**

Repeat Vitals at \_\_\_\_: T \_\_\_\_ BP \_\_\_\_/\_\_\_\_ P \_\_\_\_ RR \_\_\_\_ O2Sa \_\_\_\_%/\_\_\_\_  
**Constitutional:** Head :  NC/AT

**Eyes:**  PERRLA  conjunctiva clear  EOMI

**ENT:**  no fluid in EACs  TMs clear

**Neck:**  WNL  trachea midline

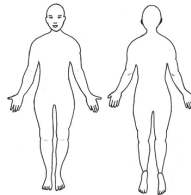
**C-spine:**  non-tender  C-collar in place

**Chest:**  chest wall NT  no bruising/deformity

**Respiratory:**  Lungs CTAB

**Cardiovascular:**  RRR no MRG  strong pulses

**Abdomen:**  S/NT/ND  no guarding/rebound



<b>Best Verbal</b>	
Oriented communication	5
Disoriented communication	4
Inappropriate words	3
Incomprehensible	2
No response	1
<b>Best Verbal (infant)</b>	
interacts/orients to sound	5
consolable	4
inconsistently consolable	3
inconsolable	2
no response	1



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**TRAUMA REPORT**

VCMC-388-015 (06/2012)

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Page 1 of 3

Patient Label  
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Two Patient Identifiers

Sample: Trauma History & Physical (VCMC-388-015) - page 2 of 3

Rectal:  good tone Guaiac  neg  pos  not done

GU:  no blood at meatus  foley catheter placed

Skin/Wounds (see diagram):

Musculoskeletal:  Pelvis stable

T/L/S spine and back:

Extremities:

Neuro:  MAEE

Laboratory Studies:

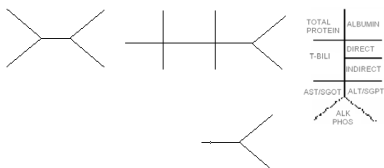
BAL:

UTox:

B-hCG:  pos  neg

amylase:

CK:



Preliminary Imaging Results:

FAST Exam:

Chest XR:

Pelvic xR:

CT Head:

Other:

Phone Consults (Time and Date)



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TRAUMA REPORT

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Sample: Trauma History & Physical (VCMC-388-015) - page 3 of 3

**Assessment and Plan:**

\_\_\_\_\_  
Signature Printed Name Date Time

**Attending Staff Note:**

- I saw and evaluated the patient. I discussed the case with the resident and agree with the findings and plan as documented in his/her note and/or any note I supplied.
- I was present with the resident during the history and exam. I discussed the case with the resident and agree with the findings and plan as documented in his/her note and/or any note I supplied.
- I personally reviewed the  labs,  films,  radiologic reports,  orders  other:
- \_\_\_\_\_ minutes of total critical care provided to the patient, excluding procedures.

\_\_\_\_\_  
Signature Printed Name Date Time



VENTURA COUNTY MEDICAL CENTER  
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**TRAUMA REPORT**

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VCMC-388-015 (06/2012)

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Page 3 of 3

## **TRAUMA HISTORY & PHYSICAL EXAM DICTATION**

*(Dictation Code 75)*

- **ADMISSION DATE:**
- **ADMITTING SURGEON:**
- **HISTORY**
  - Age
  - Mechanism of injury
  - Findings at scene
  - Procedures performed in field
  - Transportation type
  - Tier level
  - ED physician involved and time of arrival
  - Other physicians involved
- **PAST MEDICAL HISTORY / PAST SURGICAL HISTORY**
- **MEDICATIONS / ALLERGIES**
- **SOCIAL HISTORY**
- **REVIEW OF SYSTEMS**
- **PRIMARY SURVEY**
  - Primary survey
  - Resuscitation performed
  - Procedures performed: who performed procedure and why it was performed
- **SECONDARY SURVEY (Head to toe complete examination)**
- **RADIOGRAPHIC STUDIES & PRELIMINARY REPORTS**
- **DISPOSITION**
- **DIAGNOSIS & PLAN**

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## CHAPTER 4

# HEAD TRAUMA

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### **IN THIS SECTION**

*Traumatic Brain Injury (TBI) Management and Evaluation*

*Secondary Brain Injury and ICP Management*

*Traumatic Brain Injury Guidelines*

*Reversal of Warfarin Associated Traumatic Brain Injury, Spontaneous Intracerebral Hemorrhage, and other Critical Bleeding in Adults*

*Brain Death Evaluation and Management*

*Managing the Potential Organ Donor*

*Rehabilitation*

## Traumatic Brain Injury Management and Evaluation

### DEFINITIONS

- **Traumatic brain injury** - An injury to the brain resulting in disorders of motor, sensory and/or cognitive function.
- **Brain Contusion** - Bruising of the tissue just below the pial surface resulting from impact of the brain tissue against the skull.
- **Coup-Contre Coup** - impact injury to the side of the brain contralateral to the head impact.

### GUIDELINES

#### **Perform primary survey according to ATLS guidelines:**

- Provide urgent airway for GCS  $\leq 8$  – remember that hypoxia can be devastating to the injured brain.
  - If sedatives and paralytics are to be used, conduct a rapid but thorough neurologic exam prior, including:
    - Level of consciousness.
    - Ability to verbalize.
    - Ability to open eyes.
    - Ability to move all extremities to verbal command or pain.
    - Presence of abnormal posturing.
    - Presence of abnormal reflexes.
    - Presence of rectal tone.
    - Pupillary size & reactivity.
    - Gag reflexes.
    - Note presence of bruises, Battle's signs, lacerations, etc.
  - Consider using lidocaine with intubation (IV and topical). Repeat to match intubation (RSI) protocol.
  - Maintain C-spine precautions including rigid collar.
- Check for chest injury.
  - Ventilate to maintain mild hypocapnia ( $pCO_2 = 35-40$  mmHg).
- Determine hemodynamic status.
  - Resuscitate from shock with warm lactated ringers solution or normal saline. Maintain normovolemia and normal hemodynamics.
- If patient not sedated, do mini-neurologic exam as above.
  - Expose patient, when able, to look for any non-obvious injury.
  - Resuscitate patient as above, until hemodynamic and pulmonary stability is achieved.
  - Calculate the Glasgow Coma Scale (see end of chapter).
- Consider need for neurosurgical consult when:
  - Head CT abnormality.
  - Any patient with GCS  $<12$ .
  - Any patient with focal neurologic deficit.
  - Any patient with unequal pupils secondary to brain injury.

- Indications for a non-contrast head CT scan:
  - GCS <14.
  - Focal neurologic deficit.
  - Loss of consciousness.
- CT priorities:
  - CT should be abandoned if patient requires emergent operation to stop hemorrhage or immediately repair of life-threatening injury. Notify neurosurgery immediately of this situation.
  - CT should be obtained, otherwise, to determine presence of space occupying clot prior to other surgeries.
  - Repeat non-contrast brain CT in 6 hours for patients with contusions, SDH, EDH without shift or those triaged to conservative management.
- Sedation:
  - Sedation should be avoided, if possible, in order to allow for serial neurological exams. If required, a complete neurologic examination should be performed prior to their use.
  - Uncooperative or thrashing patients should be treated with sedation.
    - Morphine 0.1 mg/kg IV, if associated with painful injury, or fentanyl.
    - Versed 0.075 mg/kg IV for agitation.
    - If intubated, Pancuronium 0.1 mg/kg IV or vecuronium 0.1 mg/kg IV, if sedation is not satisfactory, to allow ventilatory control or cooperation with the diagnostic studies. Do not give paralyzing agent without associated pain medications or sedative.
- Hyperventilation
  - Mild hyperventilation may be used, trying to achieve a pCO<sub>2</sub> of 35-40 mmHg.
- Seizures:
  - Administer diazepam 0.075 mg/kg (usually 5 mg boluses) repeatedly until seizure breaks.
  - Prophylaxis with keppra or fosphenytoin
    - Administer if seizure has occurred.
    - Administer if there is a high likelihood of post-traumatic seizure.
      - ◇ Penetrating injury
      - ◇ Skull fracture with depression
      - ◇ Intraparenchymal hematoma
- Mannitol:
  - At the discretion of the neurosurgeon, a mannitol bolus of 1 gm/kg can be given for evidence of rising intracranial pressure. This should suggest that an ICP monitor be placed as soon as possible.
- Remember – a craniotomy can be performed at the same time as other operative procedure. Consider all possibilities if patient is to be taken to the OR.
- Scalp lacerations:
  - Exsanguinating hemorrhage can arise from scalp lacerations.
  - Scalp lacerations should be closed with adequate hemorrhage control.
- Cerebral Spinal Fluid leaks:
  - Avoid prophylactic antibiotics for otorrhea or rhinorrhea, as this will only select out resistant organisms.

- Perform CT with thin cuts in coronal and axial planes through area of interest to look for basilar fracture.
- Lumbar drain needed in certain rare cases if prolonged drainage is not responsive to conservative management.
- Fluids
  - Avoid LR and 1/2 NS, as they exacerbate cerebral edema. Instead, use NS or possibly 3% NS (hypertonic Saline).
- Labs:
  - Order a standard Trauma Panel (CBC, CMP, lactate acid, Amylase, T&S) as well as PT/PTT/ INR & Fibrinogen.
- Be sure to assess spine as per spine evaluation guidelines.

**Glasgow Coma Score**

- The Glasgow Coma Score (GCS) is the most widely used scoring system in quantifying level of consciousness following traumatic brain injury. It is used primarily because it is simple, reliable & correlates well with outcome.
- The score can be given as a single number 3-15 or, preferably, by its individual components: Eye 1-4, Verbal 1-5, Motor 1-6.
- A “T” is added to the score if the patient is intubated.
- A patient has a minimum score of 3 by showing up, and doing nothing else.

Eye Opening (E)	Verbal Response (V)	Motor Response (M)
4 = Spontaneous	5 = Normal conversation	6 = Normal
3 = To voice	4 = Disoriented	5 = Localizes pain
2 = To pain	3 = Incoherent	4 = Withdraws to pain
1 = None	2 = Only sounds	3 = Decorticate (Flexion withdrawal)
	1 = None	2 = Decerebrate (Extension withdrawal)
		1 = None



Epidural Hematoma



Subdural Hematoma

## Secondary Brain Injury and ICP Management

### OBJECTIVES

- To define the brain injured patient that is at risk for secondary injury.
- To define guidelines for the prevention and management of secondary injury.
- To define the appropriate patient who will benefit from barbiturate coma.
- To provide guidelines for appropriate monitoring of barbiturate coma.
- To define a protocol for the administration of barbiturate coma.

### DEFINITIONS

- **Secondary Brain Injury:** Injury to brain parenchyma which occurs after the initial injury. Typically is due to decreased oxygen to the brain from either hypotension, elevated intracerebral pressure (ICP), hypoxia, or cerebral vasoconstriction.
- **Barbiturate coma:** The use of high dose intravenous pentobarbital in the patient with traumatic brain injury to reduce intracranial pressure and cerebral metabolic rate.

#### *Patients at risk for secondary brain injury:*

- Brain injury associated with a GCS <8.
- Severe diffuse swelling with ventricular effacement or obliteration.
- Hemispheric swelling with effacement of the ventricle or midline shift.
- Intracerebral hematoma with midline shift.

#### *Factors deleterious to recovery from brain injury:*

- Hypotension
- Hypoxia
- Hypercarbia (and severe hypocarbia)
- Hyperthermia
- Hyponatremia
- Jugular venous obstruction (clear c-spine as soon as possible)
- Excessive Stimulation
- Straining

### GUIDELINES

If a patient is defined as being “at risk for secondary injury” by the neurosurgeons or trauma surgeons (see above), then the following protocol should be implemented:

1. Intubate patient
  - Maintain  $pO_2 >80$  torr; maintain  $O_2$  saturation  $>96\%$ .
  - Maintain  $pCO_2$  35-40 mmHg.
  - Monitor lactate levels every 12 hours until normal, if the patient has an episode of hemorrhagic shock.



2. Intracranial pressure monitoring
  - Indications:
    - GCS  $\leq$ 8 & Abnormal CT
    - GCS  $\leq$ 8 & Normal CT with 2 of the following
    - Age  $>$ 40
    - Systolic Blood Pressure  $<$ 90
    - Focal Lateralizing signs
    - GCS 9-12 with abnormal CT & patient will undergo prolonged extra-cranial operative procedure
  - Types of monitoring
    - Ventriculostomy
      - Pressure monitor with catheter in ventricular system. Allows for pressure readings as well as CSF drainage to assist in controlling elevated ICP
      - Parenchymal ICP monitor and fiberoptic or micro strain gauge device
      - Pressure monitor where sensor is on brain parenchyma. Allows for pressure measurements only (no drainage).
3. Insert arterial line.
4. Head of bed at 45° unless otherwise specified.
5. Maintain sedation and analgesics as needed.
  - Again, it is easier to neurologically assess patients who are not sedated, but sedation should be used if needed. One consideration would be short acting agents such as propofol and versed. Avoid paralytics unless absolutely indicated.
6. Treat fevers of  $>$ 37.5°C/99.5°F
  - Euthermia crucial to avoid secondary injury
  - Tylenol suppository, 650 mg every 4 hours prn.
  - Cooling blanket.
7. Calculate cerebral perfusion pressure (CPP)
  - Mean arterial pressure (MAP) minus intracranial pressure (ICP).
  - $CPP = MAP - ICP$
8. Maintain CPP 50-70 mmHg
  - If CPP  $<$ 70, determine if due to increased ICP or reduced MAP.
    - If CPP  $<$ 70 and ICP  $>$ 25 cm H<sub>2</sub>O, then consider measures to reduce ICP.
      - Drain ventriculostomy.
      - Drain for 3-5 minutes and record ICP and CPP.
      - If ICP remains above limits, may place drain to continuous drainage at the discretion of the neurosurgeon.
    - Mannitol
      - If ICP remains above limits, then give mannitol 20%, 1 gm/kg load and 0.5 gm/kg IV every four hours.
      - Obtain serum osmolality every 12 hours.
      - Hold mannitol and call neurosurgery if serum osmolality is  $>$ 320 mosm/dL.
  - Barbiturate coma
    - May be used at the discretion of neurosurgery, if no other maneuvers are effective. See *Barbiturate Coma Guideline*.

- If CPP <70, make sure hemodynamics are not compromised
    - Determine Cardiac Index (CI).
    - If CI <4.0, then determine PCWP and/or MAP.
      - Maintain PCWP at >14 cm H<sub>2</sub>O and/or MAP >90
      - Use gentle fluid boluses of lactated ringers (500 ml/hr) to increase PCWP and/or MAP to desired level to keep CI >4.0.
    - If PCWP >14 and/or MAP <90 cm H<sub>2</sub>O and CI <4.0:
      - Start dopamine 5 mcg/kg/min.
      - May go up to 10 mcg/kg/min.
    - If CI >4.0 and CPP is still <70
      - Start neo-synephrine or levophed.
      - Titrate to keep CPP >70.
9. Elevate head of bed at 45 degrees (unless patient is hypotensive).
    - Utilize reverse Trendelenburg if spinal precautions.
  10. Keep neck straight and avoid tight tape around neck.
  11. Maintain hemoglobin of 10.
  12. Maintain electrolyte and glucose homeostasis
    - (Na >140, glucose 80-120)
  13. Start Dilantin for SAH, SDH or epidural hematoma, penetrating injury, post-craniotomy, or witnessed seizure.
    - Loading dose is 20 mg/kg slow IV push over 20 minutes.
    - Give Dilantin only for 7 days unless patient had seizures or high risk such as penetrating injury.
  14. Check daily CBC, BMP, Dilantin level (if on Dilantin), PT, PTT.
    - If receiving mannitol, Lasix or hypertonic saline check bmp more often and add serum osmolality.
    - If concerned of diabetes insipidus, check urine osmolality
  15. Do not give NS.
    - Give D5NS with 20 meq KCL/L or 3% hypertonic saline if difficult to maintain serum Na >140.
  16. If there is any confusion with this protocol, contact neurosurgery or the trauma attending.
  17. Repeat CT scans according to neurosurgery requests.
  18. Start enteral nutrition as soon as possible.

## BARBITURATE COMA

### *Indications:*

- Barbiturate coma is usually reserved for patients with traumatic brain injury with intractably high (>20 mmHg) intracranial pressure in spite of optimal measures to lower ICP including mannitol, sedation, ventriculostomy drainage (if available), mild hyperventilation, as well as craniectomy.
- Because of the hemodynamic consequences of barbiturate coma, this therapy usually follows a trial of aggressive cerebral perfusion pressure optimization.

**Inclusion criteria (all of the following)**

- Serious traumatic brain injury with global or facial swelling
- Documented neurologic function
- Adequate cardiac function (preferably defined by a CI >4.0 L/min/m<sup>2</sup>)
- Adequate pulmonary function (PaO<sub>2</sub>/FiO<sub>2</sub> <200)

**Procedure**

1. Have available monitoring lines and equipment
  - Endotracheal intubation (7.0 or greater)
  - Pulse oximeter
  - Bedside EEG monitor – Requires Neurology Consult
  - DVT prophylaxis
2. Establish medical stability to compensate for following complications:
  - Cardiovascular instability
  - Cardiac depression
  - Vasodilatation
  - Loss of secretion clearance
  - Loss of cough reflex
  - Paralysis of mucociliary elevator
  - Immunologic suppression
  - Skin breakdown
3. Once patient is stable and fully volume loaded, start barbiturates
  - Initiate therapy with a loading dose of 10 mg/kg of pentobarbital sodium over 30 minutes
  - Follow with an infusion of 5 mg/kg/hr for the next 3 hours, then start a continuous drip at 1 (one) mg/kg/hr
  - Monitor for burst suppression – ideally this is 4 to 8 bursts every minute.
  - Increase dose of pentobarbital sodium up to 3 mg/kg/hr to maintain burst suppression

**Goals of therapy**

- ICP control – try and maintain below 20 mmHg
- Burst suppression – 4-8 bursts per minute
- Barbiturate levels are not important, but if drawn, should be between 3 and 4 mg/dL (levels as high as 9 mg/dL can be seen)

**Expectations and complications**

- Hypotension
  - Initially measure PCWP and fluid load if necessary
  - Dopamine will overcome myocardial suppression
- Pneumonia – secretion stasis
  - Aggressive pulmonary toilet
  - Positioning patient for pulmonary drainage if possible
- Miosis – common (at higher doses can occasionally see mydriasis)
- Skin breakdown – need to move and roll patient if possible

- Hypothermia – keep temp above 36° C/96.8°F
- DVT – maintain optimal prophylaxis

***Discontinue barbiturate coma***

- When ICP is under control for 24-48 hours.
- When all signs of brain activity cease – must confirm brain death with cerebral blood flow study. Neurology consult is highly recommended to establish brain death after barbiturate coma.
- Discontinue the barbiturate. No need to taper.

## **Traumatic Brain Injury (TBI) Guidelines**

- The following chapter is a quick review of the Brain Trauma Foundation's outline on traumatic brain injury guidelines. It is based on the 3rd Edition of the in-hospital care of the patient with traumatic brain injuries.
- This outline will be broken down to Level I, Level II and Level III recommendations based on the strength of evidence in the current scientific literature. Level I being the best, randomized controlled trials with multicenter studies, and Level III being expert consensus on the matter.
- Please refer to the Traumatic Brain Injury Clinical Guidelines Book available in the ICU and in the Trauma Director's Office. This manuscript is also available at [www.braintrauma.org](http://www.braintrauma.org). The following is only intended as a guideline. Attending involvement, and good clinical judgment is crucial for good patient outcomes.

### **BLOOD PRESSURE AND OXYGENATION**

#### **OVERVIEW**

For ethical reasons, a prospective, controlled study concerning the effects of hypotension or hypoxia on outcome from severe traumatic brain injury (TBI) has never been done. Nevertheless, there is a growing body of evidence that secondary insults occur frequently and exert a powerful, adverse influence on outcomes from severe TBI. These effects appear to be more profound than those that result when hypoxic or hypotensive episodes of similar magnitude occur in a trauma patient without neurologic involvement. Therefore, it is important to determine if there is evidence for specific threshold values for oxygenation and blood pressure support.

#### **RECOMMENDATIONS**

- Level I** There is insufficient data to support a Level I recommendation for this topic.
- Level II** Blood pressure should be monitored and hypotension (systolic blood pressure less than 90 mm Hg) should be avoided at all times.
- Level III** Oxygenation should be monitored and hypoxia (PaO<sub>2</sub> less than 60 mm Hg or O<sub>2</sub> saturation less than 90%) should be avoided.

### **HYPEROSMOLAR THERAPY**

#### **OVERVIEW**

Hyperosmolar agents currently in clinical use for traumatic brain injury (TBI) are mannitol and hypertonic saline.

## RECOMMENDATIONS

- Level I** There are insufficient data to support a Level I recommendation for this topic.
- Level II** Mannitol is effective for control of rise intracranial pressure at doses of 0.25 gm/kg to 1 g/kg body weight. Arterial hypotension systolic blood pressure less than 90 mm Hg should be avoided.
- Level III** Restrict Mannitol use prior to ICP monitoring to patients with signs of transtentorial herniation or progressive neurological deterioration not attributable to extracranial causes.

### *Hypertonic Saline*

**Mechanism of action.** The principal effect on ICP is possibly due to the osmotic mobilization of water across the intact blood-brain barrier which reduces cerebral water content. While not applicable as evidence, in animal studies, hypertonic saline was shown to decrease water content, mainly of a nontraumatized brain tissue, due to an osmotic effect after building up a gradient across the intact blood brain barrier. Effects on the microcirculation may also play an important role. Hypertonic saline dehydrates endothelial cells and erythrocytes which increases the diameter of the vessels and deformability of erythrocytes and leads to plasma volume expansion with improved blood flow. Hypertonic saline also reduces leukocyte adhesions in a traumatized brain.

## PROPHYLACTIC HYPOTHERMIA

### OVERVIEW

Although hypothermia is often induced prophylactically on admission and used for ICP elevation in the ICU in many trauma centers, the scientific literature has failed to consistently support its positive influence on mortality and morbidity. There have been multiple meta-analyses of hypothermia in patients with traumatic brain injuries that have been published. At this time all analysts concluded that the evidence was still insufficient to support the routine use of hypothermia. However, the normothermia or euthermia literature coming out recently has advocated a strong adherence to both the euthermia and avoidance of hyperthermia which may cause nonreversible neurological changes. Therefore, there is a strong trend in the literature currently for normothermia or euthermia.

## RECOMMENDATIONS

- Level I** There are insufficient data to support a Level I recommendation for this topic.
- Level II** There are insufficient data to support a Level II recommendation for this topic.

**Level III** Pooled data indicate that prophylactic hypothermia is not significantly associated with decreased mortality when compared with normothermic controls. However, preliminary findings suggest that a greater decrease in mortality risk is observed when target temperatures are maintained for more than 48 hours.

Prophylactic hypothermia is associated with significantly higher Glasgow Outcome Scale (GOS) scores when compared to scores for normothermic controls.

Multiple studies are currently in trial for evidence base support of prophylactic hypothermia.

## **INFECTION PROPHYLAXIS**

### **OVERVIEW**

In severe traumatic brain injury (TBI) patients, the incidence of infection is increased with mechanical ventilation and invasive monitoring techniques. Infections contribute to morbidity, mortality, and increased hospital length of stay. As many as 70% of mechanically ventilated patients can develop pneumonia and ICP monitoring infection rates can be as high as 27%. While there is no current evidence that short-term use of ICP monitors leads to increased morbidity and mortality, health care costs can increase with device reinsertion and administration of antibiotics. Infection prophylaxis for TBI can be divided into several aspects of care, including external ventricular drainage and other ICP monitoring devices, and prophylaxis to prevent nosocomial systemic infections.

### **RECOMMENDATIONS**

**Level I** There are insufficient data to support a Level I recommendation for this topic.

**Level II** Perioperative antibiotics for intubation should be administered to reduce the incidence of pneumonia. However, it does not change length of stay or mortality.

Early tracheostomy should be performed to reduce mechanical ventilation days. However, it does not alter mortality or the rate of nosocomial pneumonia.

**Level III** Routine ventricular catheter exchange or prophylactic antibiotic use for ventricular catheter placement is **not** recommended to reduce infection.

Early extubation in qualified patients can be done without increased risk of pneumonia.

## **DEEP VEIN THROMBOSIS PROPHYLAXIS**

### **OVERVIEW**

Patients with severe traumatic brain injury are at significant risk of developing venous thromboembolic events with their accompanying morbidity and mortality. Review of data from the National Trauma Databank shows the risk of developing deep vein thrombosis in the absence of prophylaxis was estimated to be more than 20% after severe traumatic brain injury.

To this end, there has been some aggressive movement in DVT prophylaxis in the recent literature.

### **RECOMMENDATIONS**

**Level I** There are insufficient data to support a Level I recommendation for this topic.

**Level II** There are insufficient data to support a Level II recommendation for this topic.

**Level III** Graduated compression stockings or intermittent pneumatic compression stockings are recommended, unless lower extremity injuries prevent their use. Use should be continued until patients are ambulatory. If the lower extremities are injured and compression stockings cannot be used it is recommended to put them on the hand or the upper extremities.

Low molecular weight heparin or low dose unfractionated heparin should be used in combination with mechanical prophylaxis. There is insufficient evidence to support recommendations regarding the preferred agent dose, or timing of pharmacologic prophylaxis for deep vein thrombosis.

However, at Ventura County Medical Center it has been decided that if there is a patient with traumatic brain injury, radiographic stable traumatic brain injury, within 72 hours or a craniotomy after 72 hours, or evidence of no clinical lateralizing signs for an intracranial hemorrhage, prophylaxis should be started within 72 hours for those patients with neurosurgical consent. If the neurosurgical team does not support prophylaxis DVT treatment, a note in the chart justifying the **non-use** of DVT prophylaxis in those patients is required. This has been agreed upon by the Division of Trauma and the Department of Neurosurgery.



## **INDICATION FOR INTRACRANIAL PRESSURE MONITORING**

### **OVERVIEW**

It is now clear that only part of the damage to the brain during traumatic brain injury (TBI) occurs at the moment of impact. Numerous secondary insults compound the initial damage in the ensuing hours and days. A large body of published data since the 1970s reports that significant reduction in mortality and morbidity can be achieved in patients with severe traumatic brain injury by using intensive management protocols. These protocols emphasize early intubation, rapid transportation to an appropriate trauma care facility, prompt resuscitation, early CT scanning, and immediate evacuation of intracranial mass lesions, followed by meticulous management in an intensive care unit setting, which includes monitoring for ICP.

### **RECOMMENDATIONS**

- Level I** There are insufficient data to support a Level I recommendation for this topic.
- Level II** Intracranial pressure (ICP) should be monitored in all salvageable patients with a severe traumatic brain injury; Glasgow Coma Scale score between 3 to 8 after resuscitation and an abnormal computed tomography scan. An abnormal CT scan of the head is one that reveals hematomas, contusions, swelling, herniation, or compressed basal cisterns.
- Level III** ICP monitoring is indicated in patients with severe traumatic brain injury with a normal CT scan if two or more of the following features are noted at admission: age over 40 years, unilateral or bilateral motor posturing, or systolic blood pressure less than 90 mm Hg on presentation.

## **INTRACRANIAL PRESSURE THRESHOLDS**

### **OVERVIEW**

Quantitative guidelines are needed for intracranial pressure (ICP) management. The impact of ICP on outcome from severe traumatic brain injury appears to lie in its role in determining cerebral perfusion pressure (CPP), and as an indicator of mass effect. Since CPP can be managed by manipulation of arterial pressure to a great extent, the issue of herniation is more determinant of the ICP threshold. The goal is to balance the risks of herniation against the iatrogenic risks of overtreatment.

### **RECOMMENDATIONS**

- Level I** There are insufficient data to support a Level I recommendation for this topic.

**Level II** Treatment should be initiated with intracranial pressure thresholds above 20 mm Hg.

**Level III** A combination of ICP values, and clinical and brain CT findings, should be used to determine the need for treatment.

## **CEREBRAL PERFUSION THRESHOLD**

### **OVERVIEW**

There is substantial body of evidence that systemic hypotension independently increases the mortality and morbidity from traumatic brain injury, both clinical and histological. Cerebral perfusion pressure (CPP) has been used as index of the input pressure determining cerebral blood flow and therefore perfusion. CPP is defined as the MAP minus the ICP. It has long proven its value as a perfusion parameter in physiological studies. Its clinical use as a monitoring parameter started in the late 1980s in parallel with the concept that induced hypertension may improve outcome. Until this period, it was the practice to avoid systemic hypertension as it was felt to contribute to intracranial hypertension.

### **RECOMMENDATIONS**

**Level I** There are insufficient data to support a Level I recommendation for this topic.

**Level II** Aggressive attempts to maintain cerebral perfusion pressure above 70 mm Hg with fluids and pressors should be avoided because of the risk of adult respiratory distress syndrome (ARDS).

**Level III** CPP of less than 50 mm Hg should be avoided.

The CPP value to target lies within the range of 50-70 mm Hg. Patients with intact pressure autoregulation tolerate higher CPP values.

## **ANESTHETIC ANALGESIC AND SEDATIVES**

### **OVERVIEW**

A variety of pharmacological agents have been advocated to treat pain and agitation in the traumatic brain injury patient. It is felt beneficial to minimize painful or noxious stimuli as well as agitation as they may potentially contribute to elevations in ICP, raises in blood pressure, body temperature elevations and resistance to controlled ventilation. Until recently the primary concern over the utilization of these agents have been related to their tendency to obscure the neurologic exam, with a secondary concern over potential adverse hemodynamic effects.

## RECOMMENDATIONS

**Level I** There are insufficient data to support a Level I recommendation for this topic.

**Level II** Prophylactic administration of barbiturates to induce burst suppression EEG is not recommended.

High-dose barbiturate administration is recommended to control elevated ICP refractory to maximal standard medical and surgical treatment. Hemodynamic stability is essential before and during barbiturate therapy.

Propofol is recommended for the control of ICP, but not for improvement in mortality or six-month outcome. High-dose propofol can produce significant morbidity.

## NUTRITION

### OVERVIEW

There are still few studies specifically addressing the impact of nutrition on traumatic brain injury (TBI) outcome. The effects of TBI on metabolism and nitrogen wasting have been studied most thoroughly. Prior to the 1990s, there were occasional case reports of hypermetabolism in TBI. The general attitude toward nutritional replacement was based on the assumption that, due to the coma, metabolic requirements were reduced. However, over the last 25-30 years, numerous studies have documented hypermetabolism and nitrogen wasting in the TBI patients. Data measuring metabolic expenditure in rested comatose patients with isolated TBI yielded a mean increase of approximately 140% of the expected metabolic expenditure with variations from 120% to 250% of that expected.

## RECOMMENDATIONS

**Level I** There are insufficient data to support a Level I recommendation for this topic.

**Level II** Multiple studies have shown that patients should be fed to attain full caloric replacement by day 7 post-injury.

## ANTISEIZURE PROPHYLAXIS

### OVERVIEW

Post-traumatic seizures are classified as early, occurring with 7 days of injury, or late, occurring after 7 days following injury. It is desirable to prevent both early

and late post-traumatic seizures (PTS). However, it is also desirable to avoid neurobehavioral and other side effects of medications, particularly if they are ineffective in preventing seizures.

The incidence of seizures following penetrating injuries is about 50% in patients followed for 15 years. In civilian traumatic brain injury studies that followed high-risk patients up to 36 months, the incidence of early PTS varied between 4% and 25%, and the incidence of late PTS varied between 9% and 42% in untreated patients. In the acute period, seizures may precipitate adverse events in the injured patient because of elevations of intracranial pressure (ICP), blood pressure, changes, changes in oxygen delivery, and also excess neurotransmitter release. The occurrence of seizures may also be associated with accidental injury, psychological effects, and loss of driving privileges.

## RECOMMENDATIONS

**Level I** There are insufficient data to support a Level I recommendation for this topic.

**Level II** Prophylactic use of Phenytoin or valproate is not recommended for preventing late posttraumatic seizures.

Anticonvulsants are indicated to decrease the incidence of early PTS (within 7 days of injury). However, early PTS is not associated with worse outcomes.

## HYPERVENTILATION

### OVERVIEW

Aggressive hyperventilation of arterial PaCO<sub>2</sub> less than 25 mm Hg has been a cornerstone in the management of severe traumatic brain injury (TBI) for more than 20 years because it can cause a rapid reduction of ICP. Brain swelling and elevated ICP develops in 40% of patients with severe TBI, and high or uncontrolled ICP is one of the most common causes of death and neurologic disability after TBI. Therefore, the assumption has been made that hyperventilation benefits all patients with severe TBI. As recent as 1995, a survey found that hyperventilation was being used by 83% of U.S. trauma centers.

However, hyperventilation reduces ICP by causing cerebral vasoconstriction and a subsequent reduction in cerebral blood flow. Research conducted over the past 20-25 years clearly demonstrates that cerebral blood flow during the first day after injury is less than half that of normal individuals and that there is a risk of causing cerebral ischemia with aggressive hyperventilation.

## RECOMMENDATIONS

**Level I** There are insufficient data to support a Level I recommendation for this topic.

**Level II** Prophylactic hyperventilation (PaCO<sub>2</sub> of 24 mm Hg or less) is not recommended.

**Level III** Hyperventilation is recommended as a temporizing measure for the reduction of elevated intracranial pressure.

Hyperventilation should be avoided during the first 24 hours after injury when cerebral blood flow is often critically reduced.

If hyperventilation is used, jugular venous oxygen saturation or brain tissue oxygenation measurements are recommended to monitor oxygen delivery.

## STEROIDS

### OVERVIEW

There have been multiple studies, meta-analysis and multicenter studies, to conclusively make the recommendation.

### RECOMMENDATION

**Level I** The use of steroids is not recommended for improving outcome or reducing intracranial pressure. In patients with moderate or severe traumatic brain injury, high-dose steroids is associated with increased mortality and it is contraindicated.

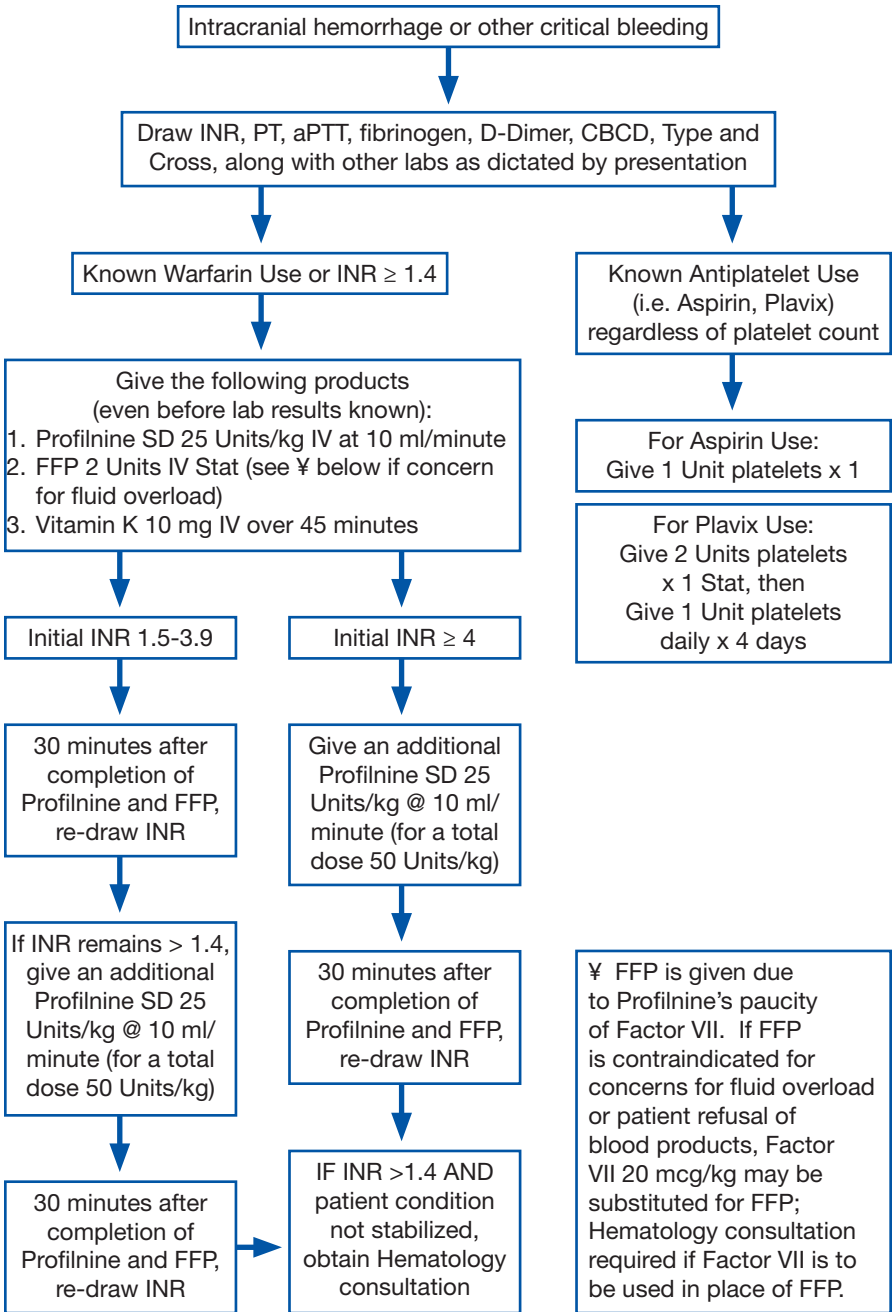
## **Reversal of Warfarin Associated Traumatic Brain Injury, Spontaneous Intracerebral Hemorrhage, and other Critical Bleeding in Adults**

- Known warfarin use or INR  $\geq 1.4$ :
  - Draw INR, PTT, Fibrinogen, CBCD, T&C, along with other labs as dictated by presentation.
  - 25 units/kg Profilnine SD @ 10ml/minute IV
  - 2 Units FFP ASAP IV
  - 10 mg Vitamin K IV over 10-30 minutes
- If INR returns  $> 4$ :
  - 25 units/kg Profilnine SD @ 10ml/minute IV (total dose 50/kg)
- 30 minutes after completion of Profilnine SD and FFP redraw INR:
  - If INR  $\geq 1.4$  give an additional 25 units/kg Profilnine and 2 Units FFP as above
- 30 minutes after completion of Profilnine SD and FFP redraw INR:
  - If INR  $\geq 1.4$  and patient condition not stabilized obtain hematology consult

### • Discussion for P&T:

Vitamin K and FFP are the traditional treatment for warfarin related critical bleeding. Vitamin K's onset of action is about 6 hours and full effect is at about 12-24 hours (1). Limitations of FFP are volume, TRALI, delay to infusion secondary to thaw time and lab screening. 2 units of FFP (500 ml or about 7ml/kg) is unlikely to result in adequate reversal. A median dose of 12.2 ml/kg resulted in only 11% increase in factor 7 and an 8% increase in factor 9 and inadequate correction of INR (2). A median dose of 33.5 ml/kg resulted in a median increase of 38% in factor 7 and 28% increase in factor 9 and adequate correction of INR in most cases (2). 33.5 ml/kg is 2,345 ml or about 9.4 units of FFP. Each plasma unit infused represents a significant volume challenge for the frequently elderly already hemodynamically challenged patient (2).

PCCs (prothrombin complex concentrates) such as Profilnine SD can be given rapidly. Although not yet proven to decrease mortality in this setting they have been associated with more rapid and complete correction of INR, decreased clot expansion in ICH, and improved neurologic outcome (3) (4) (5) (6) (7). PCCs available in the USA are "3-factor" with only a small amount of factor 7. The addition of a small amount of FFP (2 units) corrects this problem (8).



References: CHEST 2012; 141(2)(Suppl):e152S–e184S.

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## **Brain Death Evaluation and Management**

### **INTRODUCTION**

In accordance with state law, patients who have suffered irreversible cessation of entire brain function, despite the presence of spontaneous cardiac activity, are considered dead. Brain death is defined as the irreversible loss of the clinical function of the whole brain, including the brainstem. Declaration of brain death then allows withdrawal of artificial means of respiratory and hemodynamic support in addition to allowing organ harvesting for transplantation. The formal process of declaring brain death is usually not necessary for withdrawal of life support from patients whom either irreversible cessation of conscious functioning (vegetative state) is present or continued support is considered futile or known to be against the wishes of the patient and/or family. (See VCMC's Policy on Withdrawal of Life Support, 100.022 and/or Non Heart Beating Donor, 100.050.)

Declaration of brain death must be verified and documented independently by two licensed physicians, neither of whom have any relationship to the transplantation centers, and who are members of the medical or resident staff of this hospital. At least one of the physicians must hold staff privileges and must be experienced in the process of determining brain death. The time of death should be recorded as the time the second physician documents the brain death.

### **POLICY**

#### ***Declaration of brain death at VCMC requires the following prerequisites:***

1. Known Cause of Coma/Brain Injury:
  - Clinical evidence of an acute CNS catastrophe that is compatible with the clinical diagnosis of brain death.
  - A diagnosis as to the cause of brain injury must be known. Where the cause is not apparent, diagnostic studies should be carried out to establish the nature of the injury before declaration of brain death.
2. The presence of brain death cannot be declared if one of the following conditions exists:
  - Drugs, severe hypothermia or other metabolic derangements, alone or in association with head injury. Any or all may cause severe depression of CNS function leading to an incorrect assessment of the degree of brain injury. Hence, the following should be considered in all cases:
    - Core temperature should be at least 95 degrees Fahrenheit.
    - An intoxicated state must be excluded by a reliable history or negative toxicology studies for CNS depressant drugs.
    - Hypoperfusion, hypoxemia, hypercarbia or recent use of neuromuscular blocking drugs should also be excluded (i.e.: demonstrated absence of neuromuscular blockade).
    - Other complicating medical conditions that can confound clinical assessment (e.g. severe electrolyte, acid-base or endocrine disturbance).
3. In the presence of confounding variables, brain death can still be determined with the aid of ancillary tests. A period of observation of at least 24 hours without clinical neurological change is necessary if the cause of the coma is unknown.

4. Guidelines for the determination of brain death in adults shall be established by the Medicine and Surgery Committees.
5. Guidelines for the determination of brain death in infants and children shall be established by the Pediatric Committee.
6. Guidelines should be reviewed on a regular basis to be sure they comply with the most recent national standards.
7. In patients 1 year of age or less, a pediatric consult must be obtained, and a pediatric neurologist should be involved if available. Detailed neurological examinations should be done at least 24 hours apart by a pediatrician experienced in the neurological examination of the child. A confirmatory test should be performed if deemed appropriate by the pediatric consultant. If an EEG is obtained, it must be coordinated and interpreted by the pediatric neurologist.

### BRAIN DEATH DETERMINATION PROTOCOL

The following protocol will assist the physician in determining brain death. It is necessary to confirm the absence of cranial nerve function, motor response and spontaneous respirations for determination of brain death.

1. Absence of cranial nerve function:
  - Absent pupillary light reflex (pupils fixed at 4-9 mm and unresponsive to light)
  - Absent corneal reflex
  - Absent oculocephalic reflex – doll’s eyes (no ocular movement with head turning)
  - Absent gag reflex (no response to suctioning of pharynx, trachea or bronchi)
  - No swallowing, yawning or blinking
  - No oculovestibular reflex - cold calorics (with irrigation of ears with up to 120 mL of ice water)
2. Coma with complete absence of motor response to central pain stimulation (i.e.: intense pain stimuli delivered above the clavicles, excluding spinal reflexes). NOTE: It is common to witness nonpurposeful movements and spinal reflexes in brain death.
3. Absence of spontaneous respirations. Apnea testing can be performed as follows: (\*\*An attending physician must be present during apnea testing\*\*) (The use of an arterial line is suggested to expedite the drawing of ABG’s.)
  - Core temperature: 95°F or higher (if possible)
  - Systolic BP:  $\geq 90$ mmHg
  - PaCO<sub>2</sub>:  $\geq 40$ mmHg (a normal PaCO<sub>2</sub>)
  - Arterial pH: 7.35-7.45 (if possible)
  - Preoxygenate with 100% FiO<sub>2</sub> for 20 minutes. Obtain ABG.
  - Disconnect ventilator, give O<sub>2</sub> @ 8-10 LPM by tracheal cannula. Do NOT extubate and do not occlude the tracheal cannula. (Remove nasal prongs from cannula and pass through ETT.)
  - Observe continuously for spontaneous respirations.
  - After 10 minutes, draw ABG. (If the patient becomes unstable before 10 minutes, reconnect the ventilator and immediately draw ABG.)
  - Reconnect the ventilator.

- Patient is apneic if PaCO<sub>2</sub> is  $\geq 60$  mmHg or pH  $\leq 7.30$  or PaCO<sub>2</sub>  $\geq 20$  mmHg over baseline, and there is no respiratory movement.
- If hypotension and/or arrhythmia develop, immediately reconnect the ventilator, and consider another confirmatory test.

### CONFIRMATORY TESTS

Brain death is a clinical diagnosis. If severe facial trauma, pre-existing pupillary abnormalities, toxic levels of various drugs are present, inability to tolerate apnea test, or if the patient has a baseline severe chronic retention of CO<sub>2</sub>, other confirmatory testing may be required.

- One should consider a Neurology or Neurosurgery Consult
  - An electroencephalograph may be ordered. No electrocerebral activity present during at least thirty (30) minutes of recording adheres to the minimal technical criteria for EEG recording in suspected brain death. The core body temperature must be above 95°F.
  - A cerebral blood flow study demonstrating no cerebral blood flow
  - A cerebral angiography demonstrating no cerebral blood flow

### DOCUMENTATION

The declaration of brain death must be documented independently in the medical record by two (2) licensed physicians (one of whom must be a staff physician) and should address the following points. Each licensed physician must sign, date and time the notation.

- Time of declaration of brain death
- Cause and irreversibility of the condition
- Absence of brainstem reflexes
- Coma including absence of motor response to pain
- Absence of respiration by PaCO<sub>2</sub> or pH criteria (as per apnea test)

### ORGAN PROCUREMENT

The hospital is required to call OneLegacy before the withdrawal of life support and in a timely manner on all individuals whose death is imminent or who have died. Their staff will determine if the patient may be an appropriate candidate for organ procurement. They will assist in patient management and will approach the family if donation is appropriate. **A physician is NEVER to initiate a conversation about organ procurement with a family member.**

**OneLegacy: 1-800-338-6112**

### REFERENCES

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## Managing the Potential Organ Donor

### FIRST STEP

Determine Brain Death (See Brain Death Evaluation Guideline)

### SECOND STEP

#### **Check Labs, Resuscitate & Optimize Labs**

- Labs: ABG, Serum Lactate, CBC, PT, PTT, & Lytes Q 4 hours
- Resuscitate & Optimize Labs (continue throughout process)
- Bolus 1 Liter warm NS
- Transfuse to maintain Hct >30
- Control active bleeding
- Place central line
- Maintain MAP >70, CVP >7 and PAOP > 12 mmHg with fluid
- Protect from Hypothermia
- Protect from hypoxia
- Maintain serum potassium >4

### THIRD STEP

#### **Determine if Map >70**

- MAP >70
  - Continue to fluid resuscitate (warm NS or LR) & correct lab abnormalities as needed
  - Goals of resuscitation include:
    - Normalization of base deficit, lactate, CVP and/or PAOP 8-15 with minimal use of pressors (dopamine <5)
    - Rule of 100's: SBP >100mm Hg, U/O >100ml/hr, PaO<sub>2</sub> >100
- MAP <70
  - Continue to fluid resuscitate with NS & 5% albumin until MAP >70 with dopamine <5 mcg/kg/min
  - Double dose of dopamine Q 5 minutes to maintain MAP >70 to max of 20 mcg/kg/min
  - If MAP <70 and Dopamine is at 20 mg/kg/min then start epinephrine drip.
    - Double epinephrine drip Q 5 minutes to maintain MAP >70
  - Are CVP and/or PAOP >17?
    - No: Continue to bolus with NS/Albumin
    - Yes: Does patient have symptoms and labs suggestive of diabetes insipidus?
      - ◊ No: Consider Norepinephrine if CI 4
      - ◊ YES: See DI below (hypotensive)
  - Is patient requiring a combined vasopressor need > 15 mcg to maintain SBP >100 after pretreatment of obtained CVP > 7 and PAOP > 12 mmHg?
    - No: Continue with Third Step
    - Yes: Proceed to T4 Treatment while continuing with above

## T4 PROTOCOL

- Administer IV boluses of the following in a rapid succession:
  - 1 amp D50% Dextrose
  - 2 Gm Solumedrol
  - 20 Units Regular Insulin
  - 20 mcg Thyroxin (T4)
- Start drip of 200 mcg T4 in 500 ml NS (0.4mcg/mL)
  - T4 drip rate
    - 25 mL/hour (10 mcg/hr) for patients > 100 pounds
    - 19 mL/hour (7 mcg/hr) for patients 75-100 pounds
    - 13 mL/hour (5 mcg/hr) for patients < 75 pounds
  - Reduce other pressors as much as possible and then adjust T4 as necessary to maintain SBP>100 mmHg
- After 30-60 minutes the donor will usually become tachycardiac, hypertensive and febrile
- Monitor serum potassium carefully (Usually decrease and require aggressive replacement)

## POTENTIAL PROBLEMS

- Avoid hypernatremia (See DI): If serum Na >145 then change from NS to LR. Do not use more than 3L albumin per day.
- DIC: If patient has clinical signs of DIC, transfuse immediately with 4-6 Units of FFP.
- Diabetes Insipidus (DI):
  - If normotensive, serum NA >148 and UOP >600 mL/hr, give 1-2 mg DDAVP IV (Q 2-8 hours PRN) and replace 1 mL of 1/2 NS for every 1 mL of urine output over 200 mL per hour.
  - If hypotensive, start vasopressin at 1-8 units/hour and replace 1 mL of NS for every 1 mL of urine output over 200 mL per hour.
- Tachycardia & Hypertension: Commonly occurs prior to complete herniation. Once herniation occurs, BP will drop precipitously. If treatment is given, be sure it has a very short half-life
- Neurogenic pulmonary edema: Increase ventilator support and FiO<sub>2</sub> as needed
- Hypokalemia: manage aggressively
- Hyperglycemia: manage with insulin drip
- Hypothyroid: T4 Donor Protocol (see above)

## Rehabilitation

Traumatic Brain Injury is a nondegenerative, noncongenital insult to the brain from an external mechanical force, possibly leading to permanent or temporary impairment of cognitive, physical, and psychosocial functions, with an associated diminished or altered state of consciousness.

### PREDICTORS OF OUTCOME AFTER TBI

#### **Indicators of Severity in TBI**

- The best GCS score in first 24 hours of injury
- Mayo TBI Severity Classification System
- Length of coma
- Duration of posttraumatic amnesia (PTA)

#### **Posttraumatic Amnesia (PTA)**

- Defined as the period of time during which new information is not incorporated into long-term memory. Duration length is assessed using the standard Galveston Orientation and Amnesia Test (GOAT).
- PTA is one of the most commonly used and most powerful predictors of severe disability. PTA <2 months is unlikely to have a severe disability; >3 months is unlikely to have a good recovery; >2 months is unlikely to return to work.

#### **Rancho Los Amigos Levels of Cognitive Functioning Scale**

Coma levels are commonly assessed by two different scales: the Glasgow Coma Scale and the Ranchos Los Amigos Scale. The Glasgow Coma Scale is a standardized system used to assess the degree of brain impairment and to identify the seriousness of injury in relation to outcome. The Ranchos Los Amigos Scale rates cognitive functioning and expected behaviors through an assessment of levels one through 10. It is used to facilitate communication among team members.

Following is a breakdown of how the scores are assigned on each level of the Ranchos Los Amigos Scale:

- Level I:** No response to pain, touch, sound or sight.
- Level II:** Generalized response regardless of type of location of stimuli.
- Level III:** Localized response. Blinks to strong light, turns toward or away from sound, responds to physical discomfort, inconsistent response to commands.
- Level IV:** Confused/agitated. Alert, very active, aggressive or bizarre behaviors, non-purposeful motor movement, short attention span, inappropriate verbalization.
- Level V:** Confused/inappropriate/non-agitated. Gross attention to environment, distractible, requires continual redirection, agitated by too much stimuli, inappropriate social interactions.

- Level VI:** Confused/appropriate. Inconsistent orientation, recent memory attention impaired, follows simple directions, goal-directed with assistance, begins to recall past. Emerging awareness of self.
- Level VII:** Automatic/appropriate. Performs daily routine in robot-like manner, skills deteriorate in unfamiliar environment, unrealistic planning. Superficial awareness.
- Level VIII:** Purposeful/appropriate. Stand-by assist. Uses memory device with intermittent assist, over or under estimates abilities, irritable, self-centered, acknowledges other's feelings with minimal assist, low frustration tolerance, carries out familiar tasks with intermittent assist.
- Level IX:** Purposeful/appropriate. Stand-by assist on request. Completes familiar tasks independently, independently shifts between tasks, self-monitors and anticipates problems with stand-by assist, uses assistive memory devices to recall schedule.
- Level X:** Purposeful/appropriate. Modified independence. Handles multiple tasks simultaneously, independently initiates and carries out unfamiliar routines, anticipates impact of impairments, independently thinks about consequences of decisions, social interaction is consistently appropriate.

### ***Posttraumatic Agitation***

- Described as a subtype of delirium specific to TBI patients occurring in up to 50% of patients in acute setting.
- Medical etiologies should be suspected and evaluated first. These include infection, metabolic abnormalities, hypoxemia, pain, seizures, hydrocephalus, cerebral edema, and hematoma formation.
- First-line intervention includes environmental management with alterations in staff and family behavior. Floor beds can eliminate the need for restraints. Use physical restraints if patient is a danger to self or others. Please see VCMC's Restraint & Seclusion Policy, 100.075, for further details.
- Medication treatment in post-traumatic agitation is controversial without well-controlled research studies. TBI experts prefer carbamazepine (most commonly used), trazodone, and amantadine. Other choices include tricyclic antidepressants, SSRIs, valproic acid, and buspirone. TBI experts avoid haloperidol, benzodiazepines (both shown to decrease recovery in animal studies), and propranolol.
- Referral for Psychiatry consultation as well as Physical Therapy, Occupational Therapy, and Speech Therapy should be placed as soon as possible. Speech Therapy assesses swallowing in TBI, as well as initiating cognitive rehabilitation and GOAT testing.
- All patients that have a TBI should be given a post-TBI handout (or given directly to friends/family) upon discharge.

## CHAPTER 5

# NECK AND SPINAL COLUMN

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### **IN THIS SECTION**

*Cervical Spine Evaluation and Clearance*

*Thoracic and Lumbar Spine Evaluation*

*Blunt Cervical/Vascular Injuries*

*Traumatic Spine Injury*

*Penetrating Neck Injury*

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## **CERVICAL SPINE EVALUATION: CLINICAL CLEARANCE**

The cervical spine may be cleared either clinically or using radiologic adjuncts. Until the cervical spine is cleared, all trauma patients should be treated with spinal precautions, as if their spines are unstable.

### **DEFINITIONS:**

- C-Spine: Includes C 1 to the upper border of T1.
- Clearance of C-Spine: A clinical decision suggesting the absence of acute bony, ligamentous and neurologic abnormalities of the cervical spine based on history, physical exam and/or negative radiologic studies.
- Clinical clearance. Determination that there is no cervical spine injury after structured clinical evaluation.

### **GUIDELINES:**

- Patients should be considered to have a cervical spine injury (until cleared) if they present with any of the following conditions:
  - History of blow to the head or neck.
  - Pain in the cervical spine or paraspinal muscles.
  - Pain to palpation of the cervical spine.
  - Traumatic brain injury and/or skull fracture.
  - Facial injuries such as fractures, tooth loss or severe lacerations.
  - Neurologic deficits in torso, legs or arms not explained by peripheral nerve injuries.
- Clinical Cervical Spine Clearance
  - The literature has demonstrated that a majority of trauma patients can have spinal injury cleared by clinical evaluation. Such patients do not require radiologic studies.
  - Clinical clearance should not be performed if the patient has an abnormal mental status, to the extent that clinical evaluation is unreliable. Similarly, if a patient has other injuries causing severe pain (“distracting injuries”), clinical clearance may not be reliable.
  - Clearance can only be performed by an Emergency Physician, ICU physician, Neurosurgeon, Orthopedic Surgeon, Trauma Surgeon or Resident who is ATLS certified.
  - During Cervical Spine Evaluation:
    - Logroll patient with full C-spine immobilization to determine areas of tenderness in the cervical, thoracic and lumbosacral spine. If tenderness is present, assume the spine to be unstable.
    - Examine for areas of increased kyphosis or spinous process step off.
    - Perform neurologic exam to determine any deficits suggestive of neurologic injury.
    - Examine rectal tone (involuntary and voluntary).

- Of note, less than 1/3 of patients with cervical spine fractures will not have any associated neurological deficits

If a cervical spine injury is suspected after clinical evaluation, spinal precautions should be maintained until radiologic evaluation has been completed.

## C-SPINE CLEARANCE IN THE EVALUABLE PATIENT

- All blunt trauma patients should be considered as having a cervical spine injury until proven otherwise.
  - Hard cervical collar must be placed
  - C-spine precautions (log roll, elevating HOB via reverse Trendelenburg only) must be maintained
- Definition of evaluable patient (must fulfill all three criteria):
  - Glasgow Coma Scale of 15
  - Not intoxicated
  - No injury that would prevent the patient's full concentration on the exam (distracting injury)
- Be sure to clear the TL-Spine utilizing the TL-Spine Guidelines

**FIRST STEP** – Determine if patient has neurological deficits and/or Significant C-spine bone tenderness (not soft tissue), full range of cervical motion without pain (clinical clearance)

- Evaluable patient without cervical spine (bone) tenderness/pain and no neurological deficit.
  - No cervical spinal radiographs are required
  - The C-spine may be cleared clinically by either the attending physician or experienced resident. The physician makes the determination, removes the cervical collar and documents the patient's C-spine "clinical clearance" in the medical record including the date and time.
- Evaluable patient with significant cervical spine (bone) tenderness/pain, but no neurological deficit.
  - CT scan of C1-T1 with 3 mm helical cuts and sagittal reconstruction
  - Urgent neurosurgical consult if CT demonstrates abnormality. Also, obtain a TLS-Spine CT as described in the TL-Spine Guidelines.
  - If all studies are negative and the patient's pain resolves, one may clinically clear. If all studies are negative and the patient continues to complain of pain, obtain lateral upright c-spine film while patient is in hard collar versus MRI.
    - If subluxation is noted: consult neurosurgery.
    - If no subluxation: maintain patient in soft cervical collar, and provide with follow-up in 2 weeks
    - Consider neurosurgery consult if pain is severe
  - If patient continues to have pain after 2 weeks then obtain a non-emergent MRI.
    - Non-Emergent Neurosurgical consult if any abnormality is found
    - Remove collar if MRI is normal

- Evaluable patient with neurological deficit referable to spine injury.
  - Emergent CT (also obtain TL Spine CT)
  - Emergent MRI
  - Emergent Neurosurgical consult

### **C-SPINE CLEARANCE IN THE NON-EVALUABLE PATIENT**

- All blunt trauma patients should be considered as having a cervical spine injury until proven otherwise.
  - Hard cervical collar must be placed
  - C-spine precautions (log roll, elevating HOB via reverse Trendelenburg only) must be maintained
- Definition of non-evaluable patient (any of the following):
  - Glasgow Coma Scale <15
  - Intoxication
  - Injury that would prevent the patient's full concentration on the exam (distracting injury)

***Perform a neurologic examination and document whether patient has movement of all four extremities or not, whether there are focal neurologic findings, and what the rectal tone is.***

The following study should be obtained emergently: Axial CT scan of C1-T1 with 3 mm helical cuts and sagittal reconstruction

Any abnormality should result in an Urgent neurosurgical consult.

***Patients with normal CT scan and no focal neurological defects, who are moving all four extremities:***

- Patient is radiologically cleared. Cervical collar may be removed after documentation of radiologic clearance in the medical record.

***Patients with normal radiographic studies, but with focal neurological deficits consistent with cord injury (spinal cord injury without radiologic abnormality - SCIWORA):***

- Emergent Neurosurgical Consult
- Emergent MRI

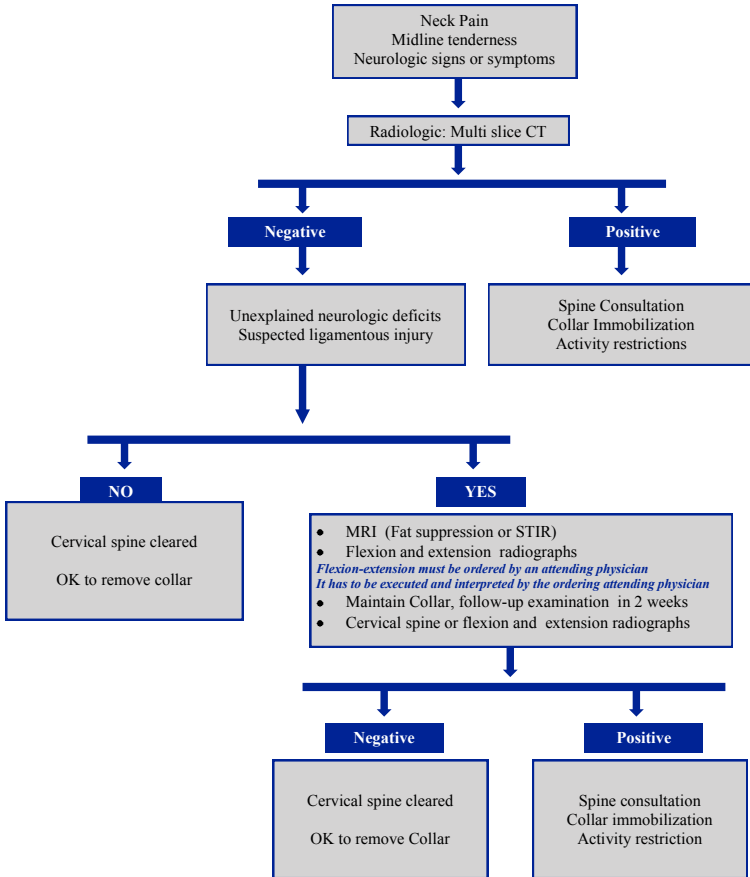
***Patient with normal radiographic studies, but not moving their extremities:***

- MRI
- If MRI is normal, a physician may remove the cervical collar after documentation of the patient's C-spine "radiographic clearance" in the medical record. If a radiologic abnormality is found, an urgent Neurosurgical consult is obtained.

C-SPINE CLEARANCE ALGOS

C-SPINE CLEARANCE

Symptomatic



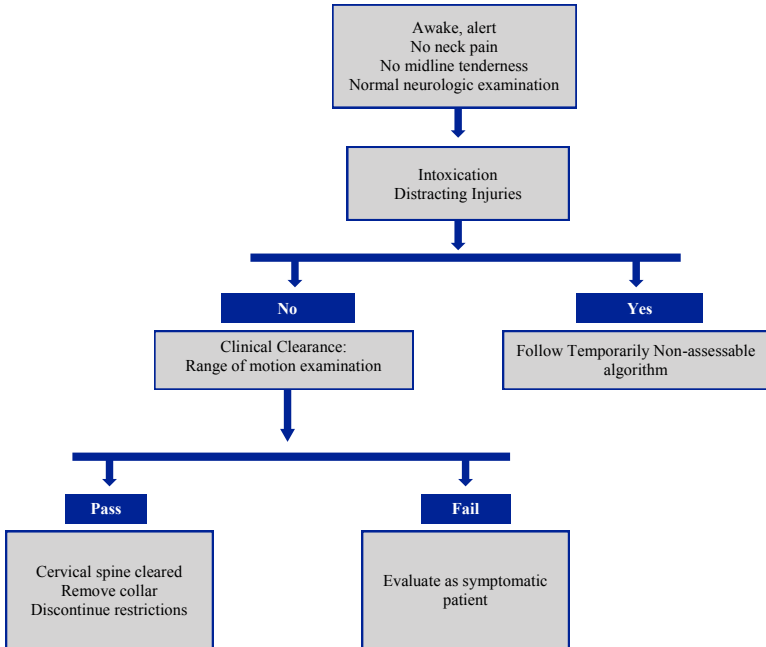
All collars should be changed to ASPEN collar either before the patient leaves E.R. or before admission to the floor

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## C-SPINE CLEARANCE

### Asymptomatic



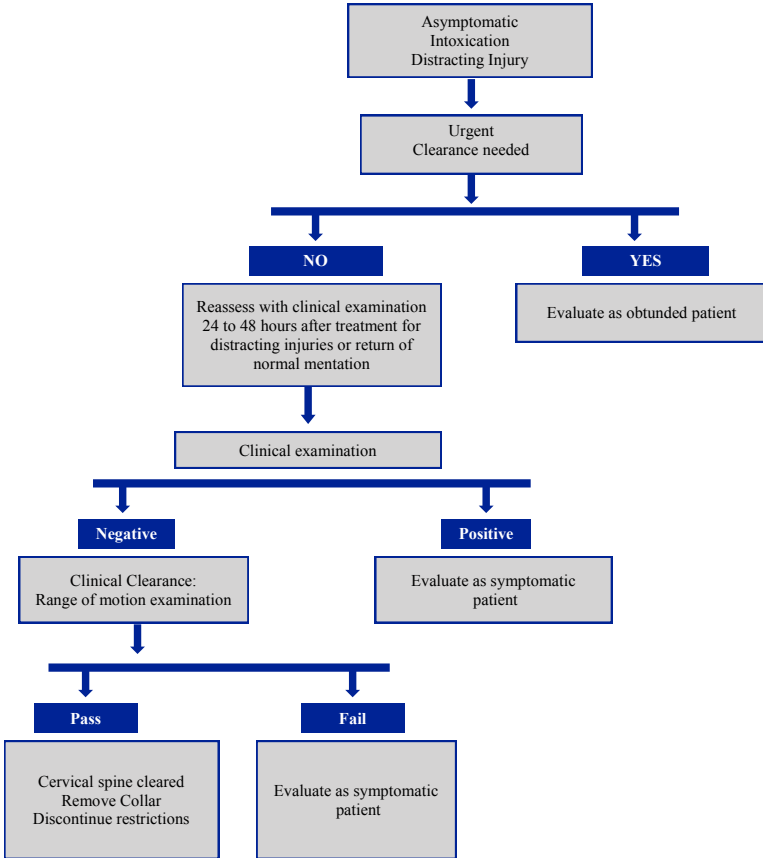
*All collars should be changed to ASPEN collar either before the patient leaves E.R. or before admission to the floor*

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# C-SPINE CLEARANCE

## Temporarily Non-assessable



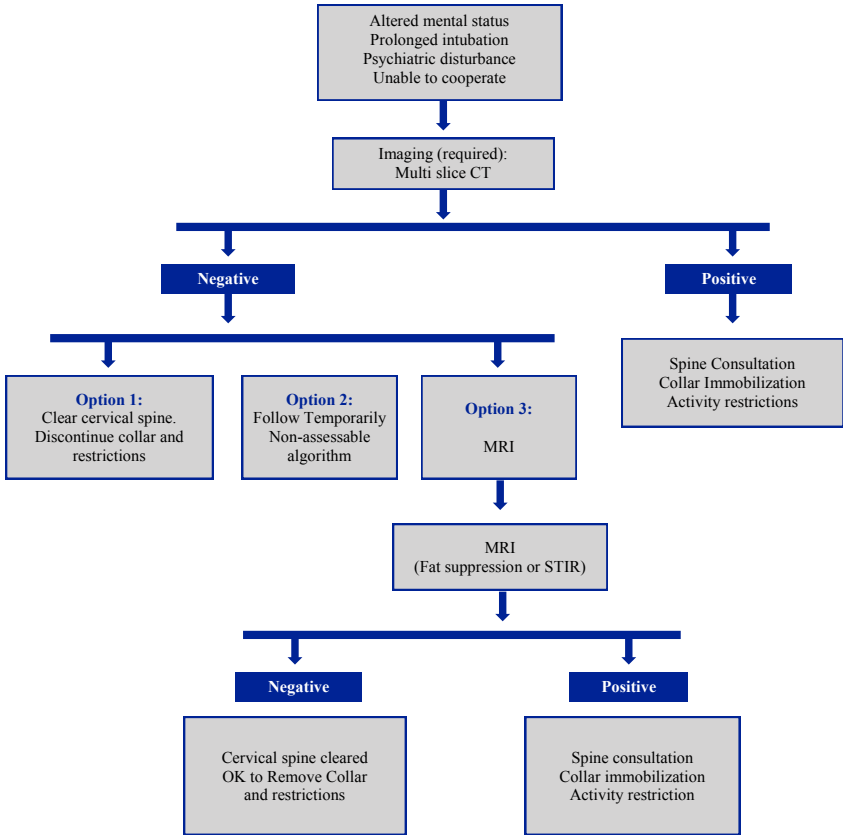
*All collars should be changed to ASPEN collar either before the patient leaves E.R. or before admission to the floor*

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# C-SPINE CLEARANCE

## Obtunded

Flexion-extension contraindicated for obtunded patients



All collars should be changed to ASPEN collar either before the patient leaves E.R. or admitted to the floor

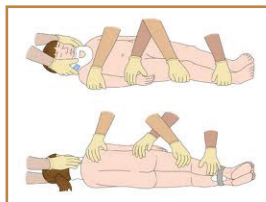
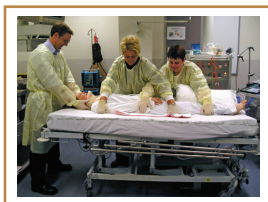
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## Thoracic and Lumbar Spine Evaluation

### GUIDELINES:

- Secondary survey:
  - Logroll patient with full C-spine & TL spine immobilization (requires 1 person at head, two on one side and another to examine – 4 people in total) to determine areas of tenderness in the cervical, thoracic and lumbosacral spine. If tenderness is present, assume the spine to be unstable.



- The person maintaining c-spine stabilization should be in charge of initiating timing of logroll.
- Examine for areas of increased kyphosis or spinous process step-off.
- Perform neurologic exam to determine any deficits suggestive of neurologic injury.
- Examine rectal tone (involuntary and voluntary).
- Obtain AP and lateral thoracic X-rays (or CT scan) for patients with pain in thoracic vertebrae.
- Obtain AP and lateral lumbosacral X-rays (or CT scan) for patients with pain in the lumbosacral vertebrae. Keep high index of suspicion for possible lumbar fracture in patients with abdominal wall “seatbelt sign.”
- If neurologic injury is found without bony injury, obtain an MRI scan of the involved spine.
- Consult neurosurgery service if bony injury or neurologic deficit is found.
  - Types of consults:
    - Emergent: requiring Neurosurgical evaluation, plan and note within 30 minutes
    - Urgent: requiring Neurosurgical evaluation, plan and note within 2 hours
    - Non-Urgent Consult: requiring Neurosurgical evaluation, plan and note within 20 hours.
- A patient’s thoracic & lumbar spine may be clinically cleared if:
  - GCS 15
  - Not intoxicated
  - No distracting injury
  - Clinically cleared:
    - No spine step-off or deformity noted on exam
    - No “boney” spine tenderness
    - No neurologic deficits.
- Maintain spinal precautions until cleared either clinically, radiographically or by neurosurgery if consult obtained.



- If a fracture is noted in one area of the spine, complete spine radiographs should be obtained to assess for additional fractures.
- Patient positioning: maintain spinal precautions until spine is cleared. Prior to clearance, elevate the head of bed via reverse Trendelenburg (no flexion or bending).

### **TL-SPINE CLEARANCE IN THE EVALUABLE PATIENT**

- All blunt trauma patients should be considered as having a spine injury until proven otherwise.
  - Spine precautions (logroll, elevating HOB except via reverse Trendelenburg only) must be maintained
- Patients considered to have high energy mechanism of injury (MOI) include:
  - Fall from >10 feet
  - Motor Vehicle Collision (MVC) or All Terrain Vehicle (ATV) collision
  - Auto vs. pedestrian (AVP)
  - Crush injury
  - Concomitant cervical, thoracic or lumbar spine fracture
- Definition of evaluable patient (must fulfill all criteria):
  - Glasgow Coma Scale (GCS) of 15
  - Not intoxicated
  - No injury that would prevent the patient's full concentration on the exam (distracting injury)
  - Reliable clinical exam
- Be sure to clear the Cervical Spine utilizing C-Spine Clearance Guidelines

**FIRST STEPS** – Determine if patient has neurological deficits, if they have a high energy mechanism of injury (MOI) and if they have bone spine tenderness

#### ***Evaluable patient, without spine tenderness/pain, no neurologic deficits and do not have high energy MOI.***

- No spinal radiographs are required
- The spine may be cleared clinically by the attending physician with subsequent documentation of the patient's TL-Spine "clinical clearance" in the medical record with removal of TL-Spine precautions.

#### ***Evaluable patient with significant cervical spine (bone) tenderness/pain or have high energy MOI, but no neurological deficit.***

- If patient has a CT scan for other reasons, obtain reformatted axial collimation of TL-Spine (can be extracted from data of CT abdomen/pelvis, but order needs to be written for CT Thoracic and/or Lumbosacral Spine).
  - Urgent neurosurgical consult if CT demonstrates abnormality (be sure to CT C-spine)
  - If CT is negative and the patient's pain resolves, one may clinically clear the spine as described above.

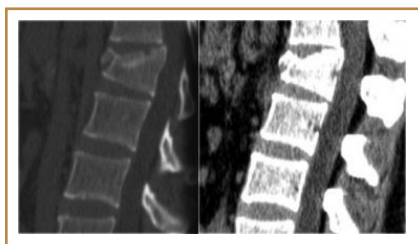
- If CT is not required for other reason, obtain Thoracic and/or Lumbosacral Spine series.
  - If spine series demonstrates abnormality: order CT of Cervical and TL-Spine, and obtain urgent neurosurgical consult.
  - If Spine series is negative and the patient's pain resolves, one may clinically clear the spine as described above.
  - If Spine series is negative and significant pain continues, continue Spine precautions and order a non-emergent CT of Thoracic and/or Lumbosacral Spine and proceed as described above.

### **Evaluable patient with neurological deficit referable to spine injury.**

- Emergent CT with reformatted axial collimation of Cervical and TL-Spine
- Emergent MRI
- Emergent Neurosurgical consult

### **TL-SPINE CLEARANCE IN THE NON-EVALUABLE PATIENT**

- All blunt trauma patients should be considered as having a spine injury until proven otherwise.
  - Spine precautions (log roll, elevating HOB via reverse Trendelenburg only) must be maintained for patients who cannot be clinically evaluated, whose mechanism of injury puts them at risk of spine injury, obtain CT scan of TLS spine.
- Patients with normal radiographic studies and no focal neurological deficits:
  - The physician may remove the patient's "TL-Spine Precautions" and documents "radiographic clearance of the TL-Spine" in the medical record.
- Patients with normal radiographic studies but focal neurological deficits referable to spine injury:
  - Emergent MRI
  - Emergent Neurosurgical Consult
- Patients with abnormal radiographic studies and no focal neurological deficits:
  - Urgent Neurosurgical consult
- Patients with abnormal radiographic studies and focal neurological deficits:
  - Emergent MRI
  - Emergent Neurosurgical Consult



*L1 Fracture*



*L1 Fracture*

## Blunt Cervical/Vascular (Carotid/Vertebral) Injuries

### OBJECTIVES

- To provide guidelines for the screening, diagnosis and management of blunt cervical vascular injuries (BCVI).

### DEFINITIONS:

- Types of injuries:
  - Dissection: Injury with propagation
  - Mural Thrombus/Occlusion: further injury extending into media and leading to thrombus formation
  - Pseudoaneurysm: Partial disruption of the adventitia
  - Transection: Complete disruption of the adventitia
  - Arteriovenous Fistula: An abnormal connection between an artery and vein.
- Incidence: ~ 1% of all blunt trauma admissions
- Risk factors for injury:
  - Mechanism of injury with drastic extension, flexion, or lateral rotation of head, especially during high speed crashes or falls from height.
  - Signs/Symptoms
    - > Arterial Hemorrhage
    - > Cervical hematoma
    - > Lateralizing neurologic deficit (not explained by head CT)
    - > Infarct on head CT
    - > GCS  $\leq 6$  without significant CT findings
    - > Amaurosis fugax/Horner's Syndrome
    - > Cervical bruit or thrill <50 years of age
    - > May be asymptomatic until neurologic disaster
  - Common associations
    - > Cervical Spine Fracture\*\*
    - > Basilar skull fracture\*
    - > LeForte II or III facial fracture\*
    - > Seatbelt sign above clavicle with significant swelling
    - > Near hanging



### GUIDELINES:

- Evaluation
  - Patients who have risk factors as noted above should have a CT angiogram of the Carotid and Vertebral arteries. Should have low threshold to perform this test in at risk patients. Duplex ultrasound may be useful for evaluating carotid injuries, but misses vertebral injuries.
  - Patient with equivocal results should proceed to have a four vessel cerebral angiogram
  - Management

- No prospective randomized controlled trials
- Many of these injuries are in surgically inaccessible locations
  - ◊ High Carotid (near base of skull)
  - ◊ Vertebral artery within foramen Transversarium
- Treatment modalities
  - Surgery, Anticoagulation, Antiplatelet therapy, Stent, Embolization
- Suggested Treatment Modalities
  - Management (carotid artery injury)
    - Transection – open repair versus ligation. **Warning:** Consider ligation in patients with delayed presentation or with ischemic stroke, as reperfusion may worsen neurologic condition
    - Pseudoaneurysm
      - ◊ #1 Open repair
      - ◊ #2 Anticoagulation
      - ◊ #3 Stent
    - Dissection/Occlusion
      - ◊ #1 Anticoagulation
      - ◊ #2 Open repair versus stent
      - ◊ **Warning:** Consider not re-canalizing occluded vessels with delayed presentation or ischemic stroke, as reperfusion may worsen neurologic condition
  - Management (vertebral artery injury)
    - Transection
      - ◊ Open ligation or embolization
    - Pseudoaneurysm
      - ◊ No ischemia: Open ligation or embolectomy
      - ◊ Ischemia: Stent + anticoagulation
      - ◊ **Warning:** Consider ligation if delayed presentation or ischemic stroke
    - Dissection/Occlusion Symptoms
      - ◊ Stroke – thrombolysis/embolectomy + stent + anticoagulation
      - ◊ Ischemia (no stroke) Anticoagulation
    - Dissection/Occlusion
      - ◊ Anticoagulants/Antiplatelet agents
  - Anticoagulation
    - Dosage:
      - ◊ Heparin titrated to therapeutic PTT
      - ◊ Warfarin titrated to therapeutic INR
    - Duration: (No Data), but often for at least 6 months.
    - Follow-up:
      - ◊ For intimal injuries, repeat imaging in 7 days to see if healed-consider shorter course of anticoagulation
      - ◊ Otherwise repeat 6 months to demonstrate re-canalization before stopping anticoagulation
    - Bleeding complications: as high as 40%
      - ◊ Intracranial, retroperitoneal, GI
    - Major cerebral infarction: risk hemorrhagic transformation
    - If there is prohibitive risk of anticoagulation, consider aspirin therapy as lower risk alternative

## Traumatic Spine Injury

### DEFINITIONS:

- Stable spine injury: Those injuries not associated with a neurologic deficit and not at risk for development of neurologic deficit and not prone to late collapse (e.g., transverse process fractures, spinous process fractures, minimal compression fracture).
- Unstable spine injury: Any fracture pattern associated with a neurologic deficit and those that are prone to develop a neurologic deficit or those prone to late collapse (e.g., fracture subluxation and dislocation, severe burst fractures).
- Traumatic quadriplegia: Any complete spinal cord injury associated with a spinal cord or nerve root deficit not involving the cranial nerves above and including C8, T1 roots.
- Traumatic paraplegia: Any complete spinal cord injury associated with a spinal cord or nerve root deficit below and including T2.
- Complete: Any spinal cord injury associated with a complete motor and sensory deficit below the level of injury.
- Incomplete: Any sensory or motor sparing below the level of injury including perianal sensation.
- Neurogenic shock – hypotension and bradycardia associated with high cervical spine injuries (typically above C6) resulting from sympathetic outflow denervation and resultant unopposed parasympathetic outflow.
- Spinal shock – thought to be the spinal equivalent to concussive injury of the brain. Findings include loss of distal segmental reflexes and bulbocavernosus reflex. The majority of these patients resolve with 5-10days, but some may take several months.

### GUIDELINES:

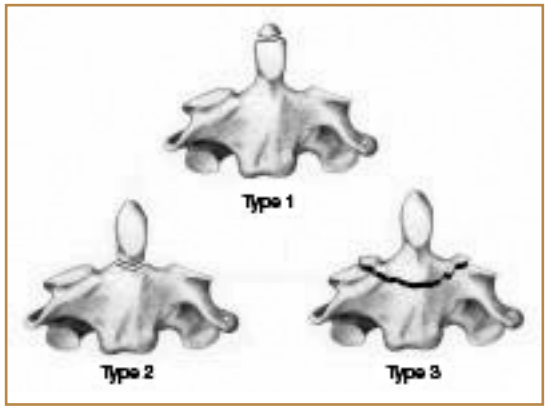
- Follow the ABCs.
- Maintain spine precautions.
  - Rigid collar
  - Log roll only
- Perform a complete neurologic exam looking for neurologic deficit and the level of deficit.
- Obtain X-rays according to the C-spine, thoracic, and lumbosacral injury protocols.
- If quadriplegia or paraplegia are noted, perform a bulbocavernosus reflex test:
  - Male: pull on penis while examining for an increase in rectal tone.
  - Female: pull on Foley catheter while examining for an increase in rectal tone.
  - If this reflex is present, spinal shock is not occurring and injury will usually not improve.
  - If this reflex is absent, spinal shock may be occurring and ultimate outcome of injury is masked.
  - Document presence or absence of bulbocavernosus reflex.

- Consult the neurosurgery service immediately.
- Neurogenic shock may occur with injuries down to T4-6.
  - Place Foley and monitor urine output.
  - Follow frequent blood pressures.
  - If patient has SBP <90 mmHg or MAP <65 mmHg and urine output <50 ml/hr and hemorrhagic shock has been ruled out (by CXR, DPL, Fast Scan or CT scan of the abdomen), follow the steps outlined below until improvement occurs:
    - Administer 2000 ml IV fluid.
    - Insert central line and monitor OVP.
    - Insert art line.
    - Start dopamine at 5 mcg/kg/min; continue fluid resuscitation as necessary.
    - If no response, increase dopamine to 10 mcg/kg/min.
    - If still no response, insert pulmonary artery catheter to assess filling pressures and cardiac index.
    - Consider phenylephrine starting at 30 mcg/min if filling pressures and cardiac index are satisfactory.
- For quadriplegics with potential pulmonary problems:
  - Nearly all patients with a C-5 or higher neurologic deficit will require intubation (C3, 4, 5 keep the diaphragm alive!)
  - Assess vital capacity: if less than 1000 ml (or 10 ml/kg), consider intubation.
  - Assess ability to clear secretions: consider intubation if secretions cannot be cleared spontaneously or with quad cough maneuver.
  - Closely monitor in ICU or step down unit for the first 24 hours, with good pulmonary toilet, and be ready to intubate at a moment's notice.
  - If there is a question about retention of secretions or development of atelectasis in the first 24 hours, intubate – it will only get worse!
- Provide DVT prophylaxis (see DVT Prophylaxis Protocol)
- Beware of ileus in patients with spinal fractures. Consider early use of NG tube.
- Begin steroid protocol after if complete or incomplete neuro deficit is found within 8 hours of injury. **Only applicable to blunt trauma patients; not indicated in penetrating trauma patients.**
- If fracture is noted in one area of spine, complete C/T/LS spine radiographs should be obtained to assess additional fractures.
- Request full rehab services consult on the second hospital day.

**INJURY DESCRIPTIONS**

**TABLE: MCAFFEE CLASSIFICATION OF VERTEBRAL FRACTURES**

Injury Type	Pathology
Wedge-compression fracture	Isolated anterior column failure
Stable burst fracture	Anterior – and middle-column compression failure, posterior column intact
Unstable burst fracture	Compressive failure of anterior and middle columns, disruption of posterior column
Chance fracture	Horizontal vertebral avulsion injury with center of rotation anterior to vertebral body
Flexion-distraction injury	Compressive failure of anterior column, tensile failure of posterior column. The center of rotation is posterior to anterior longitudinal ligament
Translational injuries	Disruption of spinal canal alignment in transverse plane, shear mechanism common

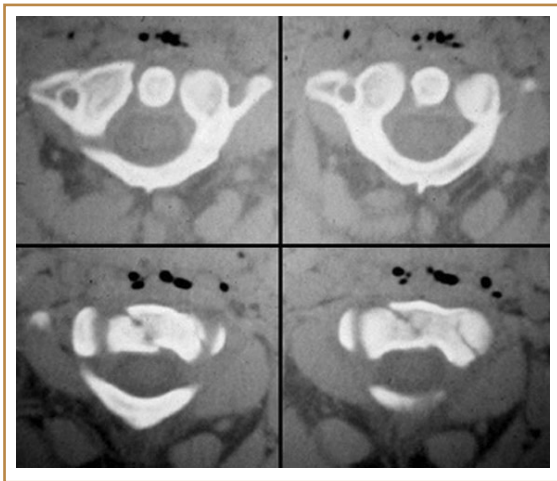


*Odontoid Fracture*

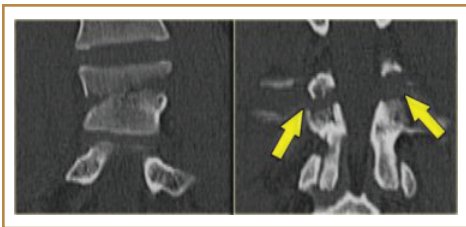
**Cervical Fracture Classification**

- Atlanto-occipital dislocation and fracture
  - Occipital condyle fractures
  - Fracture dislocation
- Atlas C1 ring fractures (Jefferson fractures, any combination of fractures through ring)
- Combination C1-C2 fractures (atlantoaxial rotatory subluxation with/without other fracture)

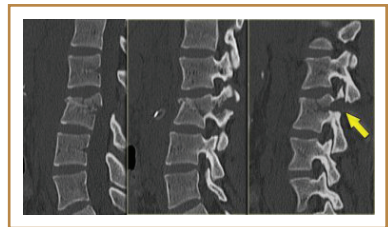
- Hyperextension fracture-dislocations of subatlantal spine Posterior fracture-dislocation of the dens (i.e., odontoid fractures I, II, III)
  - Traumatic spondylolisthesis of the axis (Hangman's fracture and variants)
  - Hyperextension sprain (momentary) dislocation with fracture
  - Hyperextension fracture-dislocation with fractured articular pillar
  - Hyperextension fracture-dislocation with comminution of the vertebral arch
- Hyperflexion fracture-dislocations of subatlantal spine
  - Anterior fracture-dislocation of the dens (i.e. odontoid fractures I, II, III)
  - Hyperflexion sprain (rare). Posterior ligaments disrupted, but facets not locked.
  - Unilateral or bilateral locked articular facets with or without fracture
  - "Teardrop" fracture-dislocation



*Jefferson Fracture*



*Chance Fracture*



*Chance Fracture*



**TABLE: NEUROLOGICAL SYNDROMES OF SPINAL CORD INJURIES**

Syndrome	Description	Treatment / Prognosis
Bulbar-Cervical	A lesion above C4 that produces almost immediate cardiopulmonary arrest and death if CPR is not started within minutes. Ventilator dependent. Very poor prognosis and long-term survivability.	No acute surgery unless highly unstable; wait for hemodynamic and autonomic stability
Central Cord	A lesion, occurring almost exclusively in the central portion of cervical spinal cord, that produces sacral sensory sparing and greater weakness in the upper limbs than lower limb. Often preexisting congenital or degenerative stenosis. Hyperpathia to sensory stimuli is common.	<ul style="list-style-type: none"> <li>• Classic teaching is to postpone surgery</li> <li>• Allow for cord edema and hematoma to pass</li> <li>• Delayed surgery to correct stenosis</li> <li>• Good chance of delayed leg function recovery</li> </ul>
Anterior Cord	A lesion that produces dissociated loss of motor function and of sensitivity to pain and temperature, while preserving proprioception. Bilateral paraplegia. May be result of either anterior spinal arterial ischemia or compression from disc or bone.	<ul style="list-style-type: none"> <li>• If compressive element seen early, early surgical decompression may be warranted</li> <li>• Worst prognosis with only 20% motor recovery</li> </ul>
Brown-Sequard	A lesion that produces relatively greater ipsilateral proprioceptive and motor loss and contralateral loss of sensitivity to pain and temperature. Usually from penetrating trauma, epidural hematoma, radiation, large disc herniations, spondylosis.	<ul style="list-style-type: none"> <li>• Best prognosis of incomplete lesions</li> <li>• 90% regain ability to ambulate independently</li> <li>• Rare indications for surgery except sometimes for debridement after penetrating trauma</li> </ul>
Cauda Equina	Injury to the lumbosacral nerve roots within the neural canal resulting in areflexic bladder, bowel, and lower limbs. Usually poor return of bowel/bladder function.	<ul style="list-style-type: none"> <li>• Surgery usually beneficial within 24-48 hours</li> <li>• Delayed root escape or improvement</li> </ul>

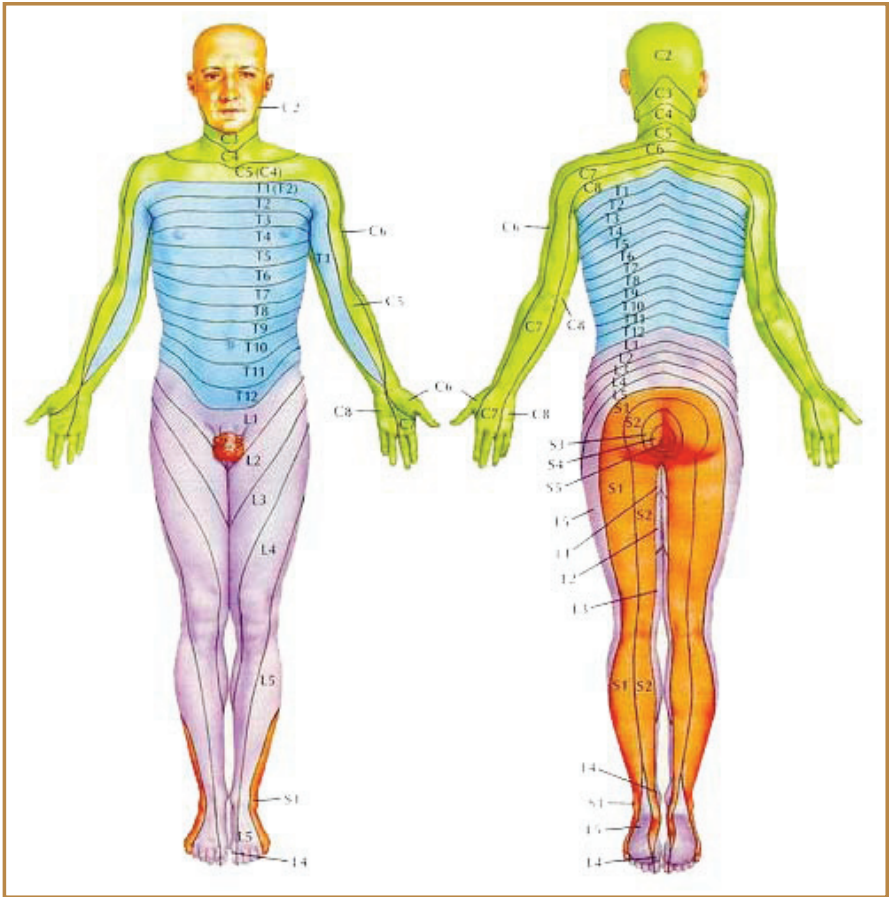
**TABLE: MAJOR MOTOR LEVELS**

Level	Muscle Group	Action	DTR
C5	Deltoid, spinati	Abduction of shoulder; external rotation of arm	
C6	Biceps, brachialis	Flexion of elbow	Biceps jerk
C7	Triceps, wrist extensors	Extension of elbow, wrist	Triceps jerk
C8	Intrinsic hand muscles	Abduction, adduction of fingers	
L2,3	Iliopsoas	Hip flexion	
L4	Quadriceps	Extension of knee	
L5	Tibialis anterior and posterior, extensor hallucis longus	Dorsiflexion of foot and bit toe	Knee jerk
S1	Gastrocnemius	Plantar flexion of foot	Ankle jerk
S4-5	Anal sphincter	Voluntary contractions of anal sphincter	

**TABLE: MAJOR SENSORY LEVELS**

C4	Clavicle
C5	Deltoid region
C6	Radial forearm and thumb
C7	Middle finger
C8	Fifth finger
T1	Medial, proximal arm
T5	Nipples
T7	Costal margins
T10	Umbilicus
T12	Inguinal ligament
L3	Anterior thigh
L4	Medial aspect of knee
L5	Lateral calf, dorsum of foot, big toe
S1	Lateral foot, fifth toe
S2	Posterior thighs
S3, 4	Buttocks, perianal region

**SENSORY DISTRIBUTION / DERMATOMES**



**TABLE: SEGMENTAL REFLEXES**

Biceps	C6
Triceps	C7
Upper abdominal*	T7-T10
Lower abdominal*	T10-T12
Cremasteric*	L1
Knee jerk	L4
Posterior tibial jerk	L5
Ankle jerk	S1
Bulbocavernosus**	S2-4
Anocutaneous	S4-5

\*Cutaneous reflexes: decreased in upper motor neuron lesion.

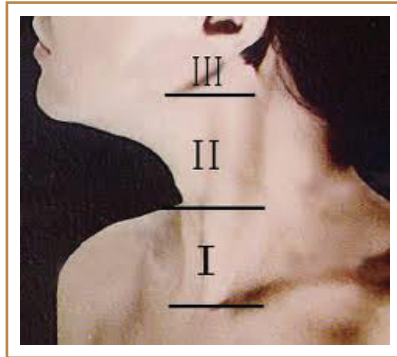
\*\* Contraction of bulbocavernosus muscle after stroking dorsum of glans penis

\*\*\*Contraction of anal sphincter after stroking the perineal skin

## Penetrating Neck Injuries

### ZONES OF THE NECK:

- Zone 1 is between the clavicle and the cricoid cartilage
- Zone 2 is between the cricoid cartilage and the angle of the mandible
- Zone 3 is between the mandible and the base of the skull



### DEFINITION:

- Neck wounds that extend deep to the platysma are considered penetrating injuries
- Most commonly these are missile injuries by firearms or stab wounds

### SYSTEMATIC PHYSICAL EXAM

- For all penetrating injuries of the neck, first apply all of the principals of ATLS (ABCs) paying special attention to the airway and any signs of injuries to vital structures in the neck or chest.
- The physical exam should be systematic according to systems in order to prevent missing any injuries. Signs of vascular or airway injuries can be subdivided into **hard signs** (those which are diagnostic of significant injury requiring treatment and immediate surgery) and **soft signs** (those which are suggestive of injury and require further workup)
- Airway: Airway management must be individualized in these situations. An airway that appears stable can be lost quickly. Care must be taken to recognize tracheal disruption, which can lead to a false passage
- **Hard signs:** Dyspnea, stridor, air bubbling through wound
- **Soft signs:** hemoptysis, hoarseness, and subcutaneous emphysema all suggest airway disruption
- Vascular Structures: Injuries to the great vessels of the neck such as the carotid artery or superior vena cava must be suspected. An expanding hematoma in the neck can quickly lead to airway compromise and thus early intubation should be considered.

- Hard signs: Severe active bleeding, large or expanding hematoma, bruit, unexplained shock, absent or diminished peripheral pulses.
- Soft signs: Stable hematoma, mild hypotension, unexplained altered GCS, focal neurodeficits.
- Digestive tract: Injuries to the esophagus and pharynx are sometimes difficult to diagnose. Symptoms include bleeding from the mouth, drooling, subcutaneous emphysema, odynophagia, and hematemesis.
- Nerves: Cranial nerves, the brachial plexus, and the sympathetic chain all run through the neck area. Cranial nerves 7,9,10,11,12 must be evaluated. Axillary, musculocutaneous, radial, medial and ulnar nerves must be evaluated. Check for Horner's syndrome (enophthalmos, ptosis, miosis, anhidrosis).
- Chest: Always get a CXR to look for possible hemothorax or pneumothorax. Also, check for peripheral pulses to evaluate for a possible subclavian artery or vein injury.

## INVESTIGATION

### *Imaging Studies:*

- Chest and Neck X-rays: are helpful to identify foreign bodies or free air as well as to rule out hemothorax or pneumothorax. Air in the prevertebral or deep neck spaces suggests injury to the larynx or trachea or NGT.
- CT scan: Stable patients can be evaluated with a CT scan of the neck (CT soft tissue portion to evaluate trajectory of bullet and proximity to anatomy as well as seeing possible air from esophagus, and a CT angio portion to evaluate the vessels). However, unstable patients or open lacerations of the larynx require surgical exploration. For a retained foreign body, CT scan is the best imaging modality.
- Color Flow Doppler: Can be performed in place of a CT. It has some limitations in the evaluation of the internal carotid artery near the base of the skull, the proximal subclavian vessels and the vertebral arteries. It also has imitations when there is a tracheal injury since the subcutaneous emphysema will reduce visibility.
- Angiography: This is considered the gold standard for evaluation of the neck arteries. Historically, it was mandated in all Zone I & III injuries penetrating the platysma. More recently, it has been largely replaced by color flow Doppler and CT angiography. It is indicated for inconclusive Doppler studies, shotgun injuries (multiple pellets), zone III injuries with a hematoma & Zone I injuries with widened mediastinum. However, CT angiography is also a viable option in these cases and is less invasive.
- Esophageal evaluation: Water soluble contrast such as Gastrografin can be used to study the esophagus. In addition, rigid esophagoscopy is often very helpful. These studies should be performed in all patients with signs suggestive of aerodigestive injury, those who are unevaluable, as well as those with injuries in proximity to the esophagus (as seen on CT). Either study alone may miss cervical esophageal injuries, but the combination of both exams greatly enhances the sensitivity.

- Flexible laryngoscopy is used to fully assess the trachea and larynx in patients with signs/symptoms suggestive of injury or in those with injuries to proximity to the larynx or trachea. Rigid esophagoscopy, however, is superior to flexible esophagoscopy.

## INITIAL MANAGEMENT

- **Airway:** May be very difficult. Pharmacologic paralysis for endotracheal intubation with a large hematoma can be dangerous. Even a Cricothyrotomy in the presence of a hematoma can be difficult. Awake fiberoptic intubation is the safest way to intubate in patients with large hematomas.
- **Vascular access:** One should avoid intravenous lines on the side of injury (to prevent extravasation in case of subclavian vein injury).
- **Positioning:** Any patient with active bleeding should be placed in a Trendelenburg position in order to reduce the risk of air embolism associated with venous injury.
- **Gastric Decompression:** One should avoid placing an NGT until after the patient has been intubated and sedated in order to reduce the risk of the patient coughing and straining leading to increased bleeding.

## MANAGEMENT

- **Stable patients:** These patients undergo thorough investigation as described earlier and then proceed to surgical exploration or observation (at least 24 hours) as warranted by the work-up
- **Unstable patients**
  - These patients include: severe active bleeding, shock not response to resuscitation, expanding hematoma, pulsatile hematoma, absent or diminished peripheral pulses associated with shock, bruit associated with shock, air bubbling through wound.
  - These patients are brought to the operating room for exploration followed by triple endoscopy (laryngoscopy, bronchoscopy, and esophagoscopy).

## CHAPTER 6

# CHEST TRAUMA

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### **IN THIS SECTION**

*Management of Blunt Chest Injuries*

*Evaluation of the Widened Mediastinum*

*Blunt Cardiac Injury*

*Penetrating Chest Trauma*

*Transmediastinal Gunshot Wounds*

*Peripheral Vascular Injuries*

TRAUMA

BOOK

2012



## **Management of Blunt Chest Injuries**

### **DEFINITION:**

#### **Chest Injury**

Any injury to the thoracic cage and its contents, including the lungs, heart, great vessels, tracheobronchial tree and esophagus.

### **GUIDELINES:**

#### ***Blunt chest injuries are characterized by***

- Mechanism:
  - Severe blunt force applied to the chest.
  - Rapid deceleration injury.
- Signs:
  - Chest wall deformity
  - Chest wall contusion
  - Chest wall laceration
  - Seatbelt sign (ecchymosis) to chest
- Symptoms:
  - Tachypnea
  - Pain
  - Absent breath sounds
  - Crepitus or subcutaneous emphysema
  - Hemoptysis
  - Discordant breathing pattern
  - Hypotension
  - Distended neck veins

#### ***With any of the above findings, consider the possibility of the following chest injuries***

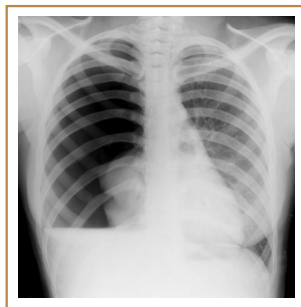
- Tension pneumothorax
- Open pneumothorax
- Flail chest/pulmonary contusion
- Massive hemothorax
- Cardiac tamponade
- Blunt cardiac injury
- Ruptured diaphragm
- Ruptured tracheobronchial tree
- Ruptured thoracic aorta
- Ruptured esophagus
- Simple pneumothorax
- Fractured ribs

**Maintain airway**

- Intubate for respiratory distress or airway obstruction.
  - Remember that current condition may deteriorate – intubate early (prevent hypoxia or hypercarbia)
  - If patient has a marginal airway, remember that unmonitored periods of time will be present – i.e., CT scanning
  - Intubating outside the ED or ICU is difficult. Consider intubating marginal patients prior to CT scanning
- Intubate for severe chest wall deformity and/or flail chest
  - Patient’s ability to ventilate will worsen
  - Patient will likely develop pulmonary contusion with worsening oxygenation (i.e. flail chest injuries)
- Beware of worsening pneumothorax as pressure is applied to the airway.
- If time allows, obtain portable AP check x-ray:
  - Evaluate for possible chest injury.
  - Confirm tube placement.
  - In general, all transfers who have had a chest X-ray at another facility should have a repeat chest X-ray after arrival.
  - Chest tubes should be placed prior to the chest X-ray if there is a hemodynamic compromise (never pick up tension pneumothorax on chest X-ray).
- Obtain CT angio of the chest to rule out aortic injury (widened mediastinum, mechanism)
  - See Blunt Cardiac Injury Guidelines
- Treat injury according to the diagnostic findings

**TENSION PNEUMOTHORAX****Physiology**

- Air enters the pleural space and cannot exit (“flap valve” phenomenon):
  - Respiratory compromise due to increased pleural pressure.
  - Hemodynamic compromise due to impaired venous return.
  - Good lung is affected by mediastinal shift.

*Right Tension Pneumothorax***Diagnosis**

- Respiratory distress.
- Absent unilateral breath sounds.
- Asymmetric chest wall motion (hemithorax “stuck out”).
  - Hypotension with distended neck veins.
  - Shift of the trachea and the PMI.

### **Treatment**

- With hemodynamic compromise: needle thoracostomy (with 14 or 16 gauge angiocath, 2nd intercostal space, midclavicular line) followed immediately by chest tube.
- Without hemodynamic compromise: confirm with chest X- ray and place large bore chest tube ( $\geq 36$  Fr.).
- Obtain chest X-ray after chest tube has been placed.



*Shotgun wound to chest*

## **OPEN PNEUMOTHORAX**

### **Physiology**

- Open defect in chest wall allows air to enter the pleural space through the defect rather than through the trachea.
  - Mediastinum shifts as pressure gradients change across the midline.
  - Layman's term: "sucking chest wound."

### **Treatment**

- Insert large bore ( $\geq 36$  Fr.) chest tube. Never put the tube through the wound.
  - Cover the defect. May apply 3-sided occlusive dressing, while awaiting placement of chest tube.
  - Consider surgical closure of the defect.

## **FLAIL CHEST/PULMONARY CONTUSION**

### **Physiology**

- Blunt force to the chest.
  - Ribs fractured in multiple places lead to unstable segment of chest wall. At least two ribs at two contiguous points
  - Pain!
  - Most impressive clinical manifestation of flail chest is underlying pulmonary contusion in underlying area of lung, alveolar hemorrhage and edema resulting in focal compliance reduction and interference with gas exchange.

### **Diagnosis**

- Paradoxical chest wall movement.
- Severe pain with breathing or with palpation in the affected area.
- Respiratory distress.
- Hemoptysis.
- Chest X-ray demonstrates contusion (may not show up for several hours).

### **Treatment**

- Flail chest:
    - Pain control: epidural, PCA, morphine/Dilaudid drip, rib block, possible rib fixation, NSAIDS, lidoderm patch.
    - Pulmonary toilet, monitor vital capacity.
    - Intubate for worsening compliance and respiratory distress due to the underlying contusion or increasing pCO<sub>2</sub>.
  - Pulmonary contusion:
    - Pulmonary toilet, monitor vital capacity (patients should be able to maintain a vital capacity of greater than 1.0 L/min).
    - Intubate for worsening compliance, respiratory distress or hypoxemia.
    - Maintain normovolemia. Do not dehydrate, but utilize fluids judiciously.
- \* Ultimate goal is to prevent secondary morbidity, such as pneumonia.**

## **MASSIVE HEMOTHORAX**

### **Physiology**

- Massive bleeding into the pleural space results in hemorrhagic shock.
  - After blunt trauma, source is usually bleeding from the chest wall.

### **Diagnosis**

- Hemorrhagic shock and hemothorax on chest X-ray.
  - Absent breath sounds on affected side.
  - Dull to percussion on affected side.

### **Treatment**

- Fluid resuscitation to correct hemorrhagic shock.
  - Place large bore chest tube ( $\geq 36$  Fr.).
  - If initial drainage  $>1200$  mL or initial drainage is  $<1200$  mL, but drainage continues at  $>200$  ml/hr (150 ml/hr for elderly patients) for more than two hours, consider operative intervention.
  - Use autotransfuser pleuroevac.
  - See pleurovac reinfusion guidelines.

## **CARDIAC TAMPONADE**

### **Physiology**

- Hole in the atrium, ventricle, or intrapericardial vena cava results in blood loss into the pericardial sac.
  - As blood accumulates in pericardial sac, end-diastolic volume is reduced, resulting in a fall of the cardiac output.

### **Diagnosis**

- Hypotension and distended neck veins (JVD) without a tension pneumothorax.
  - Distant heart sounds.
  - Beck's triad – Hypotension, JVD, muffled heart tones.
  - “Blue facies”
  - FAST exam shows pericardial fluid.

### **Treatment**

- Start with IV fluid bolus
- Pericardiocentesis
  - If positive, immediately go to OR for median sternotomy or thoracotomy depending on location of injury and anticipated findings.
- Pericardial window
  - If positive, conduct median sternotomy or thoracotomy, depending on location of injury and anticipated findings.

### **Blunt cardiac injury**

- See blunt cardiac injury guidelines.

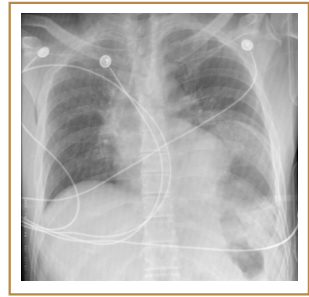
## **RUPTURED DIAPHRAGM**

### **Physiology**

- Tear in diaphragm allows abdominal contents to enter the chest, resulting in respiratory distress. The process is more rapid with spontaneous ventilation.

### **Diagnosis**

- Left:
  - Chest X-ray shows abdominal viscera in the chest.
  - Place NG tube and see if it goes up into the chest.
  - If necessary, obtain barium swallow to document the location of the stomach – only if CXR and CT are equivocal, and patient does not have peritoneal signs – otherwise, the patient should go to the OR for an ex-lap.
- Right:
  - An abnormal “hump” in the lateral diaphragm suggests laceration and protrusion of the liver into the chest.
  - Confirm with CT or thoracoscopy.
  - Laparoscopy does not appear to be helpful since the liver often obstructs the view of the diaphragmatic tear.



*Left ruptured diaphragm*

### **Treatment**

- Consider early intubation to prevent further migration of abdominal viscera into chest.

- Operative repair through the abdomen.
- If diagnosis is delayed (greater than two weeks), may need a thoracotomy.

## RUPTURED TRACHEOBRONCHIAL TREE

### Physiology

- Massive air leak into the pleural space after tear of the bronchial tree, usually near a point of fixation.

### Diagnosis

- Massive pneumothorax.
  - Continued massive air leak after placement of the chest tube.
  - Bronchoscopic diagnosis of tear.

### Treatment

- If massive, can try balloon occlusion of the affected bronchus.
  - To the operating room for thoracotomy and operative closure.
  - Avoid high pressures on the lung in the postoperative period.

## RUPTURED THORACIC AORTA

### Physiology

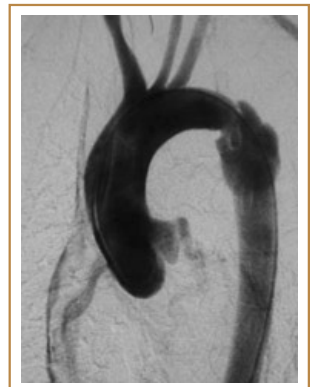
- Aorta ruptures at point of fixation after severe deceleration events. The point of rupture is usually just distal to the left subclavian artery, at the ligamentum arteriosum, or in the ascending arch.
  - Resulting hematoma is contained by adventitia or pleura.
  - 85% are dead at the scene.
  - One half of the survivors will die in 24 hours.

### Diagnosis

- History of severe deceleration impact.
- Widened mediastinum (see Guideline for evaluation of the widened mediastinum).

### Treatment

- Avoid hypertension, using beta-blocker with vasodilator if necessary.
- Consult cardiothoracic surgery and prepare for operating room.



*Descending thoracic aortic injury*

## **RUPTURED ESOPHAGUS**

### ***Physiology***

- Chest crush or penetrating injury results in rupture of the esophagus.

### ***Diagnosis***

- Air in the mediastinum.
  - Sputum or intestinal contents out of the chest tube.
  - Confirm with esophagoscopy or Gastrografin swallow (preferred)

### ***Treatment***

- Thoracotomy and repair. Type of repair is determined by the nature of the injury and time interval to diagnosis.
  - Simple injuries, quickly diagnosed – primary repair buttressed with pleura, intercostal muscle, or omentum.
  - Complex injury or delay in diagnosis – may try primary repair, but should protect with a proximal cervical esophagostomy and G-tube.
  - In all cases, the mediastinum should be widely drained with multiple chest tubes.

## **SIMPLE PNEUMOTHORAX**

### ***Physiology***

- Puncture of the lung with air leak into the pleural space. The air in the space is not under excessive pressure.

### ***Diagnosis***

- Absent unilateral breath sounds.
  - Subcutaneous emphysema.
  - Pneumothorax on chest X-ray.

### ***Treatment***

- Large bore ( $\geq 36$  Fr.) chest tube should be placed in all patients with traumatic pneumothorax seen on plain chest X-ray.
  - Occult pneumothorax seen on CT scan without plain film findings can be treated without chest tube. Usually these pneumothoraces extend over a distance of less than four rib spaces. If patient goes to the operating room, is intubated, or is transferred by air ambulance, a chest tube should be placed.

## **FRACTURED RIBS**

### ***Diagnosis***

- Chest wall pain.
  - Bony crepitus.
  - Fractured ribs on chest X-ray.
  - Remember that the anterior costochondral cartilages can be fractured and not show up on chest X-ray.

### ***Treatment***

- Pain control: epidural, PCA, morphine/Dilaudid drip, rib block, NSAIDS.
  - Pulmonary toilet.
  - Drain intrapleural fluid accumulation.
- All patients that have a hemothorax/pneumothorax (requiring, or not requiring a chest tube), should be given a post-pneumothorax hand out.



## Evaluation of the Widened Mediastinum

### OBJECTIVES

- To define the indications of pursuing an evaluation to rule out a thoracic aortic injury.
- To suggest possible diagnostic paradigms for the evaluation of thoracic aortic injury.

### DEFINITIONS

- Thoracic aortic injury:
  - A disruption of the thoracic aorta from blunt deceleration trauma. This injury is usually at the ligamentum arteriosum just distal to the take-off of the left subclavian artery. Occasionally, the aorta may rupture in the ascending portion and at the take-off of the major vessels.
- Widened mediastinum:
  - A mediastinum measurement of  $\geq 8$  cm at the level of the aortic knob on the best film that can be obtained. Two traumatic causes include disruption of the thoracic aorta and thoracic spine injury. This chapter will focus on evaluating for possible aortic injury.

### GUIDELINES

- Initially assume that there is an aortic injury on every patient with a rapid deceleration mechanism of injury.
- Evaluate and treat the ABCs. Obtain blood pressure in both arms.
- Obtain a chest X-ray. Examine for a widened mediastinum ( $> 8$  cm at level of aortic knob). The following signs are confirmatory of a possible aortic injury, but in themselves, do not suggest the need for further evaluation.
  - Pleural cap.
  - Depressed left mainstem bronchus.
  - Elevated right mainstem bronchus.
  - Trachea or esophagus deviated to right.
  - First and second rib fracture.
  - Obliterated aorto-pulmonary window.
  - NGT deviated to the right.
- Assess for symptomatic upper extremity BP differences ( $> 10$  mmHg), pseudocoarctation syndrome or infrascapular murmur. These are also suggestive of aortic injury.
- It is important to avoid hypertension if the possibility of an aortic injury is considered. Extremely high blood pressures should be treated with a short acting intravenous beta-blocker (e.g., labetalol or esmolol).
- If a widened mediastinum is found and the patient can sit up (spine is cleared), obtain an upright chest X-ray. The sitting position will decrease the possibility of spurious widening of the mediastinum due to the gravity effects on the heart (i.e., splays it apart) and magnification from the AP projection.

- If the mediastinum is still widened or an upright film cannot be performed, obtain a CT angio of the chest CT with cuts through the aortic arch. If the CT scan shows no periaortic mediastinal blood, an aortic injury has been ruled out.
- A thoracic angiogram should be obtained in the following circumstances:
  - The chest X-ray shows a widened mediastinum and a CT scan cannot be performed.
  - A chest CT scan shows blood in the mediastinum or an aortic disruption. The need for angiogram will be determined by the cardiothoracic surgeon.
  - There is a marked disparity between the pulses of the right and left arms.
  - There is sudden paraplegia explained by no other reason except acute aortic occlusion.
- A TEE (Transesophageal Endoscopic Echocardiogram) is another diagnostic test to assess for possible aortic injury. This test, however, is not available at VCMC, but is available at a nearby hospital that VCMC is contracted with – for such studies.

## Blunt Cardiac Injury

### DEFINITION

- Spectrum ranging from cardiac contusion to wall rupture.
  - Structural: Contusion, Wall motion abnormality, Valve damage, Wall rupture due to damage to myocardium
  - Conduction Abnormality: Arrhythmias due to bruising over conduction system

### GOAL

- Define at risk patients for clinically significant blunt cardiac injury (BCI).
- At risk patients: Any patient with chest trauma is at risk for cardiac injury.

#### **Particular risk factors include:**

Symptomatic	Rib, Sternum, Scapular Fractures	Mechanism
<ul style="list-style-type: none"><li>• Arrhythmia</li><li>• Hypotension</li><li>• Chest Pain</li><li>• Dyspnea</li><li>• New Murmur, thrill, rub, Associated Chest Trauma</li></ul>	<ul style="list-style-type: none"><li>• Pulmonary Contusion + Hemo/ Pneumothorax</li><li>• Chest or Abdominal Seatbelt Sign</li><li>• Anterior chest wall ecchymosis</li></ul>	<ul style="list-style-type: none"><li>• High speed chest impact</li><li>• Significant abdominal trauma</li></ul>

#### **First Step - Determine if patient is at risk for BCI**

- All “at risk” patients should have an initial EKG to evaluate for ST changes and/or arrhythmias, and serial vital sign monitoring. Such patients need at least 23 hours of continuous cardiac monitoring to rule out arrhythmias or hemodynamic instability.
- Patients may be discharged after 23 hours of normal monitoring.
- If there is any hemodynamic instability (tachycardia, hypotension), obtain echocardiography and cardiology consultation.
- If there are any arrhythmias (atrial or ventricular), continue continuous cardiac monitoring until there are 23 hours without arrhythmias, as these patients are at continuing risk for life-threatening arrhythmias.
- Low threshold to treat ventricular arrhythmias to prevent ventricular tachycardia or fibrillation.
- Patients with cardiac contusion undergoing anesthesia and operation are at special risk of hypotension and hemodynamic collapse during surgery. Anesthesiology must be aware of possible contusion preoperatively. Consider delaying non-emergent procedures. Consider aggressively intraoperative hemodynamic monitoring.

## Penetrating Chest Trauma

### DEFINITION

- Penetrating injury to the chest: A penetrating injury of the thorax in an area bounded superiorly by the lower neck and inferiorly by the lower costal margin.
  - See also: Thoracoabdominal injuries under “Penetrating Injuries to the Abdomen”.

### GUIDELINES

- Any penetrating injury to the chest must be assumed to have caused internal organ damage which may involve the:
  - Heart
  - Lungs
  - Tracheobronchial tree
  - Esophagus
  - Great vessels
  - Diaphragm
  - Spinal cord
  - Abdominal contents
- In all patients, assess the ABCs and obtain an airway as quickly as possible, if necessary.
- If patient has suffered cardiac arrest and has had signs of life (e.g., pulse or EKG present) at any time (< 10 minutes prior to arrival) or is in extremis with low blood pressure, proceed directly to left anterolateral thoracotomy while the patient is being intubated and large bore intravenous lines are being inserted. See “Emergent Thoracotomy Guidelines.”
- In the non-arrested patient, determine whether the patient is hemodynamically stable (normal) or unstable (hypotensive or tachycardiac) and whether the patient has respiratory distress.
  - If hemodynamically, unstable or has respiratory distress consider:
    - Tension pneumothorax
    - Absent breath sounds
    - Distended neck veins
    - Shift of the trachea and/or the PMI



- Insert large bore chest tube (consider needle thoracostomy to temporize).
- Massive hemothorax:
- Absent breath sounds on the affected side.
  - Dull to percussion on affected side.
  - Stabilize blood pressure with vigorous warm fluid resuscitation.
  - Insert large bore chest tube ( $\geq 36$  Fr.).
  - Take immediately to OR if
    - Initial drainage is  $>1200$  ml, or
    - If initial drainage is  $<1200$  ml, but the drainage continues at  $>200$  ml/hr ( $>150$  ml/hr for elderly patients) for 2-3 hours.
    - Consider increasing PEEP (to 10-15 cm H<sub>2</sub>O) to tamponade bleeding from lung or chest wall. Discontinue if air leak increases.

### **Cardiac tamponade**

- Entry wound between nipples.
    - Distended neck veins (JVD).
    - Distant (muffled) heart sounds.
    - Beck's triad – Hypotension, JVD, muffled heart tones.
    - "Blue facies."
    - Tension pneumothorax has been treated or ruled out.
    - Perform FAST exam.
    - If FAST exam cannot be done, or is equivocal, perform needle pericardiocentesis in ED or open subxiphoid pericardiocentesis in OR.
    - If positive, go immediately to the OR for thoracotomy or median sternotomy
- If patient is stable and has little respiratory distress, obtain AP supine chest X ray (mark the entry and exit sites with radio-opaque markers).
- If X-ray shows:
    - Pneumothorax: place large bore ( $\geq 36$  Fr.) chest tube.
    - Hemothorax: resuscitate the blood volume and place large bore chest tube.
    - Thoracotomy if drainage is higher than thresholds.
    - Consider thoracotomy if initial drainage  $> 1200$  ml, or if initial drainage is  $<1200$  mL, but drainage continues at  $>200$  ml/hr for more than two hours
  - If the wound is below the nipples, this is considered a thoracoabdominal wound.
    - Refer to Practice Guideline on "Penetrating Abdominal Injury."
  - If the injury is in Zone 1 of the neck, consider CT angiogram, bronchoscopy and esophagoscopy. Refer to Practice Guideline on "Penetrating Neck Injury."
  - If the injury is between the nipples and between the clavicle and lower costal margin, consider the possibility of cardiac injury with occult cardiac tamponade:
    - Perform FAST exam to evaluate for pericardial effusion.
    - Obtain echocardiogram if FAST is negative or equivocal to look for pericardial effusion.
  - If a bullet injury suggests a trajectory through the lung parenchyma alone, obtain a chest CT scan. The bullet track should easily be seen and its relation to the pulmonary hilum and mediastinal structures should be fairly well defined. Treat subsequent hemo/pneumothorax appropriately.

- If all X-rays are normal and there is no firm indication that the pleural space or mediastinum was penetrated, observe for 6 hours and obtain a repeat inspiratory and expiratory chest X-ray.
  - If there is a pneumothorax or hemothorax, follow guidelines above.
  - If the film is normal, consider 24 hour observation.

## Transmediastinal Gunshot Wounds

### DEFINITIONS

- Transmediastinal gunshot wound: A penetrating injury with a trajectory that suggests penetration of any of the structures of the mediastinum, including heart, great vessels, pulmonary hilar structures or esophagus.

### GUIDELINES

#### **Cardiac Arrest**

- If the patient is in cardiac arrest without “witnessed signs of life,” (>10 minutes) stop the code. Nothing you do is going to make a difference.
- If the patient is in cardiac arrest and has had “witnessed signs of life” in the pre-hospital phase (<10 minutes), proceed to open thoracotomy:
  - Perform emergent left anterolateral thoracotomy.
  - Consider right thoracotomy if there is an entry wound on the right side of the chest without an exit wound. Always remember that you can “clamshell” the thoracotomy and extend a left thoracotomy to the right, and a right thoracotomy to the left.
  - Control cardiac bleeding with finger compression, Foley balloon tamponade, sutures or skin staples.
  - Control hilar bleeding with a hilar Satinsky clamp, top to bottom.
  - Remember to take down the inferior pulmonary ligament, if you have to apply the clamp from below.
  - Control retropleural bleeding with large figure-of-eight sutures.
  - Control great vessel bleeding with Satinsky clamps, a finger, or sutures.

#### **If the patient is hypotensive:**

- Start vigorous IV resuscitation through large bore IV lines (14 or 16 gauge angiocaths), or central line (preferably a cordis) – remember in this case, one above and one below the diaphragm.
- If blood pressure improves, go to next section – “Stable or Improving.”
- If blood pressure remains low or pulse is high, then:
  - Consider tension pneumothorax – follow tension pneumothorax guideline.
  - Consider pericardial tamponade – perform FAST exam, follow cardiac tamponade guideline.
  - Consider ongoing bleeding.
  - Obtain a chest X-ray. Mark the entry and exit sites.
  - At this point, if there has been no improvement in blood pressure despite fluid infusion and possible chest decompression, consider going to the operating room. Once you have made this decision, don’t talk yourself out of it!

**If the patient has relatively normal vital signs**

- i.e., BP sys >100, P <110, proceed with rapid evaluation to determine injury.
  - Chest X-ray: treat findings of pneumothorax or hemothorax.
  - Subxiphoid ultrasound: if positive for effusion, consider rapid transport to the operating room. Consider left thoracotomy or median sternotomy to gain access to heart and other potentially injured mediastinal structures.
- If there is a widening of the mediastinum or supramediastinal enlargement, or a difference in the radial pulses, consider CT angiography of the chest.
  - All transmediastinal injuries treated non-operatively should undergo esophageal imaging studies (e.g., Gastrografin swallow, rigid esophagoscopy).
  - Bronchoscopy if any hemoptysis or rapid air leak.
  - *Alternative to above:* If the patient is stable and it appears that the missile traversed the mediastinum very anterior or very posterior, a chest CT scan with contrast will be helpful. Bullet tracks are fairly clear on CT image. However, if there is a proximity to any organ, further diagnostic studies, as noted above, need to be pursued.

All patients with transmediastinal gunshot wounds, if managed non-operatively, need admission and follow-up chest X-rays.

- These patients need to be made NPO until an injury requiring operative management is completely ruled out.



## Peripheral Vascular Injuries

### BACKGROUND

Tissues at risk from penetrating trauma to the extremities include: arteries, veins, nerves, bones, joints and soft tissue.

### CLINICAL PRESENTATION

Conscious patients will often complain of pain in the extremity. As in penetrating injuries to the neck, signs & symptoms for vascular injury are subdivided into **Hard signs** (those suggestive of an injury requiring treatment) and **Soft signs** (those which are less predictive of injury but warrant further workup. **Hard signs** include: Absent or diminished pulses, unexplained hypotension, pallor, pulsatile bleeding, expanding hematoma, or audible bruit. **Soft signs** include: isolated peripheral nerve deficit (proximity), paresthesia or paralysis of extremity, nonpulsatile hematoma, prolonged capillary refill distal to injury, diminished pulses compared to uninjured side, proximity to neurovascular bundle, diminished Ankle Brachial Index (ABI).

### INVESTIGATIONS

- Unstable patients, or patients demonstrating hard signs of vascular injury, should be taken directly to the OR for exploration. In cases of multiple wounds to that extremity, or shotgun blast, one may consider an intraoperative duplex ultrasound or angiogram to further direct the exploration. An x-ray in the ER or OR to attempt to identify a bullet track may also help in directing where the exploration should focus.
- Plain radiographs can detect foreign bodies, fractures, dislocations, air or effusions in joints, and proximity of bullets to neurovascular bundles.
- In stable patients, the next step is to perform an Ankle-brachial index. A ratio of less than 0.9 is considered abnormal and warrants further investigation.
- CT soft tissue and angiography can be utilized in patients with penetrating trauma to the extremities who are stable and are without hard signs of vascular injury.
- While formal Angiography is the gold standard for evaluation, CT angiography and duplex ultrasonography are less invasive, and are excellent alternatives in selected cases.

### COMPARTMENT SYNDROME

Compartment Syndrome may result from ischemia of a muscle compartment or from blood or fluid extravasating into a compartment. Neurovascular integrity and limb survival are threatened by delays in diagnosis. In patients with signs or symptoms suggesting compartment syndrome, fasciotomy should be performed without delay. In questionable cases, muscular compartment pressures should be

measured. Elevation of compartment pressure above 30mmHg is abnormal, and requires prompt fasciotomy. (See the Extremity Compartment Syndrome Chapter for more information). Delay of fasciotomy beyond 6 hours from the onset of ischemia is associated with poor limb survival.

## EMERGENCY ROOM MANAGEMENT

- Immediately reduce and immobilize displaced or angulated fractures
- Direct pressure to control local hemorrhage.
- Do not apply clamps to the bleeding area without operative visualization as further neurovascular injury can result.

## OPERATIVE MANAGEMENT

- Operative strategy is dictated by the patient's individual condition, and coordination amongst specialists is often necessary.
- Patients who are unstable or have multiple injuries may benefit from a 'damage control' approach with temporary shunting and later definitive repair.
- For injuries with orthopedic fractures, the typical approach is to repair the orthopedic injury first, to avoid impacting the vascular repair, as this may restore the stretched vessel to normalcy. In these situations, a temporary shunt may be placed prior to the orthopedic procedure, and definitive repair after the orthopedic procedure is completed.
- Proximal and distal thrombectomies should be performed prior to completion to remove any clot that may have accumulated.
- Systemic heparin administration and/or direct infusion heparin into the injured vessel helps prevent early thrombosis following repair. The risk of bleeding from systemic heparin infusion must be judged on the basis of the patient's other injuries.
- Most venous injuries can be ligated, however if the patient's condition permits, a repair of a large vein may be performed.

Pseudoaneurysm and arteriovenous malformations are common late complications often requiring reoperations.

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## CHAPTER 7

# ABDOMINAL AND PELVIC TRAUMA

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### **IN THIS SECTION**

*Blunt Abdominal Trauma*

*Penetrating Abdominal Trauma*

*Rectal Injuries*

*Blush on CT*

*Splenic Injuries*

*Liver Injuries*

*Evaluation of Hematuria*

*Kidney and Bladder Injuries*

*Abdominal Compartment Syndrome*

*Pelvic Ring Injuries*

*Indications for and Application of T-Pod  
Pelvic Binder*

TRAUMA  
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## Blunt Abdominal Trauma

### OBJECTIVES

- To define the patient that might have significant intra-abdominal injury after blunt trauma.
- To define appropriate diagnostic approaches to determine intra-abdominal injury.
- To define treatment strategies for patients with blunt abdominal trauma.

### DEFINITIONS

- FAST exam (focused abdominal sonography for trauma): An ultrasound examination of the abdomen that utilizes a 4-view approach for the diagnosis of blood or fluid in the abdominal cavity. A 6-view E-FAST (Extended FAST) now evaluates for pneumothorax. This is quickly becoming standard of care in most mature trauma centers.

### GUIDELINES

- Treat the ABCs first. The diagnosis of abdominal trauma is part of the secondary survey.
- Perform physical examination of the abdomen, including rectal exam and flank exam.
- Consider the possibility of abdominal injury in the following situation:
  - Seatbelt sign



- Obvious abdominal pain with or without peritoneal findings on physical examination.
- Significant external findings on the abdominal wall such as contusion, bleeding, laceration.
- Pelvic fracture.
- Fractures present above and below the diaphragm.
- Lower rib fractures.
- Lumbar or low thoracic spine fractures.
- Unexplained hemorrhage, shock or blood loss.
- A history of abdominal impact (e.g., deformed steering wheel, seatbelt sign, passenger compartment damage) in a patient with altered sensorium.

- Drugs and alcohol impairment.
- Quadriplegia, paraplegia.
- Traumatic brain injury with altered GCS.
- Prolonged non-abdominal surgery requiring anesthesia.
- Go immediately to the operating room for laparotomy in the following situation:
  - Findings of diffuse peritoneal irritation.
  - Hemorrhagic shock with indication that blood loss is in the abdomen (distending abdomen).
  - Ruptured diaphragm on chest X-ray, without known congenital diaphragmatic defect, or known prior stable/old traumatic defect.
    - Institute the MTP (Massive Transfusion Protocol) for those patients in severe shock – class III /IV, or high potential for continued massive blood loss.
- If the patient has indications of abdominal injury and has unstable vital signs, perform an ultrasound and FAST exam (see following paradigm).
  - If positive (evidence of blood in the peritoneal cavity), go to the operating room for exploratory laparotomy.
  - If negative, consider other causes of hemodynamic instability.
    - i.e., massive hemothorax, pelvic fractures, external source of bleeding, tension pneumothorax, cardiac tamponade, neurogenic shock, cerebral hemorrhage (rare), severe cardiac contusion.
- If the patient has an indication of possible abdominal injury and has stable (i.e., relatively normal) vital signs:
  - Perform ultrasound (FAST) exam.
  - Perform abdominal CT scan with IV contrast.
    - Operate on distinctively positive findings:
      - ◇ Free air.
      - ◇ Extravasation of oral contrast (mostly not given for trauma evaluation).
      - ◇ Grade V fracture of the spleen or liver.
      - ◇ Extravasation of IV contrast, or extravasation occurs from the mesentery.
      - ◇ If CT scan shows solid organ injuries without signs of active extravasation, admit the patient for observation. (See guidelines for nonoperative management of spleen and liver injuries.)
      - ◇ If CT scan shows no solid organ injuries and confirms abdominal fluid, make decision for surgery versus observation based on physical exam and labs, and ability to follow patient clinically.
      - ◇ If the ultrasound exam shows no intraperitoneal blood, repeat ultrasound in:
        - ◇ 4 hours if the patient is to be discharged from ED.
        - ◇ 12-24 hours if the patient is admitted for observation.
- If patient is observed and develops peritoneal signs, fever or prolonged ileus with no other source, consider operating on patient.

- If unable to follow patient clinically due to comatose state, intoxication/drugs, and develops fever or prolonged ileus with no other source, consider CT of abdomen and pelvis. If positive or equivocal for free fluid, without known source, consider Diagnostic Peritoneal Aspirate (DPA) versus mini laparotomy – extending as needed. If the DPA is positive, the patient will need a laparotomy.
- If patient has a head injury and you are unable to evaluate their abdomen due to emergent need of craniotomy, and FAST is equivocal, conduct DPA in OR.
  - Diagnostic Peritoneal Lavage (DPL) is rarely utilized in this institution.

## Penetrating Abdominal Trauma

### GUIDELINES

- Follow the ABCs and ATLS guidelines, and resuscitate the patient according to findings of the primary survey.
- Assess the abdomen looking for wounds, bleeding and peritoneal findings.
- Make sure that a good chest exam is performed, since chest injuries can be associated with penetrating abdominal injuries.
- Determine if there are signs or symptoms suggestive of the immediate need for operative intervention:
- Herniated abdominal contents.
  - Massive bleeding from the wound.
  - Obvious peritoneal signs consistent with hollow viscous injury or severe hemoperitoneum.
  - Signs of hemodynamic instability associated with the abdominal injury.
  - Signs of lower extremity ischemia suggestive of vascular injury.
  - All gunshot wounds with pathway or other evidence of intraperitoneal penetration or retroperitoneal organ injury.
  - Unevaluable patient with wounds suggestive of intra-abdominal injury.
- For stab wounds, if none of the above signs are present, determine the location of the wound and classify as:
  - Anterior.
  - Thoracoabdominal.
  - Posterior or flank.
- For all stab wounds where there is not an indication for immediate surgery:
  - Examine the abdomen thoroughly, document date and time. If no surgery is indicated, serial exams - preferably by the same examiner. Document each exam.
  - If the patient does not demonstrate peritonitis, the wound can be debrided, irrigated and closed. If the patient is not taken to the operating room, they should be admitted for observation with serial abdominal exams every 3-4 hours. Repeat CBC with diff and amylase in six hours and/or the following morning. NO ROUTINE prophylactic antibiotics or analgesics should be ordered.
  - Obtain chest X-ray with wound markers to determine the presence of chest injury and to determine the relationship of the entry wound to the diaphragm.
  - Insert Foley catheter to determine the presence of hematuria.
  - Obtain an IV contrast CT scan to determine injury of organs.
  - Double contrast CT scans are obtained only selectively, and should be done in collaboration with the on-call surgeon.
  - Double contrast means contrast administered IV and by mouth, or by NG tube.
  - Rectal contrast is rarely helpful. One should place a radio-opaque marker (either paperclip or radio-opaque arrow) onto the wounds to help localize the injury.



- For pelvic wounds that may have traversed the rectum:
  - Perform anoscopy and sigmoidoscopy to determine the presence of a mucosal defect.
  - Consider diversion and rectal washout if injury is found. Pre-sacral drainage should be used when contamination levels are high or there has been significant tissue destruction.
  - Take patient to OR if injury is found.
    - See rectal injury guidelines.
- For all patients taken to OR for exploratory laparotomy:
  - Once the decision to go to the OR is made, don't delay!!!
  - Make sure that there is available blood in the blood bank. Institute the MTP for severe shock (class III/IV)
  - Administer broad spectrum prophylactic antibiotics for bowel flora (e.g., cefoxitin or zosyn).
  - Prep widely for all contingencies (chin to knees, table to table).
  - Administer Tetanus Toxoid for penetrating wounds - especially those patients not up-to-date, or unknown tetanus status.

## **Rectal Injuries**

### **BACKGROUND**

Rectal trauma is rare compared to solid organ injury, but its potential complications are severe enough to warrant a high index of suspicion and investigation.

### **PATHOPHYSIOLOGY**

The most common cause of rectal trauma is penetrating injury. Gunshot wounds or stab wounds to the pelvis or gluteal region can injure the rectum. Blunt pelvic injuries are the most common causes of rectal injuries after motor vehicle crashes. Impalement, sexual assault and foreign body injuries are uncommon, but worth noting.

### **DIAGNOSIS**

Because the rectum is extraperitoneal, the diagnosis of rectal injuries is sometimes quite difficult. The presence of a pelvic fracture, or blood on rectal exam, or on rigid proctosigmoidoscopy, requires further evaluation.

In the trauma setting, the stool guaiac test is poor at identifying rectal injuries. The rigid proctosigmoidoscope is the preferred test. This scope can identify injuries to the rectal mucosa and help identify gross blood in the rectum. All patients with penetrating trauma near or with trajectory toward the anus/rectum should have a rigid proctoscopy. Care should be taken to avoid too much insufflation as this may cause increased spillage through the wound.

CT scanning of the pelvis can help identify trajectories of missiles or stab wounds, and further imaging with a water soluble contrast study can give added information.

### **TREATMENT**

Once a rectal injury is identified, broad spectrum antibiotics are warranted. Once in the operating room, the rigid scope again is useful to help identify the injured area.

In general, rectal injuries greater than 1 cm should be repaired. Smaller wounds can be left to heal on their own. The potential for fistulization is significant for unrepaired wounds. Regardless of whether the rectal injury is repaired or not, a proximal diverting colostomy is often warranted. Rarely, a colostomy may be avoided if a small, distal injury is found and one is absolutely certain that it is repaired well.

Pre-sacral drainage may be helpful in rectal trauma to help control any potential morbid infection after rectal injury. The pre-sacral space can be entered through the perineum by entering the space on either side of the anococcygeal raphe and placing drains in the presacral space. Routine pre-sacral drainage is not mandatory, but often recommended with extensive injury.

Distal rectal washout with evacuation of remaining stool in the rectum has been suggested and resulted in fewer septic complications after severe rectal injury in some studies. In a study by Shannon, rectal injuries who had a washout had significantly less abscesses (46% vs. 8%), rectal fistulas (23% vs. 7), and sepsis (15% vs. 8%).<sup>(1)</sup> A washout can be performed by placing a Foley catheter into the rectal stump and irrigating the rectum with 4-5 L of saline. The anus can be kept open with a chest tube or anesthesia tubing as the wash is completed. Some studies, however, have suggested an increase in spillage through the wound with this technique.

- 1) Shannon FL, Moore EE, Moore FA, et al: Value of distal colon washout in civilian rectal trauma-reducing gut bacterial translocation. *J Trauma* 1988;28:989-994.
- 2) *Seminars in Colon and Rectal Surgery*, Vol. 15, issue 2; Joshua M. Braveman; Mark A. Malangoni.
- 3) Weinberg J.A., Fabian T.C., Magnotti L.J., Minard G., Bee T.K., Edwards N., Claridge J.A., Croce M.A. Penetrating Rectal Trauma: Management by Anatomic Distinction Improves Outcome; *J. Trauma* 2006 Mar. 60(3)508-13.

## Blush on CT

### DEFINITIONS

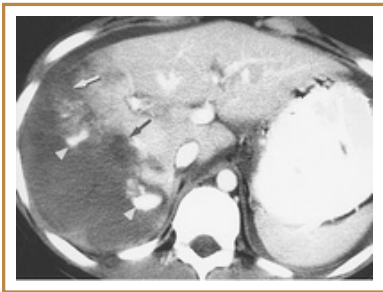
On CT scan with intravascular contrast, an area of active hemorrhage will appear as an abnormal collection of intensely dense white contrast material in the area of the bleeding. Usually, this appears as an abnormal “blush” surrounded by otherwise normal parenchyma, or as a “swirl” pattern in a cavity.

### TRAUMA GUIDELINES

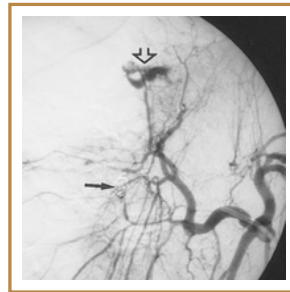
- When an abnormal area of active extravasation is diagnosed on CT scan:
  - Continue fluid resuscitation.
  - Confirm the location and extent of the extravasation by reviewing the CT scan yourself.
  - Determine how much fluid is in the body cavity or in the region of the bleeding to gain an idea of how serious the bleed is.
  - Determine the availability and potential time to obtain angiogram and embolization.
- Treatment options for the following locations of the extravasation:
  - Emergent laparotomy - Any blush in the abdomen when there is associated hypotension or significant anticipated delay to angiography.

### Liver

- If there are no other injuries, consider angiography and embolization. If there are multiple areas of extravasation in different segments of the liver consider laparotomy.



*Blush on liver CT*



*Blush on liver angio*

### **Spleen**

- Consider angiography and embolization in Grade I-III splenic injuries, and some Grade IV-V injuries without hemodynamic instability.
  - More serious injuries should undergo laparotomy.

### **Pelvis**

- Place T-Pod/pelvic binder or external fixator.
- Consider angiography as treatment of choice in most cases.
- If active bleeding has stopped at the time of the angiogram but there are cut-offs in the vessels, consider embolization of the internal iliacs.
- If there is a large hematoma, but no active arterial extravasation, consider possibility of venous bleeding and embolize both internal iliac arteries.

### **Buttock and abdominal wall**

- Consider angiography as treatment of choice.
  - For inferior epigastric bleeds, open ligation or embolization are both reasonable options.

### **Kidney**

- Consider angiography as treatment of choice.
  - Try to embolize distal vessels to preserve renal function.
  - Mesentery or bowel – go straight to laparotomy.

If the patient has multiple injuries and the possibility of chest involvement, consider performing a thoracic aortogram at the time of angiography.

## Splenic Injuries

### OBJECTIVES

- To define situations in which non-operative management of splenic injuries is safe and desirable.
- To define a clinical pathway for the non-operative management of splenic injuries.

**TABLE: SPLENIC INJURY GRADING**

Grade I	<ul style="list-style-type: none"> <li>• Subscapular hematoma, &lt;10% surface area capsular tear, &lt;1 cm in depth.</li> </ul>
Grade II	<ul style="list-style-type: none"> <li>• Subscapular hematoma, nonexpanding, 10-50% surface area intraparenchymal hematoma, nonexpanding, &lt;2 cm in diameter. Capsular tear, active bleeding, 1-3 cm, does not involve trabecular vessel.</li> </ul>
Grade III	<ul style="list-style-type: none"> <li>• Subscapular hematoma, &gt;50% surface area or expanding intraparenchymal hematoma, &gt;2 cm or expanding. Laceration &gt;3 cm in depth or involving trabecular vessels.</li> </ul>
Grade IV	<ul style="list-style-type: none"> <li>• Ruptured intraparenchymal hematoma with active bleeding. Laceration involving segmental or hilar vessels producing major devascularization (&gt;25% of spleen).</li> </ul>
Grade V	<ul style="list-style-type: none"> <li>• Shattered spleen, hilar vascular injury that devascularizes spleen.</li> </ul>

### GUIDELINES

- Indications: Non-operative management of splenic injury can be considered when all of the following conditions have been met:
  - Diagnosis of splenic injury on CT scan.
  - Hemodynamically normal patient that has not required or has responded quickly to resuscitation.
  - Grade I-III splenic injury. Consider for Grade IV or V injury in children or adults, if no significant hemoperitoneum is present.
  - No other major intra-abdominal injury.
  - Available for monitoring of abdominal exam and hemoglobin (i.e., not in a long operative procedure, and not comatose).
  - No other major sources of blood loss.
  - No other premonitory illnesses that suggest the patient could not tolerate blood loss (e.g., severe ischemic heart disease).
  - Willingness to accept blood transfusion (e.g., not a Jehovah's Witness).
- In some cases, there will be active bleeding from the spleen as defined by a blush or swirl on the CT scan or a dropping hemoglobin. Consideration should be given to angiography and embolization in these patients. If this option is taken, consider the time of the embolization as the "start time" for the following protocol.

- Admit all Grade II or higher splenic injuries to a telemetry unit/DOU. Consider admitting all Grade IV and V splenic injuries to an ICU.
  - Monitor hourly vital signs.
  - Bed rest.
  - NPO.
  - Draw serial hemoglobin and hematocrit with pediatric tubes every 4 hours until stable x2.
  - Give immunization for pneumococcus, meningococcus, and Hib.
- When hemoglobin is stable and there have been no adverse hemodynamic events:
  - Transfer to regular floor or discontinue telemetry.
  - Advance diet.
  - Hemoglobin and hematocrit daily.
  - Bed rest until H&H stabilizes -- may take 1-4 days, depending on injury grade.
  - If stable and tolerating a diet, discharge 1 day after ambulation begins.
- After discharge:
  - No school for a week.
  - No physical education for approximately six weeks.
  - No major contact sports (e.g., football) for approximately 3 months.
  - Return to clinic in 10-14 days.
  - Instruct to return to ED if developing worsening left upper quadrant pain, dizziness, syncope or hypotension.
- Failures (requires laparotomy):
  - Children: requires >40 ml/kg of blood transfusion to maintain hemoglobin >7 gm/dl.
  - Adults: requires 2 units of blood to maintain hemoglobin >7 gm/dl in the absence of other injuries.
  - Any patient:
    - New onset of diffuse peritoneal irritation suggestive of perforated viscus.
  - Sudden hypotension unassociated with other bleeding sites.
    - If splenectomy is required, administer vaccines on the next to last hospital day:
      - Pneumococcus vaccine (Pneumovax).
      - Meningococcus vaccine.
      - Hemophilus influenzae vaccine (Hib)
      - All patients that undergo a splenectomy should be given a post-splenectomy handout.

## Liver Injuries

### DEFINITIONS

**TABLE: LIVER INJURY GRADING**

Grade I	<ul style="list-style-type: none"> <li>• Capsular avulsion</li> <li>• Parenchymal fracture &lt;1 cm deep</li> </ul>
Grade II	<ul style="list-style-type: none"> <li>• Parenchymal fracture 1-3 cm deep</li> <li>• Subscapular hematoma &lt;10 cm in diameter</li> <li>• Peripheral penetrating wound</li> </ul>
Grade III	<ul style="list-style-type: none"> <li>• Parenchymal fracture &gt;3 cm deep</li> <li>• Subscapular hematoma &gt;10 cm</li> <li>• Central penetrating wound</li> </ul>
Grade IV	<ul style="list-style-type: none"> <li>• Lobar tissue destruction</li> <li>• Massive central hematoma</li> </ul>
Grade V	<ul style="list-style-type: none"> <li>• Retrohepatic vena cava injury</li> <li>• Extensive bilobar disruption</li> </ul>

### GUIDELINES

#### **Operative management**

- Operative management of liver injuries should be considered when there is ongoing bleeding from the liver injury resulting in unstable vital signs or there is the possibility of other injuries.
- Markedly unstable patient with rapidly expanding abdomen or increasing rigidity.
  - Grade V liver injury on CT scan.
  - A “swirl” pattern on CT scan suggestive of ongoing bleeding when angiography is not available.
    - > Non-operative management of active bleeding can be undertaken if:
      - Angiography for embolization is readily available.
      - Vital signs respond appropriately to fluid resuscitation.
      - There are no other obvious injuries in the abdomen.
      - The trauma team is available to monitor the patient in the angiography suite.
        - > Non-operative management of non-actively bleeding liver injuries can be undertaken in the otherwise stable patient if the CT demonstrates that the hilum is not injured and the rim of blood is fairly localized around the liver.

#### **Non-operative management**

- Admit all Grade IV-V liver lacerations or those with significant blood around the liver (with normalizing vital signs) to the ICU. All others can be admitted to the DOU.
  - Monitor hourly vital signs.
  - Bed rest.
  - NPO.



- Draw serial hemoglobin and hematocrit with pediatric tubes q 4 hours, until stable X 2.
  - > When hemoglobin is stable and there have been no adverse hemodynamic events:
- Transfer to regular floor.
- Advance diet.
- Hemoglobin and hematocrit daily.
- Liver enzymes and bilirubin on day 2 to help rule out biloma.
- Bed rest x2 days. Grade I and II liver fractures may ambulate immediately.
- If stable and tolerating diet:
  - > Grade I and II injuries: discharge on day 2-3.
  - > Grade III and IV injuries: discharge on day 3-5.

### **After discharge**

- No school for a week.
- No physical education for six weeks.
- No major contact sports:
  - Grade I and II: for six weeks.
  - Grade III, IV, and V: for three months.
- Return to clinic in 10-14 days.
- Instruct to return to the ED if:
  - Worsening RUQ pain
  - Fever
  - Jaundice
  - Hematemesis

### **Pitfalls**

- Fever and/or jaundice – consider biloma.
- CT scan to confirm fluid collection around liver.
- Radionuclide biliary excretion exam to confirm active leak.
- Percutaneous drainage
- Consider ERCP with stent placement and/or sphincterotomy.
  - UGI bleed two to four weeks after injury – consider hemato bilia.
  - CT scan to confirm large intrahepatic injury, clot, or extravasation.
  - Angiography to confirm etiology.
  - Angiographic embolization of vessel.
  - Do not explore for hemato bilia.
    - > Hypotension, drop in hemoglobin 7 to 10 days after non-operative management of severe liver injury – repeat bleed, usually arterial.
  - Admit to ICU, stabilize.
  - Angiography to confirm etiology.
  - Angiographic embolization of the vessel.
  - Attempt to avoid exploration at this time as abdominal cavity could be a mess/catastrophe.

## Evaluation of Hematuria

### DEFINITIONS

- Gross hematuria: Blood in the urine that can be seen as a change in the urine color.
- Microhematuria: Urine that appears normal, but has tested positive for blood by either a dipstick technique or by microscopic examination.

### GUIDELINES

- Treat the patient according to ATLS guidelines.
- Determine the presence of blood by either inserting a Foley catheter, or having the patient void spontaneously.
- If the urine has visible cells or is red or pink, gross hematuria is present (usually >50 RBC/HPF).
- If the urine appears normal, but is “dipstick positive” for blood (1+ or greater) and has RBCs on microscopic exam (usually <50 RBC/HPF), microhematuria is present.
- For blunt trauma:
  - For gross hematuria, obtain a CT scan of the abdomen/pelvis and cystogram.
  - For microhematuria, determine whether there is a mechanism or signs suggestive of an intraabdominal injury.
    - > If there is a mechanism or signs suggestive of intra-abdominal injury, obtain an abdominal CT scan.
    - > If there is no mechanism or signs suggestive of intra-abdominal injury, no further immediate diagnostic studies are necessary.
  - If the patient is discharged, provide information about potential gross hematuria and have patient contact Trauma Team/ED if hematuria is seen.
  - If the patient is admitted, obtain a urinalysis 24 hours after admission. If has >50 RBC/HPF, perform IVP or abdominal CT scan, if one not done already.
- For penetrating trauma – obtain a CT abdomen, pelvis, and cystogram for all hematuria.

## Kidney and Bladder Injuries

### OBJECTIVES

- To provide guidelines for the management of renal contusions, renal fractures, renovascular injuries and bladder perforations.

### DEFINITIONS

- Renal contusions: Defect(s) in perfusion of kidney on CT or IVP that is consistent with a parenchymal contusion.
- Renal fracture: A parenchymal defect of the kidney associated with hematoma or urinoma around the kidney.
- Renovascular injuries: Occlusion(s) of the renal artery as evidenced by lack of perfusion to a kidney on CT, IVP or angiogram.
- Bladder perforation: Extravasations of contrast from bladder on CT, IVP, or cystogram. Extraperitoneal perforations are contained in the retroperitoneal space around the bladder. Intraperitoneal perforation is associated with contrast in the peritoneal cavity that outlines the bowel.

**TABLE: KIDNEY INJURY GRADING SCALE**

Grade	Description	ICD-9	AIS-90
I	<ul style="list-style-type: none"> <li>• Microscopic or gross hematuria, urologic studies normal</li> <li>• Subscapular hematoma, nonexpanding without parenchymal laceration</li> </ul>	<ul style="list-style-type: none"> <li>• 866.11</li> <li>• 866.11</li> </ul>	<ul style="list-style-type: none"> <li>• 2</li> </ul>
II	<ul style="list-style-type: none"> <li>• Nonexpanding perirenal hematoma confined to renal retroperitoneum</li> <li>• Laceration &lt; 1 cm parenchymal depth of renal cortex without urinary extravasation</li> </ul>	<ul style="list-style-type: none"> <li>• 866.01</li> <li>• 866.11</li> <li>• 866.02</li> <li>• 866.12</li> </ul>	<ul style="list-style-type: none"> <li>• 2</li> <li>• 2</li> </ul>
III	<ul style="list-style-type: none"> <li>• Laceration &gt; 1 cm parenchymal depth of renal cortex without collecting system rupture or urinary extravasation</li> </ul>	<ul style="list-style-type: none"> <li>• 866.02</li> </ul>	<ul style="list-style-type: none"> <li>• 3</li> </ul>
IV	<ul style="list-style-type: none"> <li>• Parenchymal laceration extending through the renal cortex, medulla, and collecting system</li> <li>• Main renal artery or vein injury with contained Hemorrhage and segmental arterial and venous injury as well as ureter pelvic injury</li> </ul>		<ul style="list-style-type: none"> <li>• 4</li> </ul>
V	<ul style="list-style-type: none"> <li>• Completely shattered kidney</li> <li>• Avulsion of renal hilum which devascularizes kidney including thrombosis</li> <li>• Thrombosis of main renal artery</li> </ul>	<ul style="list-style-type: none"> <li>• 866.03</li> <li>• 866.13</li> </ul>	<ul style="list-style-type: none"> <li>• 5</li> </ul>

## GUIDELINES

### **Evaluation**

- Consider renal injury with any injury associated with hematuria (see Guideline for hematuria).
- Consider renal injury with penetrating abdominal injury (see Guideline for evaluation of penetrating abdominal trauma).
- Consider bladder injury when there is significant hematuria with a pelvic fracture or blunt abdominal trauma.

### **Penetrating injuries**

- All gunshot wounds to the kidney require exploration for the possibility of associated injuries.
- All stab wounds to the kidney require specific evaluation:
  - If kidney is injured from anterior stab wound, exploration is required because of the possibility of associated intra-abdominal injuries.
  - If kidney is injured from a flank wound, CT must show that the wound is limited to kidney with minimal blood in the perirenal space. If urine is present around the kidney, consider exploration for disrupted collecting system or ureter.

### **BLUNT INJURIES**

#### **Renal contusion**

- Diagnosed as a perfusion defect on CT or IVP.
- No definitive treatment necessary.
- May discharge if still has hematuria; follow-up urinalysis at clinic visit one to two weeks after discharge.

#### **Renal fracture**

- Rarely requires surgical intervention.
- Diagnosed on CT scan as parenchymal defect with surrounding hematoma and possible urinoma.

#### **If hemodynamically unstable**

- Consider angiogram.
  - If angiogram shows active arterial extravasation, consider embolization.
  - If angiogram shows occluded main renal artery, nothing more needs to be done as long as contralateral kidney is present.
  - If angiogram shows active extravasation and embolization cannot be accomplished, patient should be taken to surgery. Nephrectomy will probably be required. If there is venous extravasation, anticipate spontaneous resolution of bleeding as long as clotting factors are normal.

**If hemodynamically normal without evidence of ongoing bleeding**

- Treat non-operatively.
  - Keep patient in monitored setting (ICU, DOU, or step down bed) until hemoglobin stable.
  - Foley to remain in place until hematuria substantially clears.
  - Bed rest for 1-3 days (depending on injury grade), then mobilize in hospital on the day after H&H stabilizes. May discharge on day after H&H stabilizes, patient is ambulating and is afebrile.
  - Serial hemoglobin every 4 hours until repeated values are within 1 gm/dL, then daily hematocrits.
  - Expect abdominal and flank discomfort, fevers and mild ileus for 3-4 days.
  - The presence of a urinoma does not necessarily require operative intervention.
  - Follow-up routinely in clinic 10-14 days after discharge. Follow-up CT is unnecessary.
  - Out of school or work 10-14 days after discharge. Avoid contact sports activities for three months.
  - Discuss with the patient the meaning of hypertension in the follow-up period.

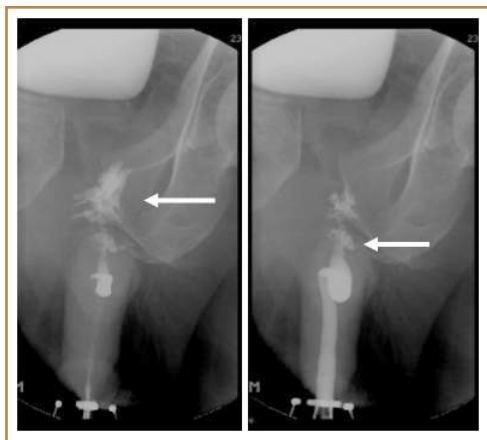
**Renovascular injury**

- Usually discovered in patient with poor visualization of kidney on contrasted CT scan or non-visualized kidney on IVP.
- Order STAT renal angiogram.
- If there is active extravasation, attempt embolization. If embolization is unsuccessful, perform laparotomy.
- If there is occlusion, most likely explanation is intimal flap from partial thickness vessel disruption from traction injury.
- With occlusion, consider the amount of time from the injury.
- Less than six hours: consider revascularization although the outcome is poor. Greater than six hours: observe. The chances of kidney survival are slim.

**Bladder and urethral injury**

- Consider bladder injury in patient with the following:
  - Gross hematuria (i.e., real bloody).
  - Severe displaced pelvic fracture.
  - Lower abdominal pain with hematuria.
  - Extravasation seen on CT scan of pelvis.
- In male, consider urethral injury with the following:
  - Displaced severe anterior pelvic fracture (i.e., open book fracture).
  - Blood at the meatus.
  - Perineal hematoma.
  - High riding or boggy prostate gland.
  - For possible urethral injury, perform a retrograde urethrogram (R.U.G).
    - > If positive, do not place Foley catheter. Consult urology.
    - > If negative, insert Foley catheter if indicated.

- For possible bladder injury, insert Foley catheter and perform retrograde CT cystogram. If there is a bladder injury, determine whether it is extraperitoneal or intraperitoneal.
- Extraperitoneal bladder rupture: contrast flows from bladder but is confined in the extraperitoneal space around the bladder.
- Consult urology.
- Usually treated with bladder drainage for 7-10 days. After 7-10 days, obtain cystogram. If bladder is intact, may remove catheter. Antibiotics generally not needed.
- Intraperitoneal bladder rupture: contrast flows from the bladder into the peritoneal cavity. Bowel is outlined.



*Urethral injury*

- Consult urology.
- Treated with exploratory laparotomy and bladder closure with Foley and JP drainage.
- Bladder drainage used for 7-10 days, at which time a cystogram is obtained. If bladder is intact, catheter may be removed.



*Bladder injury*

## Abdominal Compartment Syndrome

### OBJECTIVES

- To provide guidelines for the recognition, evaluation and management of the abdominal compartment syndrome (abdominal hypertension)

### DEFINITIONS

#### **Abdominal compartment syndrome**

A multiple organ dysfunction syndrome that occurs when pressure within the abdominal cavity exceeds a critical level.

#### **2 Hallmarks**

Oliguria and impaired pulmonary mechanics (elevated peak and plateau pressures or decreased tidal volumes)

#### **Symptoms Include**

Oliguria	<ul style="list-style-type: none"><li>• Increased renal artery vein resistance.</li><li>• Also decreased cardiac output.</li></ul>
Cardiac	<ul style="list-style-type: none"><li>• Decreased venous return via compression on aorta, IVC.</li><li>• Also increased SVR.</li><li>• Overall decrease in cardiac output, increased PA pressures &amp; CVP.</li></ul>
Pulmonary	<ul style="list-style-type: none"><li>• Increased peak airway pressure &amp; plateau pressure.</li><li>• Decreased compliance. CO<sub>2</sub> retention (respiratory acidosis).</li></ul>
Neuro	<ul style="list-style-type: none"><li>• Increased ICP and decreased CPP.</li></ul>

#### **Causes in trauma include**

- Sudden accumulations of free peritoneal fluid,
- Intra-abdominal and retroperitoneal hematomas
- Marked visceral edema or distension from intraluminal fluid or air.

#### **TABLE: GRADING**

Grade	Pressure (mmHg)
I	10-15
II	16-25
III	26-35
IV	35>

## GUIDELINES

### **Evaluation**

- Consider abdominal hypertension in any patient who has sustained severe trauma requiring large amounts of fluid for resuscitation, and/or patients with large amounts of blood within the abdomen/retroperitoneum.

### **Diagnosis**

- Diagnosis is made by clinical suspicion and measurement of bladder pressure.
  - With Foley in place, drain bladder.
  - Instill 100 ml saline into bladder and clamp outflow.
  - Insert needle into specimen collecting port.
  - Connect needle in specimen port to CVP monitoring device or other pressure monitor.
  - Should be “zeroed” at level of pubic symphysis.
  - Pressures above 30 are consistent with compartment syndrome.
  - Pressures 20 – 30 should increase the suspicion of compartment syndrome. If the patient is found to have effects on the cardiac, renal or pulmonary system, one should consider the patient to have compartment syndrome.

### **Treatment**

For full blown compartment syndrome, the treatment is laparotomy with IV bag, VAC pack, or Wound Vac closure. In rare situations where the compartment syndrome is caused only by free fluid within the abdomen (i.e., some burn patients) one can make a small incision in the abdomen and place a peritoneal dialysis catheter into the pelvis to drain the fluid. If this does not improve the patient's condition, however, a laparotomy as described above should be done.

In situations where the bladder pressures are becoming elevated, yet compartment syndrome is not present (no effects on other organs and pressure less than 25), one could consider temporary chemical paralysis and use of mannitol. Great care should be taken with this method, as one may miss a compartment syndrome which may lead to death. The use of paralytics and mannitol should never be taken lightly.



*IV bag closure*



## Pelvic Ring Injuries

### BACKGROUND

A pelvic ring injury can be one of the few orthopedic emergencies that affect a patient's mortality. The energy required to injure a pelvis is frequently seen in high-speed motor vehicle collisions as well as falls from a height and crush injuries. This high energy can also cause severe chest and abdomen injuries resulting in hemodynamic instability. The challenge with pelvic injuries lies in deciding which ones may be contributing to, or causing the patient's hemodynamic instability.

### EVALUATION

The evaluation of a trauma patient should always stick to the ATLS protocol and should always begin with the ABC's. When evaluating the pelvis, a thorough examination should be performed in addition to a complete AP pelvis radiograph.

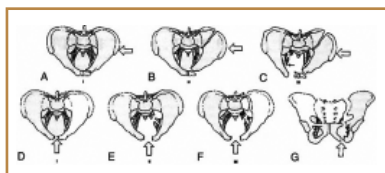
First, the pelvic area should be inspected for skin abnormalities and deformity, including lacerations, ecchymosis, and abrasions. This should include a rectal exam, a vaginal exam, and an exam of the external genitalia. In particular, the finding of blood in the rectum or vagina is highly suggestive of an open pelvic fracture. And in the male, the finding of blood at the meatus or perineal/scrotal ecchymosis suggests an injury to the urethra, which may be caused by a pubic symphysis diastasis.

Secondly, the pelvic bones should be palpated for abnormalities including fracture and instability. This is best assessed by placing both hands on the iliac wings and externally rotating one half of the pelvis while keeping the other half stable. This tests whether one side of the pelvis can be "opened." Then, the iliac wings should be compressed toward the midline to see whether the pelvis can be "closed." Recently, it has been recommended that an experienced clinician perform the stability exam once. Repeat exams may prevent a pelvic clot from forming and thus increase bleeding.

Evaluation of all high-energy blunt trauma patients must always include an AP pelvis radiograph. This is taken at an angle perpendicular to the supine patient, and it must include the entire pelvis. Femoral neck fractures and hip dislocations are other orthopedic emergencies that can be diagnosed on an AP pelvis, and should be ruled out. A CT scan can also provide valuable information, particularly concerning displacement or fracture of the sacroiliac joint. But CT scan is not always possible if the patient is unstable. In patients with a known pelvic fracture, a CT scan of the abdomen should be obtained secondary to the high incidence of associated intra-abdominal injuries. In addition, a CT cystogram if there is hematuria, and a retrograde urethrogram should be performed when one is concerned of a possible urethral injury.

Once you've decided that the patient has a pelvic ring injury, the first question that must be answered is "What is the injury pattern?" There are 3 major patterns of pelvic injury based on mechanism. After the pattern of injury has been established, the next question is, "Is this injury pattern stable or unstable?" These patterns are listed below with their associated x-ray findings and measure of stability:

- **Anterior-posterior compression (APC)** – Pubic symphysis diastasis or pubic rami fracture, resulting in an increase in pelvic volume, "open book" type injury. Typically seen in head-on impact motor vehicle collisions. Considered rotationally unstable if anterior diastasis > 2.5 cm. Most common pattern to cause hemodynamic instability (Fig. D, E, F).
- **Lateral compression (LC)** – Pubic rami fractures which may overlap, resulting in a decrease in pelvic volume. Typically seen in side-impact car collisions. Considered rotationally unstable if associated with posterior sacroiliac disruption. Less likely to cause hemodynamic instability (Fig. A, B, C).
- **Vertical shear (VC)** – one hemi-pelvis is superior to the other with complete sacroiliac dissociation or vertical sacral fracture. Always unstable. May cause hemodynamic instability, but pattern is far less common than the other two (Fig. G).



## YOUNG-BURGESS CLASSIFICATION OF INJURY

Class	Description	Grade
A	Lateral compression	I
B	Lateral compression	II
C	Lateral compression	III
D	Anterior-posterior compression	I
E	Anterior-posterior compression	II
F	Anterior-posterior compression	III
G	Vertical shear	

From Tornetta, P. III. (1999). Pelvis and acetabulum: Trauma. In J. H. Beaty (Ed.). Orthopaedic knowledge update 6. Rosemont, IL: American Academy of Orthopaedic Surgeons (pp 427-439). With permission.

## MANAGEMENT

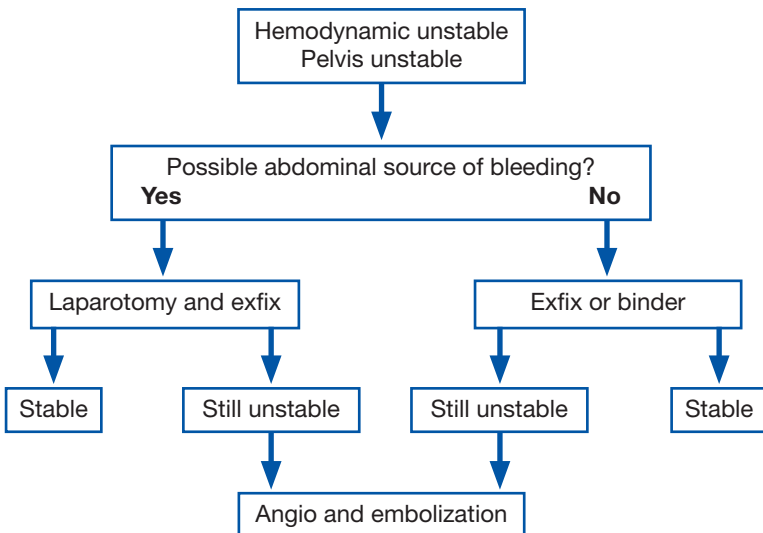
The management of pelvic injured patients depends on their hemodynamic status and whether the injury is stable. If the patient is stable and/or the pelvic injury is stable, there is little that has to be done acutely other than calling for orthopedic consultation. The situation gets tricky when the patient is still unstable after resuscitation AND the pelvis is unstable. If the patient is unstable and has an “open book” type injury with >2.5cm pubic symphysis diastasis, then the next step should be application of a pelvic binder.

A pelvic binder is basically a long piece of cloth pulled together in the front by a Velcro pulley system. It is very easy to use. It should be centered over the greater trochanters and cinched as tight as is realistically possible. Then, an x-ray should be obtained to assess the reduction. If the pubic symphysis is not completely reduced, then more tightening is needed. If a lateral compression type injury has been mistakenly overcompressed, then the tightening can be relaxed. A binder should provide as much stability as an external fixator in the initial 48 hours or so.

After stability is achieved, then other possible sources of bleeding in the chest and abdomen need to be evaluated and treated. If all other possible sources of bleeding have been ruled out, then it can be assumed that the bleeding is purely from the pelvic injury. If the pelvis is well reduced in the binder, then an argument can be made for emergent angiography and embolization. In preparation for angio, the binder may be moved superiorly or inferiorly to allow for access. Also, it is possible to cut a hole in the binder if necessary, but the binder should not be removed in the angiography suite!

The development of the pelvic binder has decreased the need for emergent external fixation of pelvic injuries because it can be safely and quickly applied in the trauma bay, and is designed to remain in place for up to 48 hours (some would argue even longer) to allow for adequate hemodynamic resuscitation prior to surgery. Unstable pelvic ring injuries do require surgical stabilization eventually, which may consist of either external or internal fixation. Pelvic binders are a non-invasive and effective way to buy the patient some valuable time. However, an external fixator should still be used acutely if the pelvis cannot be adequately reduced in the binder, or if there is a soft tissue injury with which the binder would interfere. If the patient has a chest or abdomen injury that requires surgical intervention it can be performed with the binder in place. Alternatively, that may also be a good opportunity to surgically stabilize the pelvis. One possible algorithm for an unstable patient is provided below.

## ALGORITHM



## THINGS TO KEEP IN MIND

- The algorithm above is intended to give you a rough idea of management. There are usually more variables to juggle than those presented above.
- As discussed above, not all pelvic injury patterns are likely to cause hemodynamic instability. The key is understanding which injuries are likely to INCREASE the volume of the pelvis and therefore tear the pelvic veins/arteries. For example, a severe APC type injury loses on average 14.8 units of blood, while a severe LC type injury loses on average 3.6 units of blood.
- Remember that patients with severe APC type injury patterns start out with a mortality rate as high as 40%, not to mention their other confounding problems.
- 90% of pelvic bleeding is from the bone itself or the retroperitoneal venous plexus. Which means that only 10% is arterial, and a much smaller percentage than that may actually be improved by angiography embolization. Angiography is frequently considered a last resort undertaken only if all other possible sources of bleeding have been ruled out and the pelvis has already been stabilized.
- Do not confuse pelvic ring injuries with acetabulum injuries. Acetabulum injuries involve the articular surface of the hip socket. Though they may also affect the stability of the pelvic ring they are rarely life threatening.
- Transfuse blood, FFP and Cryoprecipitate as needed. Trigger the massive transfusion protocol (MTP) for the hemodynamically unstable patient with a pelvic fracture, or those requiring >4 units PRBC. Keep the patient warm to reduce coagulopathy. Utilize a level 1 transfuser for large volume resuscitations.
- Get orthopedics involved as soon as possible. Never be afraid to call for help.

## Indications for and Application of T-Pod Pelvic Binder

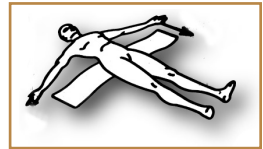
### INDICATIONS

- Open book pelvic fracture
- Sacro-iliac joint separation

### INSTRUCTIONS

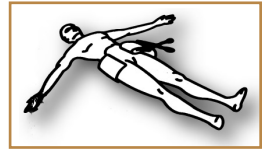
#### Step 1: Unroll Support Binder

- Make sure the patient is lying on his/her back.
- Unroll the Support Binder with the label side away from the patient's body.
- The Pulley System will be attached to one end of the Support Binder.
- Detach the Pulley System from the Support Binder.



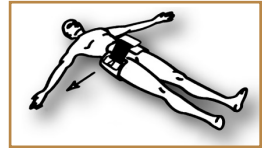
#### Step 2: Placement of Support Binder

- Gently slide one end of the support binder under the small of the patient's back.
- Stop when the end has extended 12 to 18 inches beyond the patient's side.
- Gently slide the support binder down the patient's body, until it lies flat under the pelvis centered over the greater trochanters



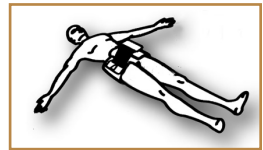
#### Step 3: Sizing of Support Binder

- Fold the short end of the support binder over the patient's lower abdomen
- Cut the longer end at a point that will leave a 6 to 8 inch gap between the two ends.



#### Step 4: Placement of Pulley System

- Pull the two halves of the pulley system open until the strings are fully extended.
- Gently press one half to one end of the support binder until the velcro areas have securely fastened, and the other half to the other end.



#### Step 5: Activation

- Once the pulley system is securely fastened, slowly and steadily pull the handles
- When the pulley system has closed, secure the compression by wrapping the strings around the four protruding hooks until the handle can be securely fastened to the velcro area on either side.
- The patient is now ready for transport.

(re-printed from T-Pod Device Instruction Insert)

## CHAPTER 8

# EXTREMITY TRAUMA

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### **IN THIS SECTION**

*Peripheral Vascular injury*

*Extremity Trauma*

*Rhabdomyolysis*

*Extremity Compartment Syndrome*

## Peripheral Vascular Injury

### BACKGROUND

Tissues at risk from penetrating trauma to the extremities include: arteries, veins, nerves, bones, joints and soft tissue.

### CLINICAL PRESENTATION

Conscious patients will often complain of pain in the extremity. As in penetrating injuries to the neck, signs & symptoms for vascular injury are subdivided into **Hard signs** (those suggestive of an injury requiring treatment) and **Soft signs** (those which are less predictive of injury, but warrant further workup). **Hard signs** include: Absent or diminished pulses, unexplained hypotension, pallor, pulsatile bleeding, expanding hematoma, or audible bruit. **Soft signs** include: Isolated peripheral nerve deficit (proximity), paresthesia or paralysis of extremity, nonpulsatile hematoma, prolonged capillary refill distal to injury, diminished pulses compared to uninjured side, proximity to neurovascular bundle, diminished Ankle Brachial Index (ABI).

### INVESTIGATIONS

Unstable patients or patients demonstrating hard signs of vascular injury should be taken directly to the OR for exploration. In cases of multiple wounds to that extremity: or shotgun blast, one may consider an intraoperative angiogram to further direct the exploration. A quick x-ray in the ER or OR may also help in directing where the exploration should focus.

Plain radiographs can detect foreign bodies, fractures, dislocations, air or effusions in joints, and proximity of bullets to neurovascular bundles.

In stable patients, the next step is to perform an Ankle-brachial index. A ratio of less than 0.9 is considered abnormal and warrants further investigation.

CT soft tissue and angiography can be utilized in patients with penetrating trauma to the extremities who are stable and are without hard signs of vascular injury.

Angiography is the gold standard for evaluation.

Color Flow Doppler and CT angiography can also be used to assess the arteries. True angiography is useful in stable patients with decreased/absent pulses or bruit/thrill prior to taking to the operating room. Otherwise, a CT angio can be sufficient.

## COMPARTMENT SYNDROME

Compartment Syndrome may result from ischemia of a muscle compartment or from blood or fluid extravasating into a compartment. Limb survival is threatened by delays in diagnosis. In patients with signs or symptoms suggesting compartment syndrome, consider emergent fasciotomy or measurement of compartment pressure. The compartment pressures can be measured with a manometer. Elevation of pressure above 30mmHg is abnormal (and a pressure of 15mmHg less than diastolic pressure requires fasciotomy). (See the Extremity Compartment Syndrome Chapter for more information).

## EMERGENCY ROOM MANAGEMENT

- Immediately reduce and immobilize displaced or angulated fractures
- Direct pressure to control local hemorrhage.
- Do not apply random clamps to the bleeding area, as this can make the injury worse.

## OPERATIVE MANAGEMENT

- Operative strategy is dictated by the patient's individual condition, and coordination amongst specialists is often necessary.
- Patients who are profoundly ill with other injuries, may require a 'damage control' approach with temporary shunting and later definitive repair. Others may allow for longer vascular repairs requiring harvesting saphenous vein with transposition.
- For injuries with orthopedic fractures, the typical approach is to repair the orthopedic injury first, to avoid impacting the vascular repair, as this may restore the stretched vessel to normalcy. In these situations, a temporary shunt may be placed prior to the orthopedic procedure, and definitive repair after the orthopedic procedure is completed.
- Proximal and distal thrombectomies should be performed prior to completion to remove any clot that may have accumulated.
- Infusion of 1:10 heparin solution helps prevent early thrombosis following repair without risk of bleeding complications.
- Most venous injuries can be ligated. However, if the patient's condition permits, a repair of a large vein may be performed.
- Pseudoaneurysm and arteriovenous malformations are common late complications often requiring reoperations.

### ***Fasciotomies***

- Therapeutic fasciotomies are required whenever signs or symptoms of compartment syndrome exist. All compartments should be released, and a 2 incision technique is preferred. Prophylactic fasciotomies are more controversial. These may be considered when a major artery or vein is ligated or if ischemic time exceeds 6 hours.



## Extremity Trauma

### BACKGROUND

- Musculoskeletal injuries may be dramatic or subtle in presentation. They must be recognized and treated accordingly, to protect the patient from further disability and prevent complications. Continued re-evaluation of the patient is necessary to identify all injuries.

### PRIMARY SURVEY

- **Hemorrhage:** It is imperative to recognize and control hemorrhage. Soft-tissue lacerations may lead to hemorrhage which is best controlled by direct pressure. Hemorrhage from long-bone fractures may be significant and can be controlled by (reduction and) splinting to decrease motion and enhance tamponade effect of muscle. Open fractures require a sterile pressure dressing.
- **Deformity:** All fractures, whether open or closed, should be reduced as close to anatomic position as possible and splinted to control bleeding, decrease pain, and minimize soft-tissue injury. Joint dislocations should be splinted as found, or in an anatomic position if reduction was successful.
- **Radiographs:** Typically obtained during secondary survey, but an AP pelvis should be obtained ASAP if the patient is hemodynamically unstable and no source of hemorrhage has been identified.

### SECONDARY SURVEY

- **History:** Mechanism of injury can be very useful in determining presence and severity of injuries not readily apparent. (e.g., Vehicular crash, fall, crush, explosion). Environment: temperature, toxic agents, broken glass, bacterial contamination.
- **Prehospital observation:** position of the body, bleeding or pooling of blood at scene, bone or fracture ends exposed, open wounds, obvious deformity or dislocation, motor and/or sensory deficit, delays in extrication.
- **Physical Exam:** Patient must be completely undressed. Four components assessed:
  - skin
  - neuromuscular function
  - circulatory status
  - skeletal and ligamentous integrity
- **Look & ask:**
  - Check for color and perfusion, wounds, deformity, swelling, bruising. Observe for spontaneous motor function. The ability to move all major joints through a full range of motion usually indicates that the nerve-muscle unit is intact and the joint is stable.

- **Feel:**
  - Palpate to check sensation (nerve function) and areas of tenderness (fracture or muscle injury). Pain, tenderness, swelling, deformity, and abnormal motion through a bone confirm the presence of a fracture. Joint stability is assessed by clinical exam. Abnormal motion indicates ligamentous injury, but spasm may mask injury due to muscular contraction.
- **Circulation:**
  - Check distal pulses of each extremity and capillary refill of the digits. In cases of hypotension, use a Doppler probe which ensures no proximal lesion if a triphasic signal is present. A Doppler ankle/brachial index (ABI) of  $< 0.9$  is indicative of abnormal arterial flow and requires further workup by vascular duplex studies or angiography. A pulseless extremity requires emergent Trauma Surgery Evaluation. One should also examine for any palpable thrills or audible bruits.
  - ABI = systolic pressure of injured extremity (at the ankle) divided by systolic pressure of uninjured upper extremity Normal is 0.9 to 1.1.
- **Radiographs:**
  - Typically suggested by clinical examination. Radiographs are obtained prior to reduction maneuver unless there is vascular compromise or impending skin breakdown. Always include the joints above and below any area of question.

## POTENTIALLY LIFE-THREATENING EXTREMITY INJURIES

- **Major Pelvic Disruption with Hemorrhage**
  - Emergent Trauma & Orthopedic consult is required. (See appropriate chapter)
- **Major Arterial Hemorrhage**
  - Injury: May result from penetrating or blunt trauma. Significant hemorrhage may result through an open wound or into soft tissues.
  - Assessment: Check for external bleeding, change in quality or loss of pulse, ABI.
  - Management: Immediate consult with a surgeon (skilled in vascular surgery), direct pressure, and fluid resuscitation. Proper use of a pneumatic tourniquet can be lifesaving. Open fractures should be reduced and splinted with direct pressure applied to the open wound. Emergent Trauma consult should be obtained.
- **Crush Syndrome (Traumatic Rhabdomyolysis)** (See appropriate chapter)
  - Injury: Syndrome encompasses direct muscle injury, muscle ischemia, and cell death with release of myoglobin. May lead to acute renal failure. Seen in individuals with crush injury of a significant muscle mass.
  - Assessment: Results in dark amber urine that tests positive for myoglobin.
  - Management:
    - Intravenous fluid resuscitation is critical in protecting the kidney.
    - Sodium bicarbonate will reduce intratubular precipitation of myoglobin.
    - Maintain UOP  $\geq 100$  mL/hr.
    - Emergent Trauma consult should be obtained.

## LIMB-THREATENING INJURIES

- **Open Fractures and Joint Injuries**

- **Injury:** In addition to surrounding soft tissue injury, open fractures pose the problem of bacterial contamination. This makes these injuries prone to problems with infection as well as bone and soft tissue healing, potentially affecting function. This is a surgical emergency! Open fractures have a worse prognosis and their treatment may need to be significantly altered if they are left untreated for greater than six hours.
- **Assessment:** It is important to note the circumstances of the injury and the time of occurrence. If a fracture and an open wound exist in the same limb segment, the fracture is considered open until proven otherwise. If an open wound is noted over or near a joint, it is considered to be a traumatic arthrotomy until proven otherwise.
- **Management:** An open fracture or joint injury must be promptly recognized, surgically explored, and debrided in the operating room. An emergent orthopedic consult is warranted.

- **Vascular Injuries**

- **Injury:** Should be suspected if there is vascular insufficiency associated with a history of blunt, crushing, twisting, or penetrating injury to an extremity.
- **Assessment:** Check peripheral pulses using palpation and/or Doppler probe, capillary refill, and ABI.
- **Management:** An acutely avascular extremity must be recognized promptly and treated emergently. Muscle begins to undergo necrosis after 6 hours of ischemia. Vascular compromise may develop in an extremity that has been splinted or casted. Traumatic amputations are severe open fractures. A patient with multiple injuries requiring resuscitation and emergency surgery is not a candidate for replantation. An emergent vascular and orthopedic consult is warranted for suspected vascular injuries.

- **Compartment Syndrome** (See appropriate chapter)

- An emergent Trauma & Orthopedic consult is warranted.

- **Neurologic Injury Secondary to Fracture Dislocation**

- **Injury:** A bone fracture or joint dislocation may result in injury to a nerve due to their relative proximity. Outcome is optimized by prompt recognition and treatment of the injury.
- **Assessment:** The patient's neurologic status must be determined and monitored for changes. Assessment usually requires a cooperative patient.
- **Management:** The extremity should be splinted in the dislocated position until a knowledgeable physician is available to perform a gentle reduction. After reduction the neurologic status is re-examined and the extremity splinted. An emergent orthopedic consult is warranted.

## OTHER EXTREMITY INJURIES

### • Contusions and Lacerations

- Lacerations must be assessed for injury to underlying structures including vessels and nerves. They need to be explored, irrigated, debrided, and closed either in the ER or if extensive/complex in the OR. Contusions are recognized by local pain and decreased use of the extremity. Treated by rest and ice.

### • Joint Injuries

- Injury: Ligament injury may occur without joint dislocation and result in compromised function.
- Assessment: Patient may report an abnormal stress to the joint. Examination will reveal tenderness of the affected ligament and passive ligament testing will reveal instability. Radiographs are usually negative except for occasional avulsion fragments.
- Management: Joint should be immobilized, and neurovascular status re-checked. A non-emergent orthopedic consultation is warranted.

### • Fractures

- Injury: A break in the continuity of the bone cortex. Usually associated with some form of soft tissue injury, whether closed or open.
- Assessment: Examination usually reveals pain, swelling, deformity, tenderness, crepitus, skin discoloration, and abnormal motion at fracture site. Radiographs must be taken to provide at least two views at right angles to each other and include the joint above and below to explore the possibility of dislocation or other injury.
- Management: Immobilization of the joint above and below, followed by neurovascular re-examination. A non-emergent orthopedic consultation is warranted.

## PRINCIPLES OF IMMOBILIZATION

- Extremity injuries must be splinted prior to transport. The neurovascular status of a limb must be checked after reduction and splinting.
- Femur fracture: Immobilized in traction splints. Traction must be periodically released to avoid skin and/or neurovascular compromise.
- Knee injuries: Knee immobilizer or long leg splint with knee in 10 degrees of flexion.
- Tibia fracture: Immobilized in a long leg splint, knee flexed ~30 degrees.
- Ankle fracture: Must be splinted out of the equinus position (i.e., in neutral) to avoid a heelcord contracture.
- Shoulder injuries: Sling or sling and swathe.
- Humerus fractures: Coaptation splint.
- Elbow injuries: Posterior mold splint usually at about 90 degrees flexion.
- Forearm injuries: Sugartong splint, MCP joints free.
- Wrist injuries: Sugartong splint, MCP joints free.
- Finger injuries: Wrist slightly dorsiflexed, MCPs at 70-90 degrees, IPs extended.

## **OCCULT SKELETAL INJURIES**

- Ongoing reassessment of the patient is necessary through the primary and secondary surveys as well as later during the hospital stay. Injuries of the small bones/structures of the hands and feet often go unnoticed initially. Press on EVERY PART of EVERY BONE to elicit tenderness and/or crepitation!

## **PITFALLS**

- Occult blood loss sources include the retroperitoneum from pelvic ring injuries, the thigh from femur fractures, and any open fracture with blood loss occurring prior to arrival at the hospital.
- Compartment syndrome is limb-threatening, must be recognized and treated promptly to optimize ultimate function.

## Rhabdomyolysis

### INTRODUCTION

Rhabdomyolysis occurs in the setting of trauma. While rhabdomyolysis is rarely an impressive part of the presentation of the trauma patient, it is important to anticipate and prevent the serious complications that can arise from rhabdomyolysis.

The diagnosis and treatment of trauma associated rhabdomyolysis is not fundamentally different than the diagnosis and treatment of rhabdomyolysis due to other causes such as medications, malignant hyperthermia, infection, inflammation, metabolic or other etiologies.

Rhabdomyolysis should be anticipated in the setting of major trauma, burn injury, electrical injury, crush injury, major fractures, peripheral compartment syndromes or situations where patients were lying in one position for prolonged periods of time (i.e., intoxicated patients, stroke patients, following prolonged procedures or ICU stay for morbidly obese patients). Rhabdomyolysis is characterized by the cellular destruction of skeletal muscle. Most of the immediate clinical problems arise either as a direct consequence of electrolyte release from dying muscle cells or from renal failure induced by the deposition of myoglobin pigments in the renal tubules. With proper care, complete recovery is the rule and the patient's clinical course is dictated by the extent of accompanying injuries. Only with the most severe cases of rhabdomyolysis, or with repeated instances of rhabdomyolysis does permanent muscle weakness present an important clinical threat.

The diagnostic hallmark of clinically significant rhabdomyolysis is the elevation of CPK in excess of 10,000 IU/L. Rhabdomyolysis is often not a serious clinical issue until the CPK rises above 20,000 IU/L, but supportive care should begin when the CPK is 10,000 IU/L. Other chemical markers of rhabdomyolysis are abnormalities of electrolytes or enzymes normally found in skeletal muscle. Typically, these include hyperkalemia, hyperphosphatemia, hypocalcemia and much less commonly, an elevation in serum or urinary myoglobin. As the myoglobin pigment breaks down and/or is filtered by the glomeruli, red pigmented casts may be seen by microscopic examination of the urine. An additional lab study suggesting rhabdomyolysis is a urinalysis demonstrating "blood", yet a cell count demonstrating no RBCs (secondary to myoglobin being confused for hemoglobin).

The most life threatening effect is renal failure secondary to pigment deposition and associated inflammation in the tubules. Hypocalcemia occurs early as metastatic calcification occurs in the high phosphorous environment of necrotic muscle. Later, as this muscle is digested, hypercalcemia may occur. Uric acid routinely increases from the breakdown of muscle.

## TREATMENT

By tradition, the treatment of rhabdomyolysis is normal saline, alkalization of the urine with bicarbonate and diuresis with mannitol to clear the renal tubules of myoglobin pigments. There is little evidence to support either alkalization of the urine, or the use of mannitol. These both can have adverse consequences. The preferred approach is rapid and complete volume resuscitation to support the GFR and to dilute the urine. The patient's serum should be sampled frequently for potassium, phosphate, CPK, calcium, uric acid and other electrolyte abnormalities that may arise in these seriously ill patients with a diminished homeostatic reserve.

Plasma volume expansion with intravenous isotonic saline should be given as soon as possible, even while trying to determine the cause of the rhabdomyolysis. Adequate volume expansion should not be inferred by seemingly normal blood pressures. Severe hypovolemia and hypoperfusion is commonly found coincident with seemingly "normal" or "adequate" blood pressures. The patient should be assumed to be hypovolemic after major trauma irrespective of the blood pressure, until adequate tissue perfusion has been demonstrated. At the risk of over saturation, there is no blood pressure goal that is an adequate proxy for adequate perfusion. Adequate perfusion should only be inferred from measures of adequate end organ, tissue, global and regional perfusion. Two of the more reassuring measures of adequate perfusion are urinary output of 0.5ml/kg/hr and lactate levels that are normal. Even the presence of "normal" mixed venous oxygen saturation may be misleading. Having said that, mixed venous Oxygen saturations may be misleading in the face of hypoperfusion. These measures are vastly superior to blood pressure measurements.

The immediate goal is to achieve a forced diuresis. Therefore, brisk urinary output is the major guide to volume expansion. Mannitol infusion can be used to assist in achieving diuresis, but care must be taken to replace the osmotic induced volume loss with equal volumes of isotonic saline. Packed red blood cells should be used for volume expansion only if there are other compelling clinical issues. On the other hand, patients with extremely low oncotic pressures, normally caused by very low serum albumin concentrations, may require colloidal substances in order to maintain adequate plasma volumes and the subsequent diuretic effect.

Since the goal is dilution of the urine achieved by a brisk diuresis, it is normally not helpful to follow other measures of plasma volume. If the patient does not experience a brisk diuresis after what seems to be an adequate volume challenge, or if the patient develops pulmonary complications, then other measures of plasma volume should be obtained. Direct estimates of cardiac preload and plasma volume are preferred. These include echocardiographic estimates of the left ventricular volume or pulmonary artery catheter measurements of right ventricular end diastolic volume. Of these two measurements, only the latter is readily reproducible and operator independent. Indirect estimates are occasionally helpful, and can be inferred by measuring the change in stroke index or cardiac index in response to volume and/or by measuring the mixed venous oxygen saturations. It cannot be overstressed that attempting to estimate plasma volume or cardiac

preload from the CVP or the PWCP is fraught with error and should be abandoned. Studies have shown that these measurements have a high degree of intraobserver variability. Furthermore, even if the correct pressure is reproducibly determined, there is not a direct relationship between any combination of these pressures and cardiac preload.

The metabolic effects of rhabdomyolysis should be anticipated and treated. These include hyperkalemia, hyperphosphatemia, hypermagnesemia and hypocalcemia. Therefore, serum levels of these substances and levels for creatinine phosphokinase should be monitored every four to six hours until stability is assured.

### **CLINICAL PRACTICE GUIDELINE FOR RHABDOMYOLYSIS IN THE SETTING OF TRAUMA**

- Clinical and biochemical evidence of potential rhabdomyolysis should be sought in every case of major trauma, or any compartment syndrome that has not been promptly and completely relieved. To this end, serum should be sampled every four hours for CPK, K, Ca, phosphorous and magnesium.
- Adequate volume resuscitation should be ensured as soon as bleeding is controlled. Adequate volume resuscitation should be questioned if the urinary output is less than 0.5ml/kg/hr, or if there are other markers of global or regional hypoperfusion.
- If the serum CPK equals or exceeds 10,000, or if it is rising, then sampling of the serum for CPK, K, Ca, phosphorous and magnesium should be continued until the CPK is both falling and below 10,000.
- If the CPK equals or exceeds 10,000, then urinary output should be increased as tolerated to at least 1-3 ml/kg/hr. The preferred method of achieving this urinary output is by increasing the plasma volume with isotonic crystalloids or in select cases colloidal substances.
- Diuretics such as mannitol or furosemide may be helpful in achieving adequate urinary output, especially in the early hours after trauma or in patients with comorbid medical conditions. However, it should be recognized that the use of diuretics produces an artificially high urinary output that requires replacement of the lost volume. In addition, diuretics compromise the ability to follow urinary outputs as a marker of global perfusion, and may require institution of other measures. Finally, mannitol may induce a hyperosmolar state in the face of urinary failure, and any diuretic may cause electrolyte imbalances.
- The occurrence of hyperkalemia, hyperphosphatemia, hypermagnesemia and calcium disturbances should be anticipated. Fluids and feedings should be adjusted accordingly and electrolyte imbalances should be treated with traditional measures.
- Succinyl choline should be avoided for rapid sequence intubation. Rocuronium 0.6-1.2 mg/kg should be used instead. (This is also true for any patient who has been immobilized for prolonged periods, paralyzed, or sustained burns secondary to the risk of hyperkalemia).



## Extremity Compartment Syndrome

### BACKGROUND

A compartment syndrome is a condition in which pressure within a confined space (compartment) becomes elevated to the point where irreversible damage to its contents may occur.

### PATHOPHYSIOLOGY

The basis for an acute compartment syndrome is a disruption in the normal pressure and volume relationship within a tissue space. When the contents of a space increase without a proportionate increase in the size of the space, pressure within the space rises. Trauma often results in swelling from increased capillary permeability and/or bleeding in the affected areas. This increased fluid volume within a compartment results in elevated tissue pressure. This in turn can impair venous outflow, further increasing the volume and pressure within a compartment. Once the pressure rises to the level of arteriolar pressure, ischemia begins, damaging the contents of the compartment. Irreversible muscle and nerve damage can occur if left untreated. Common traumatic etiologies leading to compartment syndrome include crush injuries, burns, electrocutions, and severe fractures.

### DIAGNOSIS

#### *Physical Exam*

Many have learned “5 P’s” of the clinical exam seen in a compartment syndrome; **p**ain, **p**ulselessness, **p**aresthesias, **p**oikilothermia, and **p**aralysis. In fact, some of these are seen only very late in the condition and often are not seen at all. Pulselessness in a normotensive patient is not caused by compartment syndrome alone, and if present, arterial injury is likely.

A common characteristic of development of compartment syndrome is a tense, swollen compartment with severe, unrelenting pain. This pain is significantly worsened by passive stretching of the muscles in the compartment. The compartment will be very tender, even at a site distant from the level of the injury. Neurologic signs such as paresthesias, numbness, and weakness may become evident as the syndrome progresses.

Extremity trauma from conditions such as fractures, burns, contusions, and ischemia will be painful to the awake and alert patient. In addition, provocative maneuvers in physical exam such as palpation and passive motion will exacerbate the pain. The difference seen in a compartment syndrome is that the pain will be out of proportion to the expected level of pain for the injury. Although this is mostly a subjective measure, it is a reliable indicator for those with experience. Increasing analgesic requirements may also be helpful as an indicator in making the diagnosis.

## Compartment Pressure Measurements

The diagnosis is often made by clinical signs on physical examination. If these physical signs are present, the diagnosis is made without the need for measuring tissue pressure. However, in patients who are not awake, alert, or cooperative, which is not uncommon in the trauma patient due to head injury, intoxication, or sedation, physical examination is less reliable. In these patients or when the diagnosis is otherwise equivocal and physical findings inconclusive, measuring compartment tissue pressures is indicated.

It is important to measure all compartments at risk. It is also important to remember the development of an acute compartment syndrome is a dynamic process. A single pressure measurement does not rule out the possibility of one developing. Repeat or continuous pressure monitoring may be indicated.

The threshold for which a pressure measurement becomes significant has been controversial. Some have recommended fasciotomy for any pressure greater than 30 mm Hg. Others have recommended decompression for when pressures rises to as high as 45 mm Hg. Recognizing the role of the patient's clinical condition, diastolic blood pressure has been added as a parameter by some. Recent literature supports the use of the difference between the diastolic pressure and the compartment pressure, denoted as  $\Delta p$ , as a more reliable indicator than an absolute value. **A  $\Delta p$  of 30 mm Hg or less has gained favor as a clinically significant and reliable threshold.**

## TREATMENT

Once the diagnosis is made, it is important to remove any constrictive bandages and dressings. Urgent surgical decompression by fasciotomy of all involved, or at risk compartments, should be performed.

## PITFALLS

Crush injury is a condition produced by prolonged and continuous pressure on an extremity. Although many of the signs and symptoms may be similar to that of a compartment syndrome (including elevated compartment pressures), the timing of these features as well as systemic manifestations differ. This condition often begins with a flaccid paralysis and little or no pain. History is also valuable in making this differentiation which is important to do since fasciotomy is contraindicated in crush injury.

In the presence of an arterial injury, a compartment syndrome (if it develops) will usually occur after restoration of blood flow. Therefore, patients who undergo arterial repair need to be monitored closely for compartment syndrome, or undergo prophylactic fasciotomies.

## SUMMARY

Compartment syndrome is a condition in which the swelling of an anatomic space raises the pressure to the point where ischemia and damage to the compartment's contents may occur. It is characterized clinically by a tense compartment that is very painful, especially with passive stretch of the involved muscles. This pain is out of proportion to that expected for the injury. Neurologic symptoms may develop. The diagnosis is often made by physical examination in the awake and alert patient. If clinical findings are equivocal or the patient is not awake and able to cooperate, compartment pressure measurements may be indicated. **A  $\Delta p$  (difference between the diastolic pressure and the tissue pressure) of 30 mm Hg or less is clinically significant.** Treatment is surgical decompression via fasciotomies.

## CHAPTER 9

# BURNS

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### **IN THIS SECTION**

*Acute Burn Management*

*Burns Management Guide*

TRAUMA  
BOOK **2012**

## Acute Burn Management

### DEFINITION

#### **Burn Injury**

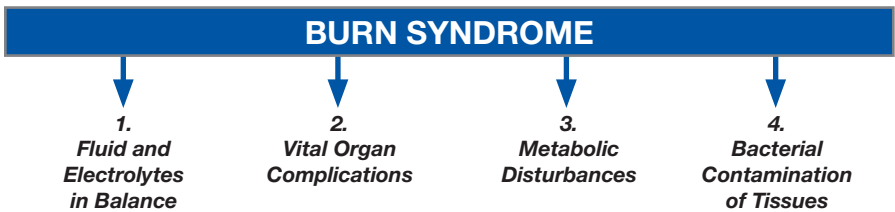
- Damage to skin and or its contents by thermal, chemical, electrical or radiation energies.

#### **Thermal Injury**

- Thermal injuries are the most common and frequently present with concomitant inhalation injuries.
- Thermal injury involves heating tissues above the critical level at which damage occurs at protein denaturization. The depth of tissue injury is determined by the heat content of the burning agent, length of exposure and thermal conductivity of the involved tissue.

#### **Burn Syndrome**

- Following major burn injury there are several physiological changes that make up the clinical presentation of a burn patient.



#### **1. Fluid and Electrolytes in Balance**

- The burn wounds become edematous secondary to microvascular changes caused by the thermal injury and the release of chemical mediators of inflammation. This produces intravascular losses of water, sodium, albumin and red blood cells.
  - Shock develops unless intravascular volume is rapidly restored.

#### **2. Complications from Vital Organs**

- All major organs can be affected by burn injury. Multi-system organ failure is a common final pathway leading to burn morbidity and mortality
  - Renal Insufficiency
    - From hypoperfusion and nephron obstruction from myoglobin (secondary to muscle/soft tissue damage).
  - Pulmonary Dysfunction
    - From the initial direct burn injury to the respiratory tract or from progressive respiratory insufficiency due to pulmonary edema, ARDS, or bronchopneumonia.

- Gastrointestinal
  - Paralytic ileus, abdominal compartment syndrome (from large volumes of fluid resuscitation) and gastrointestinal ulcerations (Curling's Ulcer).

### 3. **Metabolic Disturbances**

- Increased resting oxygen consumption (hypermetabolism), excessive nitrogen loss (catabolism), and weight loss (malnutrition).

### 4. **Bacterial Contamination of Tissues**

- Burn damaged skin has a high potential for surface invasion of microorganisms. Persons with major thermal injury have impaired immunologic defences; therefore, increasing the risks for septic shock.
  - Gram positive organisms are the most common cause of early burn wound infection

## EMERGENCY TREATMENT

### *Initial Burn Management*

#### **Ventilation**

- Patency of the airway and ventilatory status needs to be assessed to determine the need for oxygen administration, endotracheal intubation and ventilatory support.
- Administer 100% O<sub>2</sub> by mask or nasal cannula. For patients with carbonaceous sputum, hoarseness, stridor, hypoxia, abnormal chest x-ray, or elevated blood CO levels, consider endotracheal intubation.

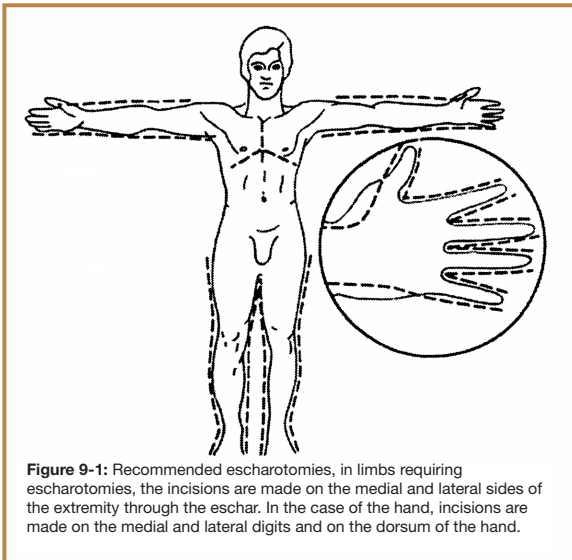
#### **Fluid Resuscitation**

- >15% TBSA. Use peripheral vein preferably in unburned skin.
- Upon ER admission:
  - Ringers lactate 1000 ml/hr in adults. Initial fluid resuscitation until burn size and fluid requirement is met.
  - 400-500 ml/m<sup>2</sup> BSA/hr in children until accurate assessment of burn size and fluid requirement is made.
  - Insert Foley catheter to monitor urinary output; maintain greater than 0.5 ml/kg/hr
  - Once TBSA is known, use Parkland formula. Ringers lactate 4 mg/kg/TBSA burned.
    - > First half given first 8 hours post-burn.
    - > Second half given over the following 16 hours.

#### **Patient Evaluation**

- Allergies – medications – pre-existing diseases, events of the injury such as time, location of other injuries.
- History of loss of consciousness.
- History of event (i.e., motor vehicle collision, assault, etc.)

- History of drug or alcohol use.
- Neurological exam.
- Facial burns should have corneal exam with fluorescence staining.
- Physical examination for associated occult injuries
- Routine Admission labs and Medications For
  - Major Burns
  - CBC
  - Serum Electrolytes
  - Glucose, BUN, Creatinine
  - Albumin, calcium
  - CPK (Rhabdomyolysis, compartment syndrome)
  - Tetanus toxoid, H2 Blockers
- In flame burns with potential inhalation injury, pulmonary assessment should include arterial blood gases, carboxyhemoglobin levels and chest X-ray.
- All extremities should be examined for pulses. If pulses are absent and fluid resuscitation is adequate to the involved limb, consider urgent escharotomy (see diagram)
- EKG in patients greater than 40 years of age and all electrical injuries.
- Fasciotomy should be considered in high voltage electrical injuries or severe crush injuries.
- Cleanse burn wound with bland soap and water.
- Begin naso-gastric tube feeding within 6 hours.
- Maintain normal body temperature.



**Figure 9-1:** Recommended escharotomies, in limbs requiring escharotomies, the incisions are made on the medial and lateral sides of the extremity through the eschar. In the case of the hand, incisions are made on the medial and lateral digits and on the dorsum of the hand.



*Begins after cardiopulmonary assessment is completed and fluid resuscitation is underway.*

### **Depth**

- Difficult and misleading; can change over 48 hours. See chart.
- Primary
  - Sunburn – inconsequential in burn wound management.
- Secondary
  - Superficial: heals in approximately 10 days.
  - Deep: heals in approximately 4 weeks.
- Tertiary
  - Full thickness: heals by scarring in more than 4 weeks.



**TABLE: BURN CLASSIFICATION**

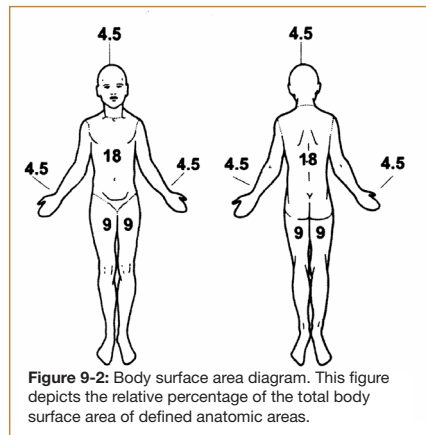
	First Degree	Second Degree	Third Degree
Cause	<ul style="list-style-type: none"> <li>Exposure to sunlight</li> </ul>	<ul style="list-style-type: none"> <li>Limited exposure to hot liquid, flash, flame or chemical agent</li> </ul>	<ul style="list-style-type: none"> <li>Prolonged exposure to flame, hot object, or chemical agent</li> </ul>
Color	<ul style="list-style-type: none"> <li>Red</li> </ul>	<ul style="list-style-type: none"> <li>Exposure of limited duration to lower temperature (40-55°C/104-137°F)</li> </ul>	<ul style="list-style-type: none"> <li>Scalds, flash burn without contact, weak chemical</li> </ul>
Surface	<ul style="list-style-type: none"> <li>Dry or small to moderate-sized blisters</li> </ul>	<ul style="list-style-type: none"> <li>Bullae or moist weeping surface</li> </ul>	<ul style="list-style-type: none"> <li>Dry, with thrombosis of superficial vessels</li> <li>Focal tissue loss – high-voltage electric injury</li> <li>Soapy tissue necrosis – strong alkali</li> </ul>
Sensation	<ul style="list-style-type: none"> <li>Painful</li> </ul>	<ul style="list-style-type: none"> <li>Painful</li> <li>Deep second-degree burns may be anesthetic to pinprick and intact pressure sensation</li> </ul>	<ul style="list-style-type: none"> <li>Insensate surface</li> </ul>
Depth	<ul style="list-style-type: none"> <li>Superficial</li> </ul>	<ul style="list-style-type: none"> <li>Partial Thickness</li> <li>Deep partial thickness</li> </ul>	<ul style="list-style-type: none"> <li>Full Thickness</li> </ul>
Healing	<ul style="list-style-type: none"> <li>3-6 days</li> </ul>	<ul style="list-style-type: none"> <li>10-21 days – superficial second degree</li> <li>21 days – deep second-degree</li> </ul>	<ul style="list-style-type: none"> <li>Requires Grafting</li> </ul>

**Estimating Burn Size**

- Rule of nines (see chart)
- Palm of hand (patient) is approximately 1% TBSA

**Burn Agents**

- Flame
- Contact
- Hot Water
- Chemical
- Electrical
- Radiation



**Classification**

- Major burns – transfer to burn unit
- Moderate and Minor burns – outpatient
- Management, occasional hospitalization

**ACUTE BURN WOUND MANAGEMENT****Thermal – Flame and Hot Water**

- Gently clean burned area with mild soap and water.
- All loose necrotic tissue and blisters should be removed.
- Cover burn wounds with topical antimicrobial (see chart).
- Systemic antibiotic not indicated unless there is evidence of cellulitis.

**Chemical**

- Irrigation of involved areas with copious amounts of water to dilute chemical agent (20-30 minutes).
- Additional treatment dependent upon chemical agent (alkaline, acid, phosphorus).

**Electrical**

- Burn care similar to thermal burns
- Need EKG, electrolytes
- Foley catheter, check for rhabdomyolysis
- Evaluate and manage for compartment syndrome

**Burn Wound Topical Antimicrobials**

Type	Advantages and Disadvantages
Antimicrobial Salves Silver Sulfadiazine (Silvadene)	Broad-spectrum antimicrobial; penetrates eschar; painless and easy to use
Mafenide acetate (Sulfamylon)	Broad-spectrum antimicrobial; penetrates eschar; may cause pain on application and metabolic acidosis
Bacitracin	Gram positive spectrum; painless
Neomycin	Narrow spectrum; painless; significant potential for allergic reactions
Mupirocin (Bactroban)	Excellent Staph coverage; painless
Nystatin (Mycostatin)	Effective in inhibiting most fungal growth
Antimicrobial Soaks Dakin's Solution 1/32 Strength (3 ml bleach/liter of water)	Effective against almost all microbes; readily available; painless
Chlorhexidine Gluconate 4ml/12ml water, then 1ml/liter of water	Effective against almost all microbes; readily available; painless

## **Burns Management Guide**

### **PURPOSE**

To establish a guideline for the care of burns patients at Ventura County Medical Center.

### **PROCEDURE**

- All patients are to have a thorough Primary Survey with immediate management of any life threatening issues.
- After completion of the Primary Survey, a complete secondary survey should be performed.
- Patients who have burns less than 10% of the total body surface area will be admitted to our facility under the TRAUMA SERVICE.
- Burn patients who require referral to a burn center will need to be transferred as soon as the patient is stable.
  - The primary and secondary survey should be performed as usual, and life threatening issues should be dealt with immediately.
  - If a burn patient requires an emergent procedure in order to be stabilized, these will be performed prior to transfer.
  - Contact should be made with VCMC's contracted burn center.
  - During the time awaiting transfer, a consultation will be obtained from the Intensive Care Physician on call. The primary lead physician will be the Trauma Surgeon.
  - The Trauma Surgeon will be expected to evaluate and document a patient's stability prior to transfer, or emergent surgery by another service.
  - Burn injuries that should be referred to a burn center include the following:
    - Partial-thickness burns of greater than 10% of the total body surface area.
    - Burns that involve the face, hands, feet, genitalia, perineum, or major joints.
    - Third degree burns in any age group
    - Electrical burns, including lightning injury
    - Chemical burns
    - Inhalation injury
    - Burn injury in patients with pre-existing medical disorders that could complicate management, prolong recovery, or affect mortality.
    - Children with any of the above burn injuries, or if the severity of the burns exceeds the level of care provided by VCMC.

Burn injury in patients who will require special, social, emotional, rehabilitative intervention.

## CHAPTER 10

# SPECIAL POPULATIONS

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### **IN THIS SECTION**

*Pediatric*

*Geriatric*

*Trauma in Pregnancy*

*Pregnancy and Radiation Risk*

TRAUMA  
BOOK **2012**

## Pediatric Trauma

Trauma remains the number one cause of childhood death and disability, with 20,000 yearly deaths, 120,000 newly disabled children, and 500,000 hospitalizations from 1.5 million injuries. Most of these injuries are caused by motor vehicle crashes, burns and falls.

Prehospital Preparation: Upon receiving preliminary information regarding the extent of injuries to the child, notify appropriate specialized personnel (e.g. Pediatric surgeon, neurosurgery, trauma team, intensivist, anesthesiologist) based on suspicion of any of the following:

- Impaired airway, breathing, or circulation
- Depressed level of consciousness
- Suspected spinal cord injury
- Extensive burns
- Penetrating trauma

### DIFFERENCES BETWEEN ADULT AND PEDIATRIC PATIENTS IN RESPECT TO TRAUMA:

- Surface area: Children have large surface area: volume ratios, increasing heat loss and resulting in rapid hypothermia.
- Skeleton: Elastic bones may allow for internal injuries without overlying fractures.
- Head/airway relationship: Large occiput can create flexion obstruction of airway in supine position, necessitating shoulder roll to straighten neck and open the airway.
- Primary Survey: Identical to adult patients, including cervical spine immobilization with appropriate size collar (or manually). Of note, children often become “combative” to emergency personnel when restrained and in an unfamiliar environment. Engaging the conscious child in conversation frequently helps minimize anxiety and allows for improved evaluation of the extent of injuries.
  - **Airway:** Cervical spine tends to flex due to large occiput in infants. Generally, small shoulder roll will bring the neck to neutral position, relieving any flexion induced obstruction (while maintaining c-spine precautions). The Larynx tends to be anterior in children and the trachea is often soft and short. Coupled with large tongue, this often makes intubation more difficult. Consider straight laryngoscope (Miller) blade in infants less than 12 months of age (see the rapid sequence intubation table). When a surgical airway is needed, one must remember that a cricothyroidotomy is contraindicated in children. Instead, a temporary needle cricothyroidotomy followed by a formal tracheostomy should be performed (see the Surgical Airway Chapter).
  - **Breathing:** Underlying lung trauma without rib fractures is possible due to elasticity of ribs. Always consider occult lung injury, pneumothorax, or hemothorax, especially in presence of poor ventilation or oxygenation

despite proper endotracheal tube placement. In addition, one should remember that infants are obligate nasal breathers and therefore an OGT should be used in place of an NGT.

- **Circulation:** Children have impressive physiologic reserve to counteract blood loss and dehydration. Normal vital signs or mild tachycardia may immediately precede decompensated shock. Assume pediatric blood volume is approximately 80-90 ml/kg (8-9% body weight).
  - Vascular Access:
    - ◇ Peripheral access is the preferred vascular access. If, however, 2 attempts are unsuccessful, then an alternative method should be used (Intraosseous line for age <6, Central line for age >6). In addition, all fluids should be warmed to prevent hypothermia. In cases of hypotension, 2 boluses of crystalloid (20ml/kg) may be given. If the patient continues to be hypotensive, one may give 10ml/kg of blood as the patient is being prepared for either the operating room or angiography.
    - ◇ **Intraosseous (IO) line:** Provides rapid, secure access to vascular space.
      - » All resuscitation fluids, medications (including “code” meds & vasoactive drips) and blood products can be given via IO line.
      - » Sites: Proximal tibia on flat, medial surface, 1-2 cm below tibial tuberosity.
      - » Contraindications: Previous IO attempt on same bone, or fracture of extremity (or pelvis) proximal to the IO site.
      - » Risk: Osteomyelitis, infusion into soft tissue resulting in compartment syndrome (see compartment syndrome chapter)
    - ◇ **Disability:** Assess pupils, movement of extremities, and GCS (see pediatric coma score table, page 209). Avoid secondary injury from hypotension or hypoxia.
    - ◇ **Exposure:** Expose the patient thoroughly to look for all signs of injury (roll them over). Then quickly place a warm blanket to prevent hypothermia.
    - ◇ **Prevention:** Large potential to significantly impact death/disability. Bicycle helmets, car seats, safe storage of firearms, smoke detectors, fire retardant clothing, pool safety.

## PITFALLS IN PEDIATRIC TRAUMA TO AVOID

### *Airway*

- Anterior located Larynx
- Large Occiput may cause flexion of neck
- Short, soft trachea
- Soft, pliable bones
- Patient may have major injuries to their brain, chest or abdomen without fractures.
- Must be hypervigilant in looking for injuries

**Risk of Aspiration**

- Kids are air-swallowers. Place NGT or OGT (in infants) to prevent over distension of stomach with subsequent emesis and aspiration

**Normal Vitals**

- Children have large reserve. Once they “crash”, it may be too late.

**Normal C-Spine Studies**

- SCIWORA: Spinal Cord Injury Without Radiographic Abnormality (due to pliable bones)

**Abnormal C-Spine Studies**

- Skeletal growth plates
- Pseudosubluxation

**Child Abuse**

- Be leery of:
  - Repeat visits
  - Discrepancy in story
  - Bites, burns
  - Perioral or genital injuries
  - Retinal hemorrhages
  - Injuries of varying ages

**TABLE: PEDIATRIC RESUSCITATION WORKSHEET**

Age	Premie	Neo- nate (0-20 D.)	1 MO	4 MO	8 MO	1 YR	2 YR
Weight	<3 kg	3.5 kg	4 kg	6 kg	8 kg	10 kg	12 kg
HR Range	120-160	100-180	100-180	120-170	110-170	110-170	90-150
Resp. Rate	40-60	40-60	40-60	30-50	25-45	20-40	20-40
SBP (mm Hg)	40-60	60-80	65-90	65-95	70-105	70-110	70-110
ET Tube	2.5-3.0	3.0	3.0-3.5	3.5	3.5	4.0	4.0-4.5
Laryng. Blade	0 Miller	1 Miller	1 Miller	1 Miller	1 Miller	1-2	1-2
Chest Tube (FR.)	8-10	10-12	10-12	10-12	12-16	16-20	16-20
Fem Vein Line (FR.)		3	4	4	4	4-5	4-5

Age	3 YR	4 YR	5 YR	6 YR	8 YR	10 YR	12 YR
Weight	14 kg	16 kg	18 kg	20 kg	25 kg	32 kg	40 kg
HR Range	80-14	75-135	65-135	60-130	60-120	60-120	60-120
Resp. Rate	20-30	20-30	20-30	15-25	12-25	12-25	12-25
SBP (mm Hg)	80-110	80-110	80-110	90-115	90-115	95-120	95-120
ET Tube	4.5	4.5-5.0	5.0-5.5	5.5	5.5-6.0	6.0-6.5	7.0-7.5
Laryng. Blade	1-2	2	2	2-3	2-3	2-3	3
Chest Tube (FR.)	20-24	20-24	24-28	24-28	24-28	28-32	32-40
Fem Vein Line (FR.)	5	5	5	5	5-7	6-7	7



**TABLE: RAPID SEQUENCE INTUBATION****Pre-Med**

	Dose	Uses
Atropine	0.01 – 0.02 mg/kg	Bradycardia, ↓ secretions
Lidocaine	1-2 mg/kg	Blunts ICP spike

**Sedatives**

	Dose	Adverse Effects
Midazolam	0.05-0.1 mg/kg	↓ BP, HR
Fentanyl	2-5 mcg/kg	Rigid Chest (tx: narcan, paralyze)
Etomidate	0.3 mg/kg	Myoclonus
Ketamine	1-4 mg/kg	↑ CP, BP, HR; laryngospasm, secretions
Thiopental	0.5-4 mg/kg	↓ BP, bronchospasm

**Paralytics Dose**

	Dose	Onset	Duration
Rocuronium	0.6-1.2 mg/kg	30-60 sec	30-60 min
Vecuronium	0.1-0.2 mg/kg	70-120 sec	30-90 min
Succinylcholine*	1-2 mg/kg	30-60 sec	3-10 min

\*Succinylcholine is contraindicated in patients with neuromuscular disease, muscular dystrophy, severe burns, hyperkalemia, or rhabdomyolysis

**TABLE: PEDIATRIC COMA SCORE**

	Points	Glascow Coma Scale	Modified Infant Coma Scale
Eye Opening	4	Spontaneous	Spontaneous
	3	To voice	To voice
	2	To pain	To pain
	1	None	None
Verbal Response	5	Oriented	Coos, babbles
	4	Confused	Irritable cry, consolable
	3	Inappropriate	Cries to pain
	2	Garbled	Moans to pain
	1	None	None
Motor Response	5	Obeys commands	Normal movements
	4	Localizes pain	Withdraws to touch
	3	Flexion withdrawal to pain	Flexion withdrawal to pain
	2	Extension posturing	Extension posturing
	1	None	None

### BURN INJURY: BODY SURFACE AREA (BSA) ESTIMATION

- Infants have larger heads, which therefore accounts for a larger percentage of their BSA. (16% vs. 9% in adults). See Burn Chapter.

### SEVERE TRAUMATIC BRAIN INJURY (GCS 3-8) IN CHILDREN

- Refer to GCS table above

### PRE-HOSPITAL/PRE-ICU MANAGEMENT

- Fluid resuscitation
- Avoid hypoxemia and hyperventilation
- BVM over ETT in field

### BASIC INTENSIVE CARE MANAGEMENT

- Priority is *PRELOAD*
  - Keep CVP > 5 mmH<sub>2</sub>O; do not fluid restrict unless SIADH
- Place *ICP Monitor/Ventriculostomy* with drain capability (preferred)

- *Cerebral Perfusion Pressure* (CPP = MAP-ICP); goal 50-70 children, >70 adults, Catecholamines to increase MAP: phenylephrine, norepinephrine, dopamine
- *Sedation*: Fentanyl, Benzodiazepines, Etomidate
  - Propofol: decreases cerebral metabolic rate, theoretically decreasing CPP
  - Adverse rxn include: metabolic acidosis, arrhythmias (BBB, junctional)
- *Paralysis* if necessary, to prevent agitation/ICP spikes: Vecuronium
- *Prevent Hyperglycemia*: Associated with pro-inflammatory state. Titrate insulin and glucose infusions with goal serum glucose 80-150.
- *Phenytoin*: Prophylaxis for seizures
- Elevate HOB 30° (Via reverse Trendelenburg, if spine is not cleared)

## ACUTE MANAGEMENT OF ELEVATED ICP

### **First Line**

- Mild Hyperventilation: Goal pCO<sub>2</sub> 30-35 mmHg
- CSF drainage via ventriculostomy
- Mannitol: 0.25 – 1 gm/kg/dose or
- Hypertonic Saline: Infuse 3% saline 0.1-1 ml/kg/hr; goal Na<sup>+</sup> 150-155 with max serum Osmolality 360 (better evidence than for mannitol)

### **Second Line**

- Hypothermia: Goal 32-36°C (89.6-96.8°F) via external cooling blankets
- Aggressive Hyperventilation: pCO<sub>2</sub> 25-30 mmHg (should monitor CBF, jugular venous saturation, or tissue O<sub>2</sub> tension)
- Barbiturate coma: Needs continuous EEG monitoring
- Craniotomy, Craniectomy, Temporal lobe resection. Guidelines for acute severe traumatic brain injury in infants, children and adolescents.

Critical Care Medicine June 2003, Vol 31(6): supplement

## Geriatric Trauma

- Trauma is the 7th leading cause of death in the elderly.
- Number of individuals > 65 rose from 1% (15 million) to 6% (342 million) over a 90-year span.
- Number of individuals > 65 projected to rise to 20% (2.5 billion) by 2050.

### **Unique Features of Geriatric Trauma**

- Injuries in older patients (> 65 years) are more likely to have fatal outcomes versus similar injuries in younger patients.

### **3 leading causes of death due to trauma in elderly**

- Falls
- Motor vehicle crashes
- Burns

### **Physiologic changes of aging**

- Decreased ability to respond secondary to medical conditions...
- e.g., osteoarthritis, osteoporosis, emphysema, heart disease, visual & auditory changes, decreased respiratory capacity, decreased cardiac activity, decreased tolerance of hypotension and nephrotoxic drugs, impaired wound healing, and decreased immunomodulation.

## GUIDELINES

### **Airway**

- Maintain patency
- Osteoarthritis may make intubation difficult
- Remove broken teeth
- Leave well fitted dentures intact

### **Breathing**

- Potential for early loss of respiratory reserve requires close monitoring
- Consider early intubation
- Chest wall injuries e.g., rib fracture and pulmonary contusions are not well tolerated
- Adequate pain control for chest injuries – Epidural; PCA

### **Circulation**

- Altered secondary to impaired cardiac function
- Beta-blockers may artificially lower heart rate
- Ca<sup>2+</sup> channel blockers contribute to hypotension
- Hypertensive patients may not demonstrate hypotension, because their hypotensive blood pressure may be normotensive for a non-hypertensive patient

- Early recognition and correction of coagulation defects and drug induced coagulation is crucial
- Blood loss is not well tolerated. Ensure appropriate, but not indiscriminate transfusions

### **Disability**

- Cerebral blood flow decreases 20% by age 70
- Increased incidence of SDH (3X) and intraparenchymal hematoma
- C-spine injury more common, though more occult – i.e., difficult to diagnose with OA and osteoporosis

### **Exposure**

- Dermis loses 20% of thickness
- Loss of thermal regulatory ability – Rapid hypothermia!

### **Musculoskeletal System**

- Decreased joint mobility
- Osteoporosis
- Early stabilization of fractures paramount
- Early rehabilitation

### **Special Cases**

- Drug interactions due to polypharmacy
  - Psychotropic meds may mask injuries, or be problematic if abruptly discontinued
- Elderly Abuse
  - Need to be vigilant of history that does not correlate with P.E.
  - Abuse includes: physical, sexual, neglect, psychologic, violation of rights, and financial/material

### **KEY FEATURES**

- Early airway control
- Obtain liberal history – Beta-blockers, antihypertensives, anticoagulants etc.
- Early aggressive treatment shown to increase survival
- Liberal use of head CT
- Adequate pain control
- Exclude M.I., TIA, hypoglycemia, or stroke for reasons causing fall or motor vehicle crash
- Honor end of life requests

## Trauma in Pregnancy

### BACKGROUND

- Incidence: 6-7 of all pregnancies
- Leading cause of non-obstetric maternal death
- Most common mechanisms: MVC, Falls, Domestic violence
- Blunt trauma is most common, but all types occur
- Maternal mortality most commonly related to severe head injuries
- Fetal mortality most commonly related to: (1) Maternal death, (2) Placental abruption, (3) Penetrating missiles, (4) Maternal hypotension
- Maternal mortality/morbidity is directly related to injury severity regardless of gestational age.
- Fetal mortality/morbidity increases with gestational age at the time of trauma. Fetal death and severe fetal injury may occur with minor trauma that results in no maternal injury.
- \*\*Seatbelts are recommended and proven to save maternal and fetal lives by preventing ejections. Lap belt should be placed UNDER uterus and across bony pelvis. Shoulder strap should cross midline of clavicle, between breasts, and lie just to the side of the uterus.\*\*

### PHYSIOLOGIC CHANGES IN PREGNANCY

Physiologic and anatomic changes exist in normal pregnancy that must be understood in managing a pregnant trauma patient. Evaluation and management decisions will depend on knowledge of these normal alterations.

HR	• ↑ 10-15 BPM above baseline
CO	• ↑ 30-50% BY 2nd trimester
CVP	• ↓ 5 mmHg (4 mmHg in pregnancy)
SBP/DBP	• ↓ 5-15 mmHg below baseline (Nadir end of 2nd trimester) • ↓ To near pre-pregnancy baseline by term
Blood Volume	• ↑ 50% + RBC volume ↑ 30% = “physiologic anemia
HCT	• 32-34%
O2 Consumption	• ↑ 15-20% (↑ metabolic demands)
PCO2	• 27-32
TV + Minute Ventilation	• ↑ 40%
FRC	• ↓ 20-25%

## ANATOMIC CHANGES IN PREGNANCY

- After 20 weeks EGA, the uterus compresses the vena cava when patient lies supine. (Thus, decreasing preload and cardiac output)
- Uterus becomes an abdominal organ after 1st trimester (susceptible to penetrating injury).
- Fundal height (cm) correlates with gestational age (weeks) above the umbilicus (20 cm).
- A fundal height  $\geq$  3-4 fingerbreadths above the umbilicus suggests a viable gestational age ( $>$  24 weeks).
- At  $>$  20 weeks EGA, abdominal viscera is displaced to the upper abdomen and retroperitoneum. (80% non-pregnant mid-lower gunshot wounds result in visceral injury vs. 20% in pregnant counterparts).
- The bladder is pushed superiorly and anteriorly by the growing uterus becoming a lower abdominal organ (vs. pelvic in nongravid) making it more susceptible to penetrating trauma injury.
- The diaphragm is displaced superiorly by 4 cm, the AP diameter increases, and the mediastinum widens. (Insert chest tubes 1-2 intercostal spaces higher in gravid trauma patients). (Keep in mind when performing chest compressions).
- Sacroiliac joints and pubic symphysis widen in pregnancy.

## EVALUATION/MANAGEMENT

\*Page OB attending + NICU if viable fetus ( $\geq$ 24 weeks)

Initial ATLS primary survey focused on maternal cardiopulmonary assessment and stabilization without difference from nonpregnant patient.

- **Airway:** Remember very high risk of aspiration in pregnancy. Consider early intubation for airway protection or respiratory distress. Always place an NGT/OGT to decompress the stomach and reduce the risk of aspiration
- **Breathing:** Remember chest cavity alterations in pregnancy. If a chest tube is indicated, place 1-2 intercostal spaces above usual to avoid diaphragm/intra-abdominal injury. Also, if on ventilator, remember pregnant patients have decreased respiratory reserve and require higher tidal volumes to maintain adequate oxygenation.
- **Circulation:** Assess perfusion as per nonpregnant trauma patients.
  - If EGA is  $>$  20 weeks, insure uterus is displaced to the left either by a 30° wedge under right flank/backboard, or by manual displacement. This relieves aortocaval compression by gravid uterus and allows for optimal preload and CO, and may improve presenting hypotension.
- **Disability**
- **Exposure/Environment**
- **Foley**
- **Gastric Tube:** Maintain a low threshold for placing a gastric tube, given increased aspiration risk in pregnant patients.
- **Hertz:** FAST scan

If catastrophic trauma, proceed with aggressive maternal stabilization as the absolute priority.

If maternal cardiac arrest, anticipate initiating emergency C-section within minutes - if unresponsive to resuscitation efforts to unload vena cava/aorta and possibly salvage fetus IF 24 WEEKS OR GREATER (Fetus unlikely to survive if undelivered after 15-20 minutes post maternal cardiac arrest).

## NON-CATASTROPHIC TRAUMA OR MATERNAL STABILIZATION

- Secondary survey initiated as with non-gravid patients, BUT now considering fetal wellbeing and alterations in gravid anatomy/physiology.
- Estimate gestational age and continuous cardiotocographic monitoring to assess fetal wellbeing.
- Non-reassuring fetal status is often an early indicator of maternal injury.
- Fetal heart tracing findings consistent with fetal distress is an indication for urgent C-section, if viable gestational age and stable maternal status.
- Frequent contraction pattern is indicative of placental abruption or preterm labor.
- Obtain plain films, CT scans, and other imaging to work up trauma as usual. Assessing maternal injury outweighs low risk of complications from fetal radiation exposure. Use fetal shielding techniques when possible.
- Maintain low threshold for early intervention for respiratory compromise because of significantly lower respiratory reserve in pregnancy and significant fetal compromise if prolonged maternal hypoxemia.
- Assessing intra-abdominal hemorrhage/injury may be falsely reassuring because peritoneal sensation is diminished after midpregnancy to allow tolerance of the growing uterus among the other intra-abdominal organs. Thus, have a low threshold for CT.
- Consider open peritoneal aspirate if unexplained shock and unstable for CT, or in patients with shock from spinal injury and unstable for CT. (Note: Blind DPA (Diagnostic Peritoneal Aspirate) likely to injure uterus or other intra-abdominal organs. Should perform DPA in pregnant patient above the umbilicus in an open fashion.)
- Maintain high suspicion for pelvic vascular injury/hemorrhage with any pelvic fracture/injury because pregnancy causes engorgement of pelvic vasculature.

## SPECIFIC PROBLEMS

- Uterine rupture → shock, vaginal bleeding, uterine tenderness, peritoneal signs, non-reassuring fetal status, or fetal death. (Rare but consider)
- Remember pre-eclampsia if 2nd-3rd trimester with proteinuria, hypertension, hyperreflexia, clonus, edema. Hypertension may be masked if hypovolemic shock present with injuries.
- Seizure → eclampsia, intracranial injury/hemorrhage, seizure disorder
- Pre-eclampsia/eclampsia → Magnesium sulfate (prepare for initial hypotension as a side effect especially in hypovolemic patients)



- If hypovolemic shock and pre-eclampsia/eclampsia, will need invasive hemodynamic monitoring for fluid management, etc. These patients will have a very tenuous fluid balance and high risk for pulmonary edema.
- Evaluate and treat specific maternal injuries as in non-pregnant trauma patients, prioritizing in this order: maternal critical injuries, then fetal compromise, then noncritical maternal injuries.

### **SPECIAL CONSIDERATIONS FOR BLUNT ABDOMINAL TRAUMA**

- Remember peritoneal sensation is blunted later in pregnancy so unexplained hypotension and non-reassuring fetal heart tracing may be early signs of intra-abdominal injury or uterine rupture.
- Must have a high suspicion for placental abruption and follow general guidelines to insure it has been ruled out. When encountered, manage obstetrically as a non-trauma patient.
- Any blunt abdominal trauma in a pregnant patient  $\geq 20$  weeks, regardless of how minor the impact, should undergo continuous prolonged fetal cardiocotographic monitoring to rule out abruption and preterm labor for at least 6 hours.
- If any signs of abruption, including contractions, uterine irritability, or nonreassuring fetal heart tracing, serious maternal injury, or rupture of membranes, then patient should be admitted and cardiocotographic monitoring continued.

### **RHOGAM FOR MATERNAL RH (-) FOLLOWING BLUNT TRAUMA**

- D- immunoglobulin [Rhogam 1 amp (300 mcg)] should be given to all blunt abdominal trauma patients who are Rh(-) and unsensitized to prevent D alloimmunization.
- Kleihauer-Betke test can identify the  $< 10\%$  incidence of trauma patients that will experience more than 30 mL of fetal-maternal hemorrhage which would necessitate additional Rhogam dosage. (300 mcg/30 mL of fetal-maternal hemorrhage)
- Rhogam is effective in preventing D alloimmunization if given within 72 hours of the event of fetal-maternal hemorrhage.

### **SPECIAL CONSIDERATIONS FOR PENETRATING TRAUMA**

- Viscera is displaced to the upper abdomen by the growing uterus.
- Upper abdominal wounds have higher risk of maternal bowel injury.
- Gunshot wounds to the uterus almost certainly results in fetal injury. Decisions to perform C-section must be made on an individual case basis depending on many factors and involving the OB attending and trauma surgeon.
- If delivering a potentially injured fetus, the neonatologist and a pediatric surgeon should be present.
- Bladder is susceptible to penetrating injury as it is an anterior abdominal organ after the 1st trimester.

## PITFALLS

- Not involving appropriate specialties early in the process.
- Not intervening for airway protection and respiratory compromise early enough in process, resulting in aspiration or prolonged maternal hypoxemia. Pregnant patients have markedly decreased respiratory reserve.
- Not utilizing fetal monitoring early in secondary survey as an early indicator of maternal injury and recognizing fetal distress early.
- Not placing gastric tube early in process to prevent aspiration.
- Having a false sense of reassurance of low impact, minor blunt abdominal trauma and/or the lack of maternal injury; thus, not monitoring adequately and missing the early signs of placental abruption.
- Becoming distracted with the presence of fetal distress while maternal critical injuries and distress are not completely addressed/resolved. Remember fetal well being is dependent on maternal well being.
- False sense of reassurance with lack of peritoneal signs in ruling out intra-abdominal injury.
- False sense of reassurance with hemodynamic stability in pregnancy...as significant volume may be lost before hemodynamic instability is evident.
- Relying on noninvasive monitoring in a trauma patient complicated by pre-eclampsia.

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## SUMMARY

No Level 1 Standards for the management of the acutely injured pregnant patient. However, several Level 2 & 3 recommendations from the Eastern Association for the Surgery of Trauma include:

- All pts > 20 weeks gestation age should undergo cardiotocographic monitoring for at least 6 hours.
- Monitoring should be continued if uterine contractions, nonreassuring fetal heart rate pattern, vaginal bleeding, significant uterine tenderness or irritability, serious maternal injury or rupture of amniotic membranes is present.
- Kleihauer-Betke analysis should be performed in all >12 week gestation patients.
- Best treatment for fetus = optimal resuscitation of mother & early fetal assessment.

- All women of childbearing age should have beta-HCG tested upon arrival and be shielded for x-rays when possible (see chapter concerning radiation & pregnancy).
- Perimortem C-section should be considered in any moribund woman  $\geq 24$  weeks gestation.
- Delivery in perimortem c-section must occur within 20 minutes of maternal death, but should be ideally started within 4 minutes of maternal arrest.
- Consider keeping the pregnant patient tilted left side down 15 degrees to prevent supine hypotension syndrome.
- OB consult should be considered in all cases of injury in pregnant patients.

## Pregnancy and Radiation Risk

### OBJECTIVES

- To define the effect of medical diagnostic radiation on the fetus in pregnant trauma patients.
- To provide a simple approach for categorizing risk by the amount of radiation to which the fetus is exposed.

### GUIDELINES

In any trauma situation, the wellbeing of the mother determines the survival of the fetus. In all lifethreatening situations, proceed with diagnostics and therapy in the best interest of the mother.

- No study to date has shown any increase in teratogenicity above baseline at fetal exposures below 10 rad or 100 mGy to the fetus.
- Determine presence and dates of pregnancy. Major risk of teratogenesis is in the first trimester and caution should be exercised for this age group.
- Shield fetus (front and back if necessary) for all non-abdominal x-rays.
- Avoid any truly unnecessary x-rays. Consider substitutions:
- Ultrasound rather than CT of abdomen
- Avoid lumbar films unless very high suspicion
- Avoid pelvis films unless very high suspicion
- Avoid IVPs for evaluation of hematuria.
- Avoid pelvic or lumbar films if patient will already be receiving CT
- Determine relative risk of radiation exposure to the fetus (all values relate to situations in which fetus is in the x-ray beam).
  - Stochastic effect – negligible over background radiation exposure. Possible increase in early spontaneous abortion for fetus < 2 weeks old.
  - Determine risk (Noncancer risk of fetus – from American College of Obstetricians and Gynecologist and Eastern Association for the Surgery of Trauma)
    - < 50mGy – None
    - 50 – 100 mGy – Possible
    - > 100 mGy – Expected
- Calculate the fetal exposure
  - Fetal exposure is determined by multiple factors:
  - Specific techniques used to acquire the images.
  - The body habitus of the woman (obesity is going to require a higher dose of energy).
  - The distance between the beam source and the fetus.
- General and average exposures: Rads

Plain Films	CT	Fluoro
<ul style="list-style-type: none"> <li>• C-Spine: 0.002</li> <li>• Chest (2 view): 0.00007</li> <li>• Pelvis: 0.04</li> <li>• Thoracic Spine: 0.009</li> <li>• Lumbosacral Spine: 0.359</li> </ul>	<ul style="list-style-type: none"> <li>• Head: &lt; 0.05</li> <li>• Chest: &lt;0.1</li> <li>• Abdomen: 2.6</li> </ul>	<ul style="list-style-type: none"> <li>• (i.e., pelvic angiography)</li> <li>• 10 mGy per minute</li> </ul>

- Discuss risk with patient
- Low risk (< 100 mGy, 10 Rads) – assure the mother and family that there is an almost negligible risk for injury to the fetus.
- Intermediate risk (100-250 mGy, 20-25 Rads)—assure the mother and family that the benefits of diagnosis and early intervention far outweigh the risk of injury to the fetus. Use an example that the natural exposure of ambient radiation can be up to 250 mGy over three years. In general, the fetus can safely tolerate up to 100 mGy without problems. However, if the fetus has been exposed to radiation levels in the intermediate range, the mother should be offered a radiation safety consultation and a perinatology consultation.
- High risk (>250 mGy, >25 Rads)—obtain a radiation safety consultation and a perinatology consultation.
- For the non-pregnant patient of childbearing age receiving a dose of radiation in the high-risk range – the risk of ova mutagenesis is small but real. These women should be advised to forego conception for a few months after receiving the radiation dose.

## CHAPTER 11

# BLOOD PRODUCTS

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### **IN THIS SECTION**

*Transfusion of Blood Products*

*Massive Transfusion Protocol*

*Prothrombin Complex Concentrate (PCC)*

*Tranexamic Acid (TXA)*

*Recombinant Activated Factor VII  
(Factor 7)*

## Transfusion of Blood and Blood Products

### DEFINITIONS

#### **Packed red blood cells**

- A blood product that contains red blood cells with most of the plasma removed. The average hematocrit of PRBCs is 70%. Each unit of PRBCs (220 ml) will raise the hematocrit by about 3%.

#### **Fresh frozen plasma**

- A blood product that contains fresh components of plasma, including colloid proteins and clotting factors. Several plasma products are available as alternatives for coagulation factor replacement:
  - *Fresh Frozen Plasma* is plasma removed from whole blood and frozen within 8 hours of collection.
  - *Plasma Frozen within 24 hours after Phlebotomy (FP24)* is plasma removed from whole blood and frozen within 24 hours of collection. Except for Factor VIII, FP24 contains similar levels of coagulation factors and inhibitors as FFP.
  - *Apheresis Fresh Frozen Plasma (Jumbo)* is the collection of the equivalent of 2 units of plasma during a single donation.
  - *Thawed Plasma-5D* is thawed plasma stored for up to 4 days beyond the outdate of the FFP/FP24. The levels of factor VIII and Factor V decline during storage, although the latter does not fall below the hemostatic level of 35%. Not available for patients diagnosed with Thrombotic Thrombocytopenic Purpura (TTP).

#### **Apheresis Platelets**

- Apheresis platelets are collected from an individual donor and contain the equivalent of 5 to 6 units of platelets. The volume of plasma in the component varies from 200 to 400 ml. One unit of Apheresis Platelets will usually increase the platelet count of 70-kg adult by 30,000 to 60,000/uL.

#### **Cryoprecipitate**

- A blood product component of plasma that primarily contains Factor VIII, Factor V, and fibrinogen, von willibrand factor. This is the best blood product for treatment of low fibrinogen (<150 mg/dL).

### GUIDELINES

- Resuscitation in the ED will begin with crystalloid infused through large-bore IV catheters.
- Upon initiating resuscitation, send blood sample to the Blood Bank for immediate type and cross. If blood requirements will be excessive, initiate MTP protocol.

- In most situations, crystalloid may be administered until type and cross-matched blood is available. However, situations arise when O-negative or type-specific blood will be necessary. 2 Units of O-negative blood will be brought to the ED by the lab for all Tier I traumas.

### ***O, Rho(D) negative blood is available immediately***

- It requires emergency release, and only two units will be released initially. Due to limited supply of O-negative blood, consider O, Rho(D) positive blood for males and sterile or postmenopausal females.
- Indications:
  - Only used in cases of severe life-threatening hemorrhage not expected to respond to crystalloid resuscitation.
  - Obvious major bleeding during transport with subsequent impending cardiac arrest due to anemia (not hypovolemia).
  - Major obvious bleeding in the emergency room resulting in hypotension requiring transfusion prior to availability of type-specific blood.
- Risks:
  - About 1.3% of all patients will have a clinically significant antibody other than anti-D and 70% of these will be women. These patients are at risk for delayed hemolytic transfusion reaction.

### ***Uncross-matched, ABO, Rho(D) compatible blood***

- Available in 10 minutes after sample received in the Blood Bank; requires signed release form.
- Indications:
  - Hypotensive; hematocrit <25% prior to availability of cross-matched blood.
  - Hypotensive; obvious source of ongoing bleeding prior to availability of cross-matched blood.
  - Hypotensive with need for immediate laparotomy/thoracotomy.
  - Depletion of typed and crossed blood with further emergency transfusion requirement.
- Risks:
  - Same as above, but prevents depletion of O-negative blood supply.

### ***Type and cross-matched***

- Four units available in 45 minutes after sample received in the Blood Bank.
  - Indications:
    - Usual transfusion indications.
    - Remember: blood loss does not stop immediately after the patient arrives in the hospital. Occult hemorrhage into contusions, hematoma, fractures will continue.
  - Risks:
    - Same as routine cross-match.



- Consider Autotransfuser
  - Chest tubes with exsanguinating hemorrhage
  - Set up autotransfuser chest drainage system (see Practice Guideline: Autotransfusion).
  - Contraindicated if there is contamination of the blood (i.e., bowel injury with diaphragmatic injury)

### **Fresh frozen plasma**

- Stored frozen and is available 30-45 minutes after sample received in the blood bank.
- Emergency release AB plasma can be available within 15-20 minutes after notification of need.
- Absolute indications:
  - Patient with seriously bleeding injury who is clinically anticoagulated on coumadin.
  - Documented coagulopathy due to dilution or DIC.
  - Administer 4 to 8 units as soon as it is available.
- Relative indications:
  - Elevated PT/PTT.
  - Massive transfusion: after the third unit of PRBCs; then one unit FFP for every one unit of PRBCs to follow (new recommendation based on experience in Iraq) 1:1 ratio.

### **Apheresis Platelets**

- Collected from individual donor and contain the equivalent of 5 to 6 units of platelets. The volume of plasma in the component varies from 200 to 400 ml. One unit of Apheresis Platelet will usually increase the platelet count to 70-kg adult by 30,000 to 60,000 /uL.

### **Platelets**

- Available in 30-45 minutes after sample received in the Blood Bank.
- Absolute indication
  - Evidence of bleeding with a platelet count <50,000.
- Relative indications:
  - Potential bleeding with platelet count < 20,000.
  - Massive transfusion with non-surgical bleeding before the platelet count can be obtained.
  - Give 1 unit of Apheresis platelets after every tenth unit of PRBCs in massive transfusion.

### **Cryoprecipitate**

- Frozen product
- Absolute indication
  - Non-surgical bleeding with fibrinogen <150 mg/dL.
- Relative indication
  - Non-surgical bleeding after massive transfusion before a fibrinogen level can be obtained.

# Massive Transfusion Protocol

## INTRODUCTION

The massive transfusion protocol (MTP) is a multidisciplinary process whereby blood and blood products are obtained rapidly. At Ventura County Medical Center, massive transfusion is defined as transfusion of 4-6 Red Blood Cells within an hour or 10 Red Blood Cells within 24 hours in an adult patient. A Massive Transfusion Protocol will be initiated by the attending Physician when immediate transfusion of six (6) or more units of Red Blood Cells is anticipated or after using the initial two (2) units of emergency release uncrossmatched O-negative Red Blood Cells and there is a request for additional blood.

## PURPOSE

To expedite and anticipate blood product requirements in emergent, massive transfusion situations.

## PROCEDURE

### ***Initiation of Mass Transfusion Protocol (MTP)***

- The attending Physician will initiate the Massive Transfusion Protocol (MTP) when:
  - The immediate transfusion of six (6) or more units of Red Blood Cells is anticipated,
  - The patient uses, or is predictably going to use, the initial two (2) units of emergency release O-negative Red Blood Cells within half an hour.
- The Blood Transfusion Service will activate the Massive Transfusion Protocol after notification by phone by the attending physician or his/her designee.
- The Laboratory will ensure that the Blood Transfusion Service will have adequate staffing to provide for Massive Transfusion demands, determine the adequacy of in-house inventory, and establish adequate lines of supply for additional blood.

### ***Patient Identification and Specimen Collection***

- A Blood Bank specimen must be collected and sent to the Blood Transfusion Service as soon as possible. The specimen must be labeled with a red Blood Bank Identification band label and must include the following identifying information:
  - Patient's first and last name/temporary name
  - Hospital medical record number
  - Date and time of specimen collection
  - Initials of the person collecting the sample
- The completed label shall be affixed to the tube before the person who drew the sample leaves the side of the patient. The transfusion service shall accept only those specimens that are completely, accurately, and legibly labeled.
- The corresponding Blood Bank ID number armband must be attached to the patient at the time of collection.

- If a patient's name is changed, after a sample is drawn, he/she must be redrawn and re-banded using the new name. A patient cannot be transfused using the new name, their hospital number and the original Blood Bank ID number. If a critical situation occurs in which the patient must be transfused before work is completed on the new sample, uncrossmatched Emergency Release O-negative Red Blood Cells will be used.
- If a patient comes in with a fictitious name, his/her sample will be used for testing, crossmatching, issuing and transfusing until he/she is stable. At that time a new sample will be obtained and tested using the proper name.
- If an unbanded patient sample is in the laboratory and the patient's physician decides that a type and screen is necessary, or that the patient needs to receive any product for which a type and screen is necessary, the patient must be redrawn. This would be required for all blood products, including Red Blood Cells, Plasma, Cryoprecipitate, and Plateletpheresis. If a critical situation occurs in which the patient must be transfused before a new sample can be drawn and testing completed, uncrossmatched Emergency Release O-negative Red Blood Cells will be used.

### **Red Blood Cells**

- Tier 1 Traumas
  - Two (2) units of emergency release uncrossmatched O-negative Red Blood Cells are delivered in an iced chest to the Emergency Department trauma room by the Laboratory upon notification by the overhead paging system that a "Code Yellow Tier 1" will be arriving in the Emergency Department.
  - These units may be used for initial support of hemorrhaging trauma patients as needed.
  - The Blood Bank will have on reserve an additional four (4) units of uncrossmatched O-negative Red Blood Cells available for immediate issue unless blood inventory constraints require the use of type O-positive uncrossmatched blood.
- Upon receipt of the specimen in the Blood Bank, the patient's ABO, Rh type and antibody screen testing will be performed immediately. The patient's blood type should be available within 15 minutes of receipt of the specimen and the antibody screen should be completed within 40 minutes of receipt of the specimen.
  - All Red Blood Cells issued prior to receiving the specimen or prior to completion of the ABO and Rh type will be emergency release uncrossmatched O-negative RBCs, unless blood inventory constraints require release of uncrossmatched O-positive RBCs.
  - Red Blood Cells issued prior to the completion of the antibody screen but after the completion of the type will be uncrossmatched-Type Specific or Type Compatible.
  - The crossmatch will be performed as soon as possible for all Red Blood Cells issued emergency release uncrossmatched.
- The Blood Bank will initiate the crossmatch of six (6) units of type-specific or type compatible Red Blood Cells immediately upon completion of the type and screen testing.

- The attending Physician will be notified by phone that six (6) units of crossmatched Red Blood Cells, two (2) units of thawed plasma, and one (1) plateletpheresis are ready for issue. The Blood Bank will continue to maintain four (4) units of crossmatched Red Blood Cells ready for issue during the entire Massive Transfusion Protocol until termination of the protocol.
- Emergency release uncrossmatched O-negative red blood cells may be released to a member of the medical or nursing staff without presentation of a request bearing the patient's first and last name and hospital medical records number.
- Emergency release uncrossmatched type specific/type compatible red blood cells or crossmatched compatible red blood cells will be released to the medical or nursing staff only upon presentation of a request bearing the patient's first and last name and hospital medical records number.
- The attending physician or anesthesiologist will be notified immediately when incompatibility or positive antibody screen is detected.

### ***Thawed Plasma and Plateletpheresis***

- When the Massive Transfusion Protocol is initiated, two (2) units of plasma will be immediately thawed and available for issue within thirty (30) minutes. If the ABO and Rh type of the patient has not been determined with a current banded sample, type AB plasma will be thawed.
- One unit of Plateletpheresis will be stocked and ready for issue. Additional plateletpheresis will be available upon request by the attending Physician.

### ***Cryoprecipitated AHF***

- Orders for cryoprecipitate will not be anticipated by the Blood Bank unless specifically requested. Pooled cryoprecipitate will be available within 30 minutes of request.

### ***Termination of MTP***

- The Blood Bank staff will notify the attending physician or designee as blood and blood products are made available. Products will be issued upon request or held in the Blood Bank until needed. The Blood Bank staff will inquire at each notification if the Massive Transfusion Protocol (MTP) should continue. It is the responsibility of the attending physician to notify the Blood Bank staff to discontinue the Massive Transfusion Protocol (MTP). The Blood Bank staff may also inquire of the attending physician or designee, if the MTP should be discontinued.

### ***Monitoring***

- Initiation of the Massive Transfusion Protocol, designation of Massive Transfusion Protocol patients and use of emergency released uncrossmatched blood will be monitored and reviewed by the Blood Utilization Committee and the Trauma Performance Improvement Committee.

**RBC/FFP-Plasma/Platelet ratio**

- The ratios of RBCs, plasma and platelets at each point in the protocol would be as follows (using “1” to represent our facilities platelet pack which contains at least  $3.0 \times 10^{11}$  platelets per single donor pheresis unit and which approximates 4-6 single donor platelet concentrates):

	RBC/Plasma/Platelets Ready for Issue	RBC/Plasma/Platelets Given
Initial Resuscitation	2/0/0	2/0/0
Set 1	4/4/1	6/4/1
Set 2	4/4/0	10/8/1
Set 3	4/4/1	14/12/2
Set 4	4/4/0	18/16/2
Set 5	4/4/1	22/20/3
Set 6	4/4/0	26/24/3

After every 2nd set of products issued, a PT/INR, Hemoglobin, Hematocrit, Platelet Count, and Fibrinogen will be checked.

## SCHEDULE OF PRODUCTS

Shipment By Set	Red Cells (Units)	Jumbo FFP (Units)	Platelet-phereses (Apheresis Units)	Tranexamic Acid / Factor VIIA	Cryoprecipitate <sup>6</sup>
Delivered in a cooler with a ratio alternating 4/4/1 and 4/4/0	<b>Immediate Access</b> O-negative  (2 units brought by lab personnel to Trauma Bay for Tier 1 activations)	1 Jumbo  (equivalent to 2 units)			
1st Set	4	2	1	#5 #6 #7	
2nd Set	4	2			#4, Call BB
3rd Set	4	2	1		
4th Set	4	2			
5th Set	4	2	1		#4, Call BB
6th Set	4	2			
7th Set	4	2	1		#4, Call BB
8th Set	4	2			

## NOTE:

1. **Immediate Access to O-negative Blood in Trauma Room.** These units are brought by a member of the laboratory personnel to ED Trauma Bay.
2. **Notify pharmacy to deliver tranexamic acid:** Ext. 6220
3. Notify Blood Bank at Ext. 6040. O-negative units OR type specific if patient testing complete.
4. Call Blood Bank for Cryoprecipitate (1 pool = 5 units) recommended for OB/GYN DIC patients if low fibrinogen levels are low.
5. Tranexamic acid 1gm IV over 10 minutes followed by 1gm over 8 hours. **See *Tranexamic Acid protocol.***
6. Profilnine SD (PCC). **See *PCC protocol.***
7. Factor VIIA (will be available by REQUEST ONLY). **See *Factor VII protocol.***

**Notify Blood Bank if MTP is no longer needed.**

## MASSIVE TRANSFUSION IN NON-TRAUMA PATIENTS

Massive blood loss can also occur during surgery or in a handful of nonsurgical settings such as GI hemorrhage and abdominal aortic aneurysm rupture. Transfusion support to such patients can meet our definition of a massive transfusion (4-6 units of red cells within an hour or 10 units of red cells within 24 hours). However, the likelihood of coagulopathy requiring aggressive and automatic transfusion of plasma and platelets is very much lower in the non-trauma setting for several reasons (see table on page 225). [Erber, Transfusion and Apheresis Science, 2002]

The MTP- which is designed on the assumption that the patient has significant complex coagulopathy contributing to uncontrolled hemorrhage - is usually not necessary for these patients. Instead, frequent measurement of platelet count, PT/INR, fibrinogen and hemoglobin should be obtained and transfusions given to maintain the various components of the coagulation system in the hemostatic ranges:

- Platelets above 50,000/uL;
- INR less than 1.6; and
- Fibrinogen greater than 100 mg/dL.

[Tien, Can J Surg 2007; Spahn, Crit Care 2007]

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## Prothrombin Complex Concentrates (PCC)

Prothrombin Complex Concentrates are hemostatic blood products containing four vitamin K-dependent clotting factors. They are as follows: II, VII, IX and X. They are very reliable and a fast alternative to fresh frozen plasma for the reversal of the effects of oral anticoagulation treatments, usually in the form of vitamin K agonist. They are sometimes used for Factor II or Factor X replacement in patients with congenital or acquired deficiency. The factor that we currently have at Ventura County Medical Center is Factor IX complex, Profilnine SD.

Profilnine SD is a non-activated Factor IX complex prepared from pooled human plasma and purified by DEAE cellulose. Each vial of Profilnine SD is labeled with the Factor IX potency expressed in International units.

The Profilnine SD that we have at Ventura County Medical Center does not contain heparin. Profilnine SD contains low levels of activated coagulation factors, as indicated by the non-activated Partial Thromboplastin Time Test. Profilnine SD contains no preservatives.

The Profilnine SD that we have at Ventura County Medical Center contains the following dosages:

Factor II:	150 Units per 100 Units of Factor IX
Factor VII:	35 Units per 100 Units of Factor IX
Factor X:	100 Units per 100 Units of Factor IX
And of course,	100 Units of Factor IX

Factor IX or Prothrombin Complex Concentrate is a useful alternative to fresh frozen plasma when volume is an issue; particularly in the elderly with coronary artery disease or congestive heart failure. Its  $\frac{1}{2}$  life is much longer than Factor VII and could be used as an adjunct with FFP for quicker reversal; particularly if an emergent operation is to be done on a patient who is on Coumadin or has a mounting dilutional coagulopathy secondary to hemorrhage.



## **Tranexamic Acid (TXA)**

### **PURPOSE**

To define and outline the use of Tranexamic Acid.

### **PROCEDURE**

- Use Tranexamic Acid in conjunction with Massive Tranfusion Protocol.
- Infuse the medication within 3 hours of injury for maximum benefit.
- Notify Pharmacy as soon as it is needed.
- Dose:
  - Loading Dose: 1gm IV over 10 minutes IVPB, pharmacy will prepare 1gm in NS 50 mL (final volume 68mL) infuse at 400mL/hr to give the 1gm over 10 minutes.
  - Maintenance Dose: 1gm over 8 hours, pharmacy will prepare 1gm in NS 250mL (final volume 285mL), infuse at 36mL/hr for the 8 hours.
  - Dose is not adjusted for renal impairment for this indication.
- Drug Properties:
  - Description/MOA: Antifibrinolytic agent, hemostatic agent
    - Lysine analogue - attaches to the lysine site of plasminogen and prevents its conversion to plasmin and inhibits proteolytic activity of plasmin forming a reversible complex → inhibition of fibrinolysis.
    - Control surgical bleeding by inhibiting the conversion of plasminogen to plasmin.
  - Dosage form: 100mg/ml, 10ml ampule (stored at room temperature)
  - Pharmacokinetics:
    - Half-life: 2 hours
    - Time to Peak serum concentration: 5 minutes
    - Excretion: greater than 95% excreted unchanged in urine
  - Compatible with: Dextrose, and Normal Saline
  - Incompatible with: Solutions containing penicillins
  - Side effects:
- Hypotension - especially if infused too quickly
- N/V/D
- Blurred vision, chronic use only
  - Drug-drug interactions: Factor VII, Human Fibrinogen Concentrate, Antifibrinolytic agents (enhanced thrombogenic events)
  - Contraindications
    - Hypersensitivity reaction (rare)
    - Acquired defective color vision
    - Active intravascular clotting
    - History of thrombosis or thromboembolism
    - Thrombogenic cardiac rhythm disease
    - Subarachnoid hemorrhage

## **Recombinant Activated Factor VII (Factor 7)**

Recombinant activated Factor VII (r FVII a)/Novoseven

### **PURPOSE**

- Recombinant activated Factor VII (r FVII a) is intended for hemostasis by activation of the extrinsic coagulation cascade. It is a vitamin K dependent glycoprotein structurally similar to human VIIa.
- FDA approved indications include the treatment of severe bleeding episodes in hemophilia A and B patients with inhibitors to factor VIII or factor IX. rFVIIa has also been shown to be useful in several animal trials and in human studies for ongoing coagulopathic bleeding despite surgical control following major trauma. This represents an off label use of rFVIIa. All instances of use of this agent will be reviewed at the monthly multi-disciplinary surgery/medical conference as part of the regular blood bank report.

### **PROCEDURE**

- When Factor VII (r FVII a) is requested, a consultation with a Pathologist or Hematologist is required
- The following criteria must be met:
  - The patient has been transfused with one complete blood volume of PRBC (8 to 10 units)
  - Surgical control of all bleeding has been performed, or in process.
  - Documented coagulopathy.
  - Attending Surgeon in presence determines that bleeding is not responsive to surgical treatment and coagulopathy will lead to death if not reversed immediately (less than 30 min). Note: every effort shall be made to diagnose the cause and quantify the severity of the coagulopathy with laboratory tests: PT, PTT, Fibrinogen. These laboratory tests must be ordered and samples obtained prior to administration of Factor VII a. The medication may be delivered and administered with the specific order of the Efforts to keep patient normothermic in progress.
  - Efforts to correct acidosis in progress.

### **Relative Contraindications**

- Known history of atherosclerotic coronary artery disease, ischemic cerebrovascular disease (CVA), or thromboembolic disease.
- Patient with DIC, crush injury or septicemia.

### **Absolute Contraindications**

- Ongoing uncontrolled surgical bleeding (e.g., Grade V splenic laceration)

**Dosage**

- Initial dose:
  - Recombinant Factor VII (r FVII a)
    - 90 mcg/kg reconstituted and given as IV bolus.
- If hemostasis is not achieved in 20 minutes, consider a second dose of 60 – 90 mcg/kg IV.
- If second dose is not effective, consider additional PRBC, platelet, FFP, cryoprecipitate transfusion prior to a third dose.
- Supplied as 1.2 mg/vial (1200 ug/vial), 2.4 mg/vial (2400 ug/vial), 4.8 mg/vial (4800 ug/vial).

**Potential Adverse Events (<1%)**

- Myocardial infarction
- Ischemic CVA
- Ischemic nephropathy
- Mesenteric ischemia
- Development of Factors VII inhibitors

**Information for Patients**

- Patients receiving Novoseven should be informed of the benefits and risks associated with treatment. Patients should be warned about the early signs of hypersensitivity reactions, including hives, urticaria, tightness of the chest, wheezing, hypertension and anaphylaxis.

## CHAPTER 12

# INJURY PREVENTION

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### **IN THIS SECTION**

*Injury Prevention and Community Outreach*

*Image and Figure Sources*

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BOOK **2012**

## Injury Prevention

### GOALS

1. To identify potentially preventable causes of injury in each trauma patient treated at the Ventura County Medical Center, and to utilize this information to prevent each of our patients from suffering future injuries.
2. To identify trends of preventable causes of injuries in our patient population, and to plan and implement community injury prevention programs specific to our patients' injury patterns.

### IMPLEMENTATION

Our facility's injury prevention goals will require collaborative effort between the nurses and physicians assigned to our trauma service, other hospital personnel, and our community. Our trauma prevention approach is as follows:

1. *The trauma service will assess each admitted trauma patient as to whether the injury was potentially preventable.*
  2. *The trauma service will document whether the injury was preventable, and identify those specific diseases, behaviors, actions that may have been causative.* Examples of such diseases, behaviors or actions include transient ischemic attacks, cardiac disease, poorly controlled diabetes, poor balance, poor vision, alcoholism, drinking and/or drug use while driving, not wearing seatbelts, not wearing protective helmets, failing to utilize child safety seats appropriately or not using child safety seats.
  3. *The trauma service, in collaboration with other hospital personnel, will formulate and document a prevention strategy for each patient, in order to minimize the risk that further injuries will occur.* Examples of these strategies include treatment of carotid artery disease, treatment of arrhythmias, better diabetic control, physical therapy for improved balance and ambulation, vision correction, education and intervention for alcohol and drug use/abuse, reporting impaired driving to the DMV, education regarding seatbelt and correct child safety seat selection/use, education regarding wearing protective helmets when riding bicycles, scooters or skateboards.
- Services provided by VCMC's Injury Prevention Program:
    - SBIRT (Screening, Brief Intervention, and Referral to Treatment) - In collaboration with our Alcohol and Drug Counselor, we will conduct a Brief intervention with those patients who answer "Yes" to any of the questions on our RAPS 4 (Rapid Alcohol Problem Screen) Screening tool. When these patients are identified, we ask that a call be placed to our Trauma



Office (652-5904) to initiate an intervention. Our Injury Prevention Coordinator or Alcohol and Drug Counselor will then meet with the patient and assess their readiness for treatment, and if necessary, will make the referral to appropriate services.

- **Bicycle Helmet replacement** - When a patient is identified as being involved in a bicycle/scooter/skateboard collision, we will replace their damaged helmet, or provide a helmet if they were not wearing one at the time of injury. Please call our Injury Prevention Coordinator at 652-5904 to request that a patient be fitted for a proper sized helmet. For those patients who are discharged over the weekend, we have a business card “voucher” that instructs the patient to contact the Injury Prevention Coordinator for a helmet.
- **Child Safety Seat Education** – When a pediatric patient is involved in a motor vehicle collision, our injury prevention coordinator is available to discuss the proper selection and use of safety seats for children.



4. *The trauma service will maintain a computerized database of each preventable injury and those preventable factors, which we identify.* This database will then be utilized to identify common preventable injuries in our patients.
5. *The trauma service will analyze preventable injuries in our patients for patterns of injury in our community. Potential injury prevention strategies will then be formulated.* The trauma service and other hospital personnel will work with the community to implement these programs. Examples of community injury prevention program include education regarding drinking and driving, fall prevention programs, identification of hazardous roads, education and warning signs in areas of frequent injuries, education on proper child restraint selection and use, education on protective helmets/equipment when riding bicycles, skateboards, and/or scooters.

## COMMUNITY OUTREACH PROGRAMS WITH OUR COMMUNITY PARTNERS

- **Start Smart with the California Highway Patrol** is a traffic safety program for teenage drivers and their parents. The Start Smart Program is aimed at helping future and newly licensed teenage drivers become aware of the responsibilities that accompany the privilege of being a licensed California driver. Start Smart provides teens and parents with an understanding of how poor choices behind the wheel can affect the lives of numerous people. The program also provides information on defensive driving, traffic laws in California, dynamics of traffic collisions, tips on avoiding traffic collisions, DUI awareness and the dangers of distracted driving. Classes are held monthly, as well as on request, in our Cafeteria Auditorium. Contact the trauma office for more details.



- **Child Safety Seat Inspection Stations with Safe Kids/Ventura County Public Health Department/Ventura County Fire Department** – We operate 3 permanent inspection sites where we will go over safety seat selection and installation in vehicles.
- **Pedestrian and Wheeled Sports (Bicycles/Skateboards/Scooters) Safety with local school districts and Safe Kids/Ventura County Public Health Department** – Every year we participate in National Walk to school day with a local elementary school. We also lead an assembly-like activity at several school sites throughout the county, and educate school aged children on the “Rules of the Road” as pedestrians and when participating in wheeled sports. We also enforce the use of helmets and other safety devices.
- **Health Fairs and Community Events with local Police Departments, local hospitals, and several Health Care Agency Programs.**
  - We have participated in the Every 15 Minutes program with local high schools, our Behavioral Health Alcohol and Drug Programs, our Emergency Medical Services agencies.
  - We participate monthly in health fairs and/or community presentation events to discuss preventing falls in our older adult population, driving under the influence of alcohol and/or drugs, proper child safety seat selection and use, use and proper wear of helmets during wheeled sports.
- **Operation Peaceworks**
  - A gang intervention program aimed at a rapid reduction in gang related assaults and homicides within the cities of Oxnard, Port Hueneme, and El Rio.
  - Conduct monthly, or every other monthly, call-in meetings involving an interaction between gang members on probation or juvenile hall inmates and the Ventura County D.A., Oxnard Police Chief, parent of a murdered child, clergy, Ventura County Probation Agency, ex-offenders that have turned their lives around, employers, service-partners, and the Trauma Medical Co-director from VCMC.

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