TRAINING MODULE ON

MANAGEMENT OF POLYTRAUMA PATIENTS
WITH MUSCULOSKELETAL INJURIES

PREPARED BY

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FOR SIHFW, RAJASTHAN
1. **NO. OF DAYS FOR TRAINING** - 3 days
2. **NO. OF PARTICIPANTS PER BATCH** - 10
3. **SESSION PLAN**

### Day 1

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<tr>
<td><em>Introduction and course overview</em></td>
<td>10 minutes</td>
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<tr>
<td><em>Course goals and objectives</em></td>
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<td><em>Pre evaluation sheet</em></td>
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| *Disaster planning and triage*
  *Initial assessment* | 40 Minutes |
| **Session II** | |
| *Upper airway management* | 90 minutes |
| *Skill station I - Airway management* | |
| **Session III** | |
| *Shock* | 90 minutes |
| **Session IV** | |
| *Spine and spinal cord trauma* | 90 Minutes |
| *Skill Station II : Immobilization techniques for neck and spine* | |
### Day 2

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| **Session I**  
*Extremity trauma*  
Skill station: Immobilization technique for extremities | 90 minutes|
| **Session II**  
*Polytrauma: pathophysiology priorities and management* | 60 minutes|
| **Session III**  
*Open fractures* | 60 minutes|
| **Session IV**  
*Stabilization and transfer* | 60 minutes|
|  
*Visit to accident and emergency* | 90 minutes|

### Day 3

**Practical training at accident emergency**

**Post-evaluation**

**Note:**

3. Head injury, abdominal injury, chest injury will be covered by the respective specialties

4. Equipment will be provided by the RSHSDP/ Medical College

5. For detailed management of fractures please refer to training module on Principles of Fracture Management and Implant Surgery.
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INTRODUCTION

Poly-trauma is defined as a clinical state followed by injury to the body leading to profound physio-metabolic changes involving multi systems. The effect of single system injury may not be life threatening. The multiple system injury, however may threaten life. To simplify this definition polytrauma includes fracture of two long bones, or a long bone fracture associated with systemic injury, or two system involvement with skeletal injury.
COURSE OVERVIEW

Trauma is a disease of all ages. Generally, it is swift in onset and slow in recovery with many pitfalls along the way for the unwary orthopaedic surgeons and casualty medical officer trying to manage its course. Trauma respects no one and is merciless in its lethal and mangling ways among the young and most potentially productive citizens of our society. Prevention is important but where that fails, we, of the medical community must be knowledgeable and prepared to meet the patient's needs.

As with most critical illnesses, the initial observations and treatment influence the ultimate outcome of the severely traumatized patients. Familiarity with the entire field of medicine is an excellent preparation for management of the trauma patient. Specific knowledge of basic treatment principles of specific injury types, such as head, chest, abdominal or spinal injuries can significantly reduce the morbidity and mortality of trauma patients.

The first person to assess the patient can affect the final outcome. The initial assessment leads to primary stabilization and should result in an optimal outcome.

Properly trained ambulance personnel and adequately equipped vehicles result only from the efforts of physicians who demand to receive their patients in the best possible condition. Standing orders for trauma patients which allow properly trained and certified personnel to initiate life
saving procedures, such as airway management, I.V. lifelines, and proper immobilization of the patient, are a necessity in the absence of a physician.

This program is dedicated to the first hour of initial assessment and primary management of the trauma patient, starting at the time and point of impact and continuing through initial assessment, life-saving intervention, re-evaluation, stabilization and, where needed, transfer to another institution and it manage polytrauma patient with musculoskeletal injuries. The course will consist of pre-and post-course tests, lectures, case presentations, discussions, development of life saving manipulative skills, practical experience and a performance proficiency evaluation.
GOALS

1. To familiarise orthopaedic surgeons and Causality Medical Officers, the force acting in Trauma victims.
2. To anticipate and find out the injuries inflicted in traumatised patients.
3. To make ABC resuscitations as part of routine examination.
4. To diagnose correctly and TREAT or REFER the polytrauma patients with musculoskeletal injuries in the GOLDEN Hours.
5. Minimize mortality in the productive age and prevent down fall of economy of the country.
GENERAL COURSE OBJECTIVES

The purpose of this course is to orient orthopaedic surgeons to the initial assessment and management of the polytrauma patients with musculoskeletal injuries. In general, the content and skills presented in the materials are designed to assist orthopaedic surgeons and casualty medical officers in providing the first hour of emergency care for the trauma patient. In piloting the course with the intended audience, it has been determined that this minimal presentation of information, combined with the accompanying development of related slides, is appropriate for the orthopaedic surgeon and CMO who does not have immediate access to Advanced Trauma Life Support care and needs to take comprehensive action for patient care until the services of critical care trauma facility can be made available for his assistance. And to orient orthopaedic surgeons towards skilled management of polytrauma cases with special reference to patients with musculoskeletal injuries.
PRE COURSE EVALUATION

1. A 21 year-old male, who was involved in an automobile accident, is cyanotic irrational and thrashing about upon arrival in the Emergency Department. Blood pressure is 70/50 mm. Hg; pulse rate is 150/min. The left anterior part of the chest is flail, and no breath sounds can be detected on the left. The abdomen is protuberant. The left pupil is enlarged. There is an open fracture of the right femur.

Each of the following should be included in the treatment of this patient:

1. Endotracheal intubation and assisted ventilation.
2. Splitting of the right leg.
3. Performance of peritoneal lavage
4. Tube Thoracostomy on the left side.
5. Intravenous cannulation and fluid therapy.

The order in which the procedures listed above should be performed is:

a. 1,4,5,3,2.
b. 1,5,4,2,3
c. 2,5,1,4,3
d. 4,5,1,2,3
e. 5,4,1,2,3

2. Which of the following is/are associated with massive blood transfusions?

1. Pulmonary microemboli
2. Hyperkalemia
3. Hypothermia
4. Shifts in the oxyhemoglobin dissociation curve.
   a. 1,2,3
   b. 1,3
   c. 2,4
   d. 4 only
   e. All are correct

6. Rapid, massive administration of banked blood produces metabolic changes resulting in:
   1. Acidosis
   2. Electrocardiographic changes
   3. Prolongation of clotting time.
   4. Hemoglobinuria
   a. 1,2,3
   b. 1,3
   c. 2,4
   d. 4 only
   e. All are correct.

7. A 14 year-old sustained a 12 gauge shotgun injury of the right axilla as he climbed over a fence while hunting. On examination in the Emergency Department, a large skin defect is found and the extremity is pale and cool without pulses. Prior to transport, ideal management, after life-threatening problems have been attended to, would include
each of the following EXCEPT:

a. Administration of gas gangrene antitoxin
b. Copious irrigation of the wound
c. Immobilization of the extremity
d. Attention to tetanus Immunization history and administration of tetanus prophylaxis as Indicated.
e. Initiation of I.V. antibiotic therapy.

8. Which of the following statements are true concerning CVP monitoring?

1. Increased intrathoracic pressure from a pneumothorax may cause a corresponding decrease in the CVP.
2. The initial CVP level and the actual blood volume are not necessarily correlated.
3. The tip of the CVP catheter is ideally placed in the subclavian vein
4. Further fluid replacement is indicated with a minimal rise in an initially low CVP.

a. 1,2,3
b. 1,3
c. 2,4
d. 4 Only
e. All are correct.

9. A patient, who is involved in a rear and collision, is admitted to the Emergency Department. He is unconscious and has no obvious
injuries or respiratory distress. Which one of the following injuries is most suspect?

a. Pelvic injury
b. C-spine injury
c. Thoracic spine injury
d. Internal hemorrhage
e. Aortic deceleration injury

10. Which one of the following extremity injuries has top management priority?

a. Open fractures
b. Major joint dislocations
c. Angulated fractures
d. Traumatic amputations.

11. Which of the following clinical signs or symptoms of a compartment syndrome would be seen first?

a. Pallor
b. Pain
c. Paralysis
d. Absence of pallor

12. Before transporting a patient with a spinal injury all of the following measures should be undertaken EXCEPT:

a. Neurosurgical or orthopedic consultation.
b. Application of cervical traction tongs or Halo traction on all C-spine injuries.
c. Immobilization with splints, spine boards, and/or cervical traction tongs.

d. Avoid unnecessary delay.

13. A husky, 24 year-old male is brought to the Emergency Department with obvious open fractures of both femurs sustained when a cement truck crushed him against the wall of a building. His pulse is 130/min; his blood pressure is 85/60 mm Hg; his skin is cold and wet. He states that he weighs 210 lbs. A reasonable initial estimate of his blood loss would be:

a. 1000 ml.
b. 2000 ml.
c. 3000 ml.
d. 4000 ml.
e. 5000 ml.

14. Rapid evaluation of a 26 year old man involved in a motorcycle crash immediately prior to arrival in the Emergency Department reveals the following findings:-

1. Hemoperitoneum.
2. Shock
3. Open fracture of the right tibia
4. Right tension pneumothorax
5. Arterial hemorrhage from the left groin.

In what order of priority should these problems be dealt with?

a. 5,4,2,3,1
b. 4,5,2,1,3
c. 4,2,5,1,3
d. 5,4,1,2,3
e. 4,5,1,2,3,

15. All of the following statements about the pneumatic anti shock garment are true EXCEPT.
a. It can tamponade not only external bleeding, but also intra-abdominal bleeding.
b. It must be deflated slowly with concomitant intravenous volume replacement to prevent recurrence of hypovolemia.
c. It provides an irreversible immediate auto transfusion of roughly two units of blood.
d. It can reduce the rate of blood loss by splinting fractures of the lower extremities or pelvis.

16. Of the following I.V. solutions, which is preferred for the initial resuscitation of trauma patients?
a. Low molecular weight dextran
b. 5% Albumin
c. Ringer's Lactate
d. Normal saline

17. A 43 year old lawyer was struck while intoxicated, by a passing car. He sustained an open fracture of the right femur and fractures of the left ninth and tenth ribs. His vital signs have remained stable after two liters of Ringer's Lactate solution. Prior to any surgical intervention for
debridement of the open fracture in the operating room, which of the following modalities should be undertaken to stabilize the patient?

1. Placement of a CVP monitoring line and urinary catheter
2. Monitor ECG
3. Placement of a left thoracostomy tube.
4. Peritoneal lavage

a. 1,2,3
b. 1,3
c. 2,4
d. 4 Only
e. All are correct.

18. Which of the following statements regarding tetanus prophylaxis best describes when tetanus toxoid for tetanus prone wounds should be administered?

1. A patient receiving previous full tetanus immunization does not require additional tetanus toxoid.
2. A patient previously immunized with the last dose given in the past 10 years, but more than 5 years ago should receive 0.5 ml absorbed toxoid.
3. A patient receiving 2 or more prior injections of toxoid, with the last dose less than 5 years ago, give 0.5ml. absorbed toxoid.
4. A patient receiving only one or no prior injections of toxoid, give 0.5 ml absorbed toxoid and 250U. of human T.A.T. in separate extremities.
19. All of the following may be used to manage the patient in hypovolemic shock EXCEPT:
   a. Administration of Ringer's Lactate
   b. Administration of whole blood
   c. Vasopressors
   d. Pneumatic anti-shock trousers.

20. In a patient with pelvic injury the decision on whether or not to operate is based on :-
   a. Type A injuries: Stabilization of the anterior pelvic ring alone is sufficient.
   b. Type B injuries: Surgical stabilization is only exceptionally indicated.
   c. Type C injuries: adequate stabilization of the ring is required to minimize the risk of secondary displacement.
   d. None of the above.

21. Which of the following is true regarding primary intramedullary nailing of the femur :
   a. Intramedullary nailing can be recommended for polytraumatized patients without significant chest injury, with ISS < 25
   b. Intramedullary nailing recommended when ISS > 40.
   c. When ISS > 40 primary stabilization with external fixator is not essential.
   d. None of the above.
22. SIRS (Systemic Inflammatory Response Syndrome) is an associated with:
   a. General capillary leak syndrome.
   b. Hyperdynamic hemodynamic state
   c. Increase in core body temperature.
   d. All of the above.
   e. None of the above.

23. The proper treatment of a sucking chest wound is:
   a. Chest tube is inserted through the hole as a purse string suture is pulled up tight.
   b. Chest tube is inserted through another site under direct vision through the sucking chest wound site.
   c. Needle thoracentesis is performed as an assistant covers the hole with a wet towel.
   d. The defect is covered with an occlusive dressing and tube thoracostomy is performed at an alternative site.
DISASTER PLANNING, TRIAGE AND INITIAL ASSESSMENT

DISASTER PLANNING AND TRIAGE

Disasters may be classified as being either natural or artificial. Natural disasters embrace events such as earthquakes, typhoons and floods. Artificial disasters include major road, rail or air crashes, industrial accidents, rioting and explosions associated with civil disorder.

When a disaster occurs, large numbers of casualties are likely to arrive at hospital within a short period of time and may overwhelm the facilities and services available. It is therefore important to set priorities, not only in the management of the individual, but for organisation of care of the totality of the injured group.

Triage:

Triage means' sorting'. The term was used during warfare when sorting out casualties at forward clearing stations but, nowadays is frequently applied to disaster situations. Triage may be necessary both in the field and in the hospital setting. In hospital triage may be used in three situations.

1. On arrival of patients at Casualty Department.
2. In the x-ray department.
3. In determining priorities for operative intervention.
INITIAL ASSESSMENT

I. ESTABLISHING TREATMENT PRIORITIES

A. Initial Assessment

The Initial assessment of a patient is divided into four phases. The primary and secondary phases are separated by the resuscitative and definitive care management Phases.

1. PRIMARY SURVEY,
2. RESUSCITATION PHASE
3. SECONDARY SURVEY
4. DEFINITIVE CARE

B. Primary Survey : ABC's

1. A - Airway Maintenance with C-Spine Control
2. B - Breathing
3. C - Circulation with Hemorrhage Control
4. D - Disability : Neurologic status
5. E - Expose: Completely undress the patient.

C. Resuscitation Phase

The management of life-threatening conditions identified in the primary survey include establishing and maintaining an adequate airway and ventilation, intravenous therapy, and initiation of shock management. Insertion of a urinary catheter and nasogastric tube may also be accomplished during the resuscitation phase, if not contraindicated.
D. Secondary Survey

The secondary survey is initiated at the top of the patient's head and proceeds to the bottom of the feet. Using the look, listen and feel techniques, the entire body is examined by sections. Each section, (head, neck, chest; abdomen, extremities and neurologic status) are examined individually. Assessment of the eyes, ears, nose, mouth, rectum and pelvis should not be neglected. This can be easily defined as "tubes and fingers in every orifice."

E. Definitive Care Phase

The definitive care phase encompasses in depth management, fracture stabilization and splinting, any necessary operative Intervention, and/or stabilization of the patient in preparation for transfer to a facility providing a higher level of medical care.

F. Pediatric Priorities

Priorities in the pediatric patient are basically the same as for adults. Although the quantity of blood and fluids, the size of the child and associated diseases may be different, assessment and treatment priorities are the same.

G. Triage

Triage is a sorting of patients on the basis of treatment need. Where initial assessment identifies the most immediate need, priority treatment should be given. A group of injured patients can be satisfactorily stabilized with the help of nurses and EMT personnel (when available). Treatment is rendered on the basis of priority according to the ABC's (Airway with C-Spine control, Breathing, and Circulation with hemorrhage control) listed above.
BASIC EMERGENCY MEDICAL TECHNICIAN (EMT) SKILLS

1. Perform technically sound cardiopulmonary resuscitation.
2. Maintain an airway (endotracheal intubation?)
3. Obtain intravenous access and start Ringer's lactate therapy.
4. Reduce and splint fracture.
5. Perform primary survey of patient and report finding to destination center.
6. Act in concert with physician in early treatment decision (radio/telephone contact).

PHILOSOPHY AND TRAUMA TEAM ORGANIZATION

- The treatment of complex injuries in multiple organ systems demands a team approach.
- Every team must have a final decision maker, The Captain

Responsibilities of captain - Team leader

- To assess patient's status
- Determine the need for specific diagnostic test and delegate these two team members
- Co-ordinate the activities of ancillary services and specialty consultants
- Make critical treatment and triage decision.

The trauma team functions optimally with the "Trauma surgeon" as the team captain at the head of the patient, where attention can be directed towards airway management, protection of cervical spine and completion of primary
survey other team members with their own tasks can be supervised best from this location.

**REVISED TRAUMA SCORE**

According to Champion 1989 revision of the score was based on the following design objectives

1. The exclusion of capillary refill and respiratory expansion.
2. Easier implementation in field triage without concurrent diminished usefulness in care evaluation

**Method of assessment of revised trauma score**

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<th>GCS</th>
<th>SBP</th>
<th>RR</th>
<th>Coded value</th>
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<td>13-15</td>
<td>&gt; 89</td>
<td>10-29</td>
<td>4</td>
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<tr>
<td>9-12</td>
<td>76-89</td>
<td>&gt; 29</td>
<td>3</td>
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<tr>
<td>6-8</td>
<td>50-75</td>
<td>6-9</td>
<td>2</td>
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<tr>
<td>4-5</td>
<td>1-49</td>
<td>1-5</td>
<td>1</td>
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<tr>
<td>3</td>
<td>0</td>
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<td>0</td>
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The sum of these 3 products is the RTS. Total score ranges from 0-12.

**ABBREVIATED INJURY SCALE AND INJURY SEVERITY SCORE**

**ABBREVIATED INJURY SCALE (AIS)**

AIS and its derivative ISS are widely used as anatomic score for rating of severity of injuries. AIS is numeric scale ranging from 1 (minor) to 6 (maximum injury scores) are subjective assessment of severity assigned by a group of experts including trauma specialists and engineers. Implicity based on four criteria i.e. threat to life, permanent impairment, treatment and energy dissipation.
For the purpose of scoring body is divided into seven regions: External, Head (including face), Neck, Thorax, Abdomen/pelvis content, Spine, Extremities.

For each body region severity code is used to describe individual injuries these are classified as: Minor, Moderate, Severe not life threatening, Severe life threatening, Critical, survival uncertain.

INJURY SEVERITY SCORING (ISS)

ISS is the sum of squares of 3 most severely injured areas. ISS is a predictor of morbidity and mortality used for trauma care evaluation and for epidemiological studies. It's value range from 1 to 75. LD50 is an important addition to this index of severity (Bull 1975). LD50 is defined as a severity of injury that is a lethal dose for 50% the patients so injured.

<table>
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<th>ISS</th>
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<td>15-44 years</td>
<td>40</td>
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<tr>
<td>45-64 years</td>
<td>29</td>
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<tr>
<td>Over 65</td>
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UPPER AIRWAY MANAGEMENT

I. UPPER AIRWAY

Upper airway obstruction may be due to:

1. The tongue (most common).
2. Foreign body (including blood, vomitus, and dentures).
3. Edema of the glottic area or injury to the vocal cords.

The mouth and pharynx should be cleared of blood, vomitus or foreign material; making sure that the tongue or dentures have not slipped into the back of the throat.

A. The Tongue and Mandible

In the unconscious patient, whatever the cause, tone is lost in those muscles which normally maintain the tongue away from the posterior pharyngeal wall.

B. Manual Methods to Open the Airway

1. Chin lift
2. Jaw Thrust

C. Mechanical Methods to Open the Airway

Mechanical methods for opening and maintaining the airway include the use of the (1) oropharyngeal airway, (2) the nasopharyngeal airway, (3) the esophageal obturator airway and (4) the endotracheal tube.
LARYNGEAL OBSTRUCTION

A. Cricothyroidotomy

INABILITY TO INTUBATE THE TRACHEA IS THE PRIMARY INDICATION FOR A CRICOTHYROIDOTOMY. When edema of the glottis, fracture of the larynx, or severe or pharyngeal hemorrhage obstructs the airway and an endotracheal tube is impossible to place through the cords, some opening must be made to allow for air passage.

B. Needle Cricothyroidotomy

Needle cricothyroidotomy is an acceptable method to the surgical route and may be preferred in an emergency situation in a child under the age of 12. Use of the jet insufflation technique will provide up to 45 minutes of extra time so that the tracheostomy can be placed on an urgent basis rather than on an emergent one.

C. Surgical Cricothyroidotomy

Surgical cricothyroidotomy is readily performed by making a vertical or transverse skin incision which extends through the cricothyroid membrane. The handle of the scalpel is then turned vertically to hold the membrane open while a small tracheostomy tube is placed. This is a rapid, safe, relatively bloodless and easy procedure.

SUMMARY

The upper airway is most commonly obstructed by the tongue, followed by foreign body, or traumatic edema. The chin lift is the preferred manual method initially to open the airway. If endotracheal intubation is required in a patient who is suspected of having a C-spine injury, the
nasotracheal route is the method of choice. If, however, endotracheal intubation is unsuccessful, or impossible, then surgical cricothyroidotomy should be performed in the adult patient. The adequacy of patency of the upper airway is mandatory and is of paramount importance in the proper treatment of the trauma patient.
SKILL STATION-I UPPER AIRWAY MANAGEMENT

NAME:_____________________________________DATE:_____________

EQUIPMENT
1. Adult intubation Manikin-2
2. Infant intubation Manikin
3. Adult oral ET tubes.
4. Adult nasotracheal tubes.
5. Laryngoscope handle.
7. Esophageal Obturator Airway
8. Esophageal Gastric Tube Airway.
10. Extra Laryngoscope bulbs.
11. Stethoscope.
12. Lubricant (Le. Silicone Spray which accompanies the intubation manikin)
13. Cetacalne(R) Spray or 4 % lidocaine and 1/4 % Neosynephrine spray.
15. Magill Forceps
17. Oropharyngeal airway
18. Nasopharyngeal airway
19. Bag valve mask device
20. Pocket face mask
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<tr>
<th>Skills</th>
<th>Yes</th>
<th>NO</th>
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<td>3. PROCEDURE: ADULT INTUBATION</td>
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<td>4. PROCEDURE: NASOTRACHEAL INTUBATION</td>
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<tr>
<td>5. PROCEDURE: ESOPHAGEAL AIRWAY</td>
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<td>6. PROCEDURE: INTUBATION OF TRACHEA WITH ESOPHAGEAL AIRWAY IN PLACE</td>
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<td>7. PROCEDURE: REMOVAL OF EOA/EGTA</td>
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<td>8. PROCEDURE: INFANT INTUBATION</td>
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**INSTRUCTOR'S COMMENTS**

Assessment/ Management done in correct sequence?  Yes______No____

Instructor's name_________________________________________________________
SHOCK

INTRODUCTION

Various types of shock may be present in the trauma patient. They are not usually manifested, however, in the first hour of management. Because this course deals with the first hour of management of the multiply injured patient, this section on shock is confined to hemorrhagic or hypovolemic shock.

Management of shock is based on cellular perfusion and its maintenance, rather than simple attention to the patient's blood pressure and pulse rate.

PATHOPHYSIOLOGICAL RESPONSE TO HEMORRHAGIC SHOCK

A. General Pathophysiology of Shock

Although shock is a complex syndrome, hypotension is one of the primary clinical manifestations. Many receptors in the body sense diminution in blood flow/ before there is assignment drop in systemic blood pressure. A series of compensatory mechanisms therefore become active after rapid loss of circulating blood volume. Cardiac output and systolic pressure fall as the blood volume diminishes, releasing catecholamines (norepinephrine and epinephrine) from the sympathctic ganglionic nerve endings.
B. Metabolic Response to inadequate Resuscitation

As the clinical syndrome of shock progresses, metabolic acidosis at the cellular level produces systemic acidosis. Due to the local injury, fluid leaks from the capillary bed and enters the interstitium further depleting the circulating volume and enhancing the patient's shock state. This compounds the problem of decreased tissue perfusion and promotes further hypoxia and acidosis. Adequate fluid resuscitation, imperative in the initial management of shock, increases the cardiac output and reverses this metabolic acidosis.

C. CLASSIFICATIONS OF. HEMORRHAGE

**CLASSES OF ACUTE HEMORRHAGE**

<table>
<thead>
<tr>
<th></th>
<th>Class I</th>
<th>Class II</th>
<th>Class III</th>
<th>Class IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blood Loss in ml</td>
<td>up to 750 ml</td>
<td>1000-1250ml</td>
<td>1500-1800 ml</td>
<td>2000-2500ml</td>
</tr>
<tr>
<td>Blood Loss in %⁴</td>
<td>up to 15%</td>
<td>20-25%</td>
<td>30-35%</td>
<td>40-50%</td>
</tr>
<tr>
<td>Pulse Rate²</td>
<td>72-84</td>
<td>&gt;100</td>
<td>&gt; 120</td>
<td>140 or greater</td>
</tr>
<tr>
<td>Blood Pressure³</td>
<td>118/82</td>
<td>110/80</td>
<td>70-90/50-60</td>
<td>&lt;50-60 systolic</td>
</tr>
<tr>
<td>Pulse Pressure (mmHg)</td>
<td>36 mm Hg</td>
<td>30 mm Hg</td>
<td>20-30mmHg</td>
<td>10-20 mmHg</td>
</tr>
<tr>
<td>Capillary Blanch Test</td>
<td>Normal</td>
<td>Positive</td>
<td>Positive</td>
<td>Positive</td>
</tr>
<tr>
<td>Respiratory Rate</td>
<td>14-20</td>
<td>20-30</td>
<td>30-40</td>
<td>&gt;35</td>
</tr>
<tr>
<td>Urine Output (ml/hr)⁴</td>
<td>30-35 ml</td>
<td>25-30 ml</td>
<td>5-15 ml</td>
<td>Neglible</td>
</tr>
<tr>
<td>CNS-Mental Status</td>
<td>Slightly Anxious</td>
<td>Mildly Anxious</td>
<td>Anxious and Confused</td>
<td>Confused Lethargy</td>
</tr>
<tr>
<td>Fluid Replacement (Use 3:1 rule for fluid resuscitation)</td>
<td>Crystalloid</td>
<td>Crystalloid</td>
<td>Crystallloid + Blood</td>
<td>Crystallloid + Blood</td>
</tr>
</tbody>
</table>

1. % of blood volume in a standard 70kg male
2. Assume normal of 72/min.
3. Assume normal of 120/80
4. Assume a normal of 40-50 ml per hour
PATIENT ASSESSMENT AND MONITORING

1. Clinical Signs and Symptoms

   Remember, the blood pressure may not be significantly affected until Class III or Class IV hemorrhage occurs.

2. Urinary Output

   Urinary output is not normally affected until a Class II hemorrhage occurs. Adequate volume replacement should produce an expected urinary output greater than 50 ml per hour in an adult patient and 0.5-1 ml per kilogram per hour in the pediatric patient.

3. Acid/Base Balance

   Persistent acidosis, in the shock patient, should be treated with increased fluids and not intravenous sodium bicarbonate.

4. Central Venous Pressure

   The response of the central venous pressure to fluid administration is the best indicator of the adequacy of volume replacement.

   Ideal placement of the intravenous catheter is in the superior vena cava, just proximal to the right atrium.

   The major drawback of central venous pressure monitoring is that it lacks the sensitivity of advanced monitoring techniques such as those used for measuring cardiac outputs and pulmonary wedge pressures.

D. SHOCK MANAGEMENT

   Remember, tachycardia may not be seen in the elderly patient due to the poor cardiac response to catecholamine stimulation or certain antihypertensive medications.
1. Physical Examination
   
i. Airway - Breathing
   
ii. Bleeding - Hemorrhage Control

2. Vascular Access Lines
   
   A fluid challenge test dose of 200 ml of Ringer’s Lactate over a period of ten minutes or 1000ml of Ringer's Lactate over a period of one hour in an adult is frequently beneficial in determining the need for more fluids. in a pediatric patient, 20-40 ml per kilogram per hour is an adequate fluid challenge. Rapid increases in the central venous pressure, which do not decrease to normal values (8-12 cm) within ten minutes, and an increased urinary output greater than 100 ml per hour are indications of fluid overload in the adult patient.

3. Urinary Output
   
   One of the best organs to judge peripheral blood flow is the kidney.

4. Pneumatic Anti-Shock Garment
   
   Management of the profound hypotensive patient is initiated with the application of the pneumatic anti-shock garment (PASG) in an effort to restore adequate circulation to vital organs.

   Pulmonary edema is the one absolute contraindication in the application of the pneumatic anti-shock garment.

   Primary indications, however, for the application of the PASG are: splinting and hemorrhage control from pelvic fractures, tamponading soft tissue hemorrhage, stabilizing multiple leg fractures. tamponadlng intra-
abdominal bleeding and the immediate translocation of fluid for shock management.

Head injuries, of themselves, do not produce shock except in terminal head injuries.

E. INITIAL FLUID THERAPY IN SHOCK

1. Crystalloid Solutions

Ringer's Lactate solution is the initial fluid replacement of choice. It is the most nearly physiologic solution available for infusion in large volumes. One half of the lactate which is present in this solution is metabolized in the liver to bicarbonate while the other half is excreted in the urine, unchanged.

Normal saline is the second choice of solution used in the emergency setting. Although normal saline is a satisfactory fluid replacement it has the potential of predisposing to hyperchloremic acidosis.

2. Blood Replacement

Type-specific, cross-matched blood is indicated in class III and IV hemorrhages.

1. Type-Specific, Type 'O' Blood

In life-threatening shock situations, when blood replacement is necessary, type-specific blood can be given without proper cross match. If type-specific blood is not available then type 'O' blood may be given. For males, type '0' positive blood of low titer is used. In females of childbearing age, low titer 'a' negative blood is used because of the Rh sensitization possibility.
2. **Blood Filters**

Macropore intravenous filtering devices are used when whole blood transfusions are given. This is particularly important when using banked, in order to remove platelet and fibrin aggregates. The use of micropore blood filters have not been demonstrated to be of significant value.

3. **Warming Blood**

Cold blood is associated with a high incidence of myocardial dysrhythmias and paradoxical hypotension.

4. **Massive Transfusions - Coagulopathy**

Patients requiring massive transfusions often need fresh whole blood or fresh frozen plasma to restore blood clotting factors.

Coagulopathy is sometimes encountered, particularly in patients receiving more than ten units of blood. This "coagulopathy" is more of a dilutional problem in that normal existent intrinsic clotting factors have been exhausted. Platelet exhaustion is not usually a problem until greater than ten units of bank blood have been given. In this instance a minimum of six to ten platelet packs should be given for every twenty units of bank blood transfused.

Binding of the calcium by anticoagulants in banked blood is a problem with massive transfusions. **The majority of patients receiving blood transfusions do not need calcium supplementation.** Regardless of the volume administered, if the infusion rate is less than 50-75 ml per minute, calcium mobilization is probably adequate. Monitoring of the QT interval is of some value and is highly recommended during the rapid infusion of citrated blood. For patients receiving blood in excess of 100 ml per minutes,
however, calcium administration 'may be indicated. An appropriate dose is 0.2 grams of Calcium Chloride (2 ml of 10% Calcium Chloride solution) in a separate line for every 500 ml of blood transfused.

F. COMPLICATIONS

Unfortunately, complicating factors do intervene during the care of the shock victim. Consider the following complications when the patient does not respond appropriately to therapy.

A. Continued Hemorrhage

When obscure hemorrhage continues and fluid therapy produces a poor patient response, consider immediate surgical intervention.

B. Fluid Overload

Fluid overload is avoided by careful monitoring of all parameters, including heart failure and the wet lung syndrome. The blood pressure cuff, stethoscope, central venous pressure, urinary output, as well as a sharp eye for signs of tachypnea, or air hunger, are essential parameters to continuously monitor, thereby minimizing the occurrence of overload. If overload is suspected repeat the arterial blood gases and stop or reduce fluid administration. Cautiously administer a diuretic, such as Furosemide intravenously, as the line between fluid overload and hypovolemia is narrow. Digoxin by the same route may be administered.

C. Failure to Respond

When there is a failure to respond to administered therapy, consider ventilatory problems. Unrecognized fluid loss, acute gastric distention, cardiac tamponade, myocardial infarction, diabetic acidosis, hypoadrenalism, and neurogenic shock.
SPINE AND SPINAL CORD TRAUMA

Objectives

Upon completion of this topic, the orthopaedic surgeon will be able to identify principles of management, demonstrate the ability to assess spinal trauma and apply immobilization techniques for patients with vertebral and/or spinal cord injuries.

Specifically, the Orthopaedic surgeon will be able to:

A. Explain the principles involved in evaluating vertebral and spinal cord trauma.

B. Identify types and explain methods of treatment for vertebral injuries.

C. Given a simulated patient with suspected cervical vertebral and spinal cord injuries; demonstrate the ability to assess the multiply injured patient.

D. Given a simulated patient with suspected cervical vertebral and spinal cord injuries and appropriate equipment; apply techniques utilized in immobilizing the neck and spine.

I. INTRODUCTION.

The Orthopaedic surgeon must be continually cognizant that injudicious manipulation or movement, and inadequate immobilization can cause additional injury and decrease the patient's overall prognosis.

Vertebral injuries may be present without spinal cord injury. The potential for cord injury, however, is always present and careful
handling of these patients is essential. A potential vertebral column injury should be presumed present until screening x-rays are obtained and fractures or fracture-dislocations ruled out.

II. HISTORY OF INJURY

Knowledge of the patient's neurological condition, is very important. A description of how the patient sustained the injury is significant in order to understand the mechanism of injury and potential for further injury. Any injury produced by high speed vehicles, should arouse suspicion of concomitant vertebral spinal cord injury.

Valuable information can be obtained from the ambulance personnel, i.e. presence of paralysis immediately post-injury of deterioration of the patient's sensorymotor status. This information is essential in assessing and documenting the site and extent of injury and/or the paralysis present.

ANY PATIENT SUSTAINING AN INJURY ABOVE THE CLAVICLE OR A HEAD INJURY RESULTING IN AN UNCONSCIOUS STATE SHOULD BE SUSPECTED OF HAVING ASSOCIATED CERVICAL SPINAL COLUMN INJURY.

III. ASSESSMENT

A. General

Examination of any suspected case of spinal injury must be carried out with the patient's neck in a neutral position and without any movement of the patient's spine. The neck and trunk must not be flexed, extended or rotated. The patient
should be brought to the Emergency Department properly immobilized with a semi-rigid cervical collar and on a spine board. They should be left completely immobilized until x-rays are taken to rule out vertebral fractures.

A patient with paralysis is usually able to identify pain at the site of injury, since loss of sensation is below this level. **Remember, paralysis and loss of sensation may mask intra-abdominal and lower extremity injuries.** As the spine is carefully palpated, listen to the patient and watch his face for signs of pain.

All information obtained from the neurological examination is carefully documented on the chart to allow for easy identification of any changes. In the paralyzed patient, any movement or sensation at or below the level of the injury is important and may affect the prognosis.

B. Vertebral Assessment:

The Orthopaedic surgeon should assess for pain, tenderness, and a posterior "step-off" deformity. This pain occasionally radiates to the arms, about the chest and abdomen, or into the lower extremities. Other diagnostic signs and symptoms include: prominence of spinous processes, local tenderness, pain on attempted motion, edema, ecchymosis, visible deformity, and muscle spasms. The Orthopaedic surgeon should also assess for tracheal tenderness or deviation and
retropharyngeal hematoma. The position of the head should be noted for muscle spasm and head tilt. These symptoms also aid in identifying and localizing the site of injury.

C. Neurological Assessment

The patient is carefully examined for motor strength and weakness, sensory disturbances, reflex changes, and autonomic dysfunction. Motor involvement is ascertained by voluntary muscle contractions or involuntary response to painful stimuli. Autonomic dysfunction is identified by lack of sweating, altered vasomotor responses, lack of bladder and rectal control, and priapism.

1. Complete vs incomplete Spinal Cord Lesions

Incomplete lesions may be differentiated from complete lesions, resulting in a mere realistically interpreted prognosis.

Sharp and dull pain discrimination indicates an incomplete lesion and lateral column preservation.

Patients should be assessed for light touch differentiation to ascertain the presence or absence of anterior column preservation.

The posterior column is assessed for positional sensation, vibratory response and deep pain sensation.

Because of the phenomenon of sacral-sparing; gently lift the leg and assess the anal, perineal, and scrotal areas. The
evaluation for sacral-sparing should include sensory perception and voluntary contraction of the anus.

The presence of sacral-sparing may indicate that paralysis is not complete and permanent, and is a **good prognostic sign for the return of sensorimotor function** (i.e. incomplete transaction of the cord with temporary paralysis).

2. Sensory/Motor Function

Ascertaining the levels of sensorimotor function aid in determining the level of injury.

a. Proximal to C-4, respiratory paralysis may be present. Ventilatory assistance may be required, less the patient succumb to this injury.

b. C-5 involves the motor function of the deltoid, biceps and brachial muscles.

c. C-6 involves the function of the abductor pollicis longus, extensor pollicis brevis, extensor pollicis longus, extensor carpi radialis longus, and extensor carpi radialis brevis.

d. C-7 involves the function of the triceps, finger extensors, flexor carpiradialis, and flexor carpiulnaris.

e. C-8 involves the function of the flexor digitorum sublimus and the flexor digitorum perfundus.
The level of sensory loss gives some indication to the level of spinal cord damage. Various areas may be used as a guide to detect changes in the sensorimotor sensation.

1. Two inches behind the tip of the ear: Level C-2.
2. Top of the shoulder: Level C-4.
3. Tip of the thumb: Level C-6
4. Tip of the middle finger: Level C-7
5. Tip of the fifth finger: Level C-8
6. At the nipple line: Level T-4.
7. At the lower tip of the sternum: Level T-6.
8. At the level of the umbilicus: Level T-10
9. Just below the iliac crest: Level L-1
10. Just above the kneecap: Level L-3
11. The top of the fifth toe: Level S-1

D. Spinal Shock

The term, "Spinal Shock" refers to the neurological condition immediately after spinal cord injury. The pulse rate is usually not increased with this type of shock and the blood pressure usually falls to approximately 80mm Hg systolic as blood pools in the dilated visceral vessels. Flaccid paralysis, flaccid sphincters, and absent pathological and normal reflexes are associated with spinal shock. After several weeks in areas,
which no function has returned, spasticity usually supercedes
the flaccid state.

A lateral C-spine and then an upright anteroposterior chest x-ray,
providing the C-spine x-ray is negative, should be obtained on every
patient sustainable multiple trauma.

1. Cervical Spine

Lateral cervical spine x-rays should be obtained as soon as life
threatening problems are identified and controlled. All seven
cervical vertebrae must be identified. The patient's shoulders
are routinely pulled down when obtaining the lateral C-spine
film to prevent missing fractures or fracture-dislocations of C-6
and C-7. If all seven cervical vertebrae are not visualized with
the lateral x-ray, a lateral Swimmer's view of the lower, cervical
and upper thoracic area is obtained.

After adequate demonstration of all seven cervical vertebrae,
the Orthopaedic surgeon can then obtain an upright chest film
assessing for mediastinal injuries; and determine the need for
further spine x-rays on a non-urgent basis. Cervical x-rays
which can be obtained after the first hour to further evaluate
the C-spine include: anterposterior, oblique cervical, and open
mouth odontoid x-rays. Tomograms may be necessary to
confirm a cervical spine injury and determine its stability.

Lateral flexion and extension x-rays of the cervical spine may
be dangerous and should be done under the direct supervision and control of a knowledgeable Orthopaedic surgeon.

2. **Thoracolumbar**

Anteroposterior and lateral thoracic films are standard. Oblique thoracic films seldom add further information. Anteroposterior, lateral and oblique film of the lumbar spine are also obtained if indicated.

**IV. TYPES OF SPINAL INJURIES**

A. **Fractures and Fracture-Dislocations of the Spine**

X-rays should be examined for the following:

a. Contour and alignment of the vertebral bodies.

b. Displacement of bone fragments into the spinal canal.

c. Linear or comminuted fractures of the laminae, pedicles, or neural arches.

d. Soft tissue swelling.

1. **Cervical Spine Fractures**

Cervical spine injuries may result from any one or a combination of the following mechanisms of injury.

1) Axial loading

2) Flexion

3) Extension

4) Rotation

5) Lateral bending

6) Distraction
C-spine injuries resulting in unstable fractures, fracture-dislocations and/or cord injury require transfer to a definitive care facility.

a. **C-1 (Atlas)**

A fracture of C-1 (atlas) usually involves a blow out of the ring (Jefferson fracture). The mechanism of injury of a C-1 fracture is usually an axial load. One should remember that one-third of these fractures are associated with a C-2 fracture. These fractures are not usually associated with cord injuries, however, they are unstable and should be treated initially with cervical traction tongs of spine board and semi-rigid cervical collar.

b. **C-2 (Axis)**

The second cervical vertebra may involve the odontoid with displacement posteriorly into the ring of the atlas. This displacement can be significant without cord injury due to Steel's rule of three: the area in the atlas is one-third occupied by the odontoid, one-third by an intervening space, and one-third by the spinal cord. It is apparent then, that room posterior to be odontoid is available for displacement. The transverse ligament posterior to the odontoid checks posterior displacement.

Three types of fractures may be associated with the odontoid.

1) Type I usually occurs above the base of the odontoid and is most often stable.
2) Type II occurs at the base of the odontoid and is usually unstable. Remember, in children under the age of six, the hypophysis may be present and may appear as a fracture at this level.

3) Type III is a fracture of the vertebral body.

Type I can be treated with a semi-rigid cervical collar or brace. Type II and III should be transported to a definitive care hospital for either surgical intervention or halo immobilization.

One may also see a rotatory subluxation of the odontoid in relation to the ring of the C-1 vertebra. Diagnosed by an odontoid view x-ray, the odontoid will appear farther from the smaller appearing C-1 segment and closer to the larger appearing C-1 segment, relative to the position of the subluxation. This is most often seen in children. Treatment of subluxation injuries are usually and generally best managed in a definitive care facility.

c. Posterior Element Fractures

The "Hangman's fracture" involves the posterior elements of C-2. The mechanism of this injury is extension and distraction or extension and axial compression. This is an unstable fracture. Patients with a "Hangman's fracture" should not be placed in cervical traction if the mechanism of the injury is secondary to distraction. The distraction type of injury received its name from judicial hangings. Patients sustaining a
"Hangman's fracture" should be transferred to a definitive care facility.

d. **C-3 through C-7.**

Various combinations of fractures and/or fracture-dislocations may be seen in C-3 thorough C-7. the mechanism of injury in stable fractures is usually flexion, extension, lateral bending or axial loading. The mechanism of injury in unstable fractures is usually flexion axial loading, extension axial loading, or flexion-rotation injuries.

When examining a lateral C-spine x-ray assess the distance between the pharynx and the anterior/inferior border of C-3. The soft tissue prevertebral thickness at this level should be less than 5 mm between the pharynx and vertebral body. An increase in this area of density is indirect evidence of a vertebral fracture. This is notoriously associated with a minimally disposed C-2 fracture. Children normally have two-thirds of the prevertebral thickness of C-2. The distance will vary with inspiration and expiration. In assessing for a hematoma at this level in children; remember, forced expiration increases the distance between the pharynx and the anterior/inferior border of C-3.

Patients with unstable vertebral injuries of C-3.7 require transfer to a definitive care hospital. Specifically, these patients include those with the following injuries:
1. An unstable fracture is identified if the anterior and all the posterior elements are disrupted.

2. An unstable fracture is identified if there is greater than 3.5mm overriding of a superior vertebra on the adjoining interior vertebra.

3. An unstable fracture is identified if there is angulation between two adjoining vertebrae greater than eleven (11) degrees.

Facet dislocations may also produce an unstable vertebral injury, especially bilateral facet dislocations. Consider a unilateral facet dislocation if there is a 25% disruption of the superior vertebra on the adjoining interior vertebra and a bilateral facet dislocation if there is a greater than 50% disruption.

Indication for transfer is determined on the basis of instability of the vertebrae or injury to the cord.

2. **Cervical Spinal Cord injuries.**

A bone fleck off the superior aspect of the vertebral body demonstrates an extension type injury and is usually stable without cord damage. The classic tear-drop sign may be seen with a bone chip off the anterior/inferior aspect. Cord injuries are many times associated with this radiographic tear-drop finding; an ominous sign due to displacement of the disc or posterior fragment of the vertebral body into the spinal canal. Spinal cord injuries can occur in the cervical spine with an essentially stable fracture by the collapsing of the vertebral
body and displacing it posteriorly into the cord. These injuries may range from fracture of the body without displacement and cord damage to severe vertebral disruption with complete paralysis.

B. Open Wounds
The most common of open spinal wounds are those caused either by missile injuries or stabbings. A bullet passing through the vertebral canal usually results in neurological deficit which is complete. The Orthopaedic surgeon should assess for cerebral spinal fluid drainage from the wound. Hemopneumothorax, acute abdomen, of great vessel injury are often associated with an open spinal injury and take precedence for treatment.

IV. Immobilization
A. Immobilization
Current levels of training pre-hospital care personnel have resulted in spinal injury patients being properly immobilized prior to their transport to the Emergency Department. Immobilization must be maintained in any patient with suspected spine injury until instability has been ruled out by x-rays. Any patient with suspected cervical spine injury is immobilized with a properly applied spine board and a semi-rigid cervical collar. If the patient is immobilized in an upright position, he may then be moved to a long backboard for
transfer. Remember, these protective devices must not be removed until x-rays are obtained.

Patients with cervical spine injury may require application of cervical traction tongs prior to transfer to a definitive care facility. In the present state of the art, it is more likely to see a halo traction placed in the definitive care facility than cervical traction tongs applied at the primary care hospital.

The cervical traction tongs can be rapidly applied in the Emergency Department and then the patient transported without the use of a backboard or cervical collar. The points of the tongs are inserted into the temporal ridge above the mastoid. They are screwed into place until the middle indicator extends out 1mm (only the Gardner-Wells Traction Tongs have this indicator). Weights may then be applied over a mobile carrier and the patient transferred without other means of spinal immobilization.

B. Intravenous Fluids

Intravenous fluids usually are limited to maintenance levels unless specifically needed for the management of shock. A urinary catheter is inserted to monitor urinary output and prevent bladder distention.

C. Medications

Proper limitation of fluid intake usually prevents the need for diuretics. The value of steroids is somewhat controversial,
however, they are frequently used in the early management of spinal injuries. The type and dosage of steroids used are determined in consultation with a neurosurgeon or orthopedic surgeon. Ideally, a management protocol is established by consultation.

D. Patients with unstable fractures or neurological deficit should be transferred to a definitive care facility. For persons not routinely seeing such injuries, the safest procedure is to move the patient after phone consultation with a specialist. Avoid unnecessary delay. The patient should be stabilized, needed splints applied, backboards, and/or cervical tongs applied and the patient transferred under medical supervision. Remember, high cervical spine injuries can result in partial or total loss of respiratory function. These patients are subsequently best managed by maintaining an adequate airway and ventilation. If endotracheal intubation is indicated the transnasal route should be used if possible.

V. SUMMARY

A. Attend to life-threatening injuries, avoiding any movement to the spinal column.

B. Proper immobilization should be applied and maintained until vertebral fractures or spinal cord injury have been ruled out.

C. Obtain lateral C-spine x-rays as soon as life-threatening injuries are controlled.
D. History and physical are of paramount importance to document, especially as a baseline for any changes in the patient's neurological status (i.e. ascertaining progress or deterioration of an Incomplete lesion.)

E. Obtain consultation with an orthopedic surgeon or neurosurgeon.

F. Patients with unstable vertebral fractures or spinal cord injury require transfer to a definitive care facility.
SKILL STATION - II IMMOBILIZATION TECHNIQUES FOR NECK AND SPINAL TRAUMA

NAME: ________________________________ DATE: __________

EQUIPMENT

1. Live patient model
2. Semi-rigid cervical collar
3. Long spine board with straps
4. Short spine board with straps
5. Sandbags
6. Chairs for make-shift car seat
7. Blankets, padding
8. Kerlix

OBJECTIVES

1. Upon completion of this station the participant will be able to demonstrate the assessment techniques utilized in examining a patient suspected of having neck and/or spinal injuries.

2. Performance at this station the participant will be able to demonstrate the assessment techniques utilized in examining a patient suspected of having neck and/or spinal injuries.
   a. Seated patient.
   b. Supine/prone patient.

3. Upon completion of this station the participant will be able to demonstrate proficiency in the use of:
   a. Semi-rigid cervical collar application.
b. Long spine board.

c. Short spine board with straps.

**PROCEDURE: ASSESSMENT OF NECK AND SPINAL INJURY**

<table>
<thead>
<tr>
<th>SKILLS</th>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A.</strong> Primary Survey</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Assessment of Respiratory Status</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Airway patency</td>
<td></td>
<td></td>
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<tr>
<td>1. Chin Lift.</td>
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<td></td>
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<tr>
<td>Intubation (nasotracheal).</td>
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<td></td>
</tr>
<tr>
<td>b. Respiratory efforts.</td>
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<tr>
<td>2. Assess patient's level of consciousness.</td>
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<td></td>
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<tr>
<td>3. Obtain vital signs.</td>
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<td></td>
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<tr>
<td>a. Deformity.</td>
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<td>b. Grating/crepitus.</td>
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<td></td>
</tr>
<tr>
<td>c. &quot;Boggy' sensation.</td>
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<td></td>
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<tr>
<td>d. Increased pain with palpation</td>
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<tr>
<td>5. Assess for spinal pain and location.</td>
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<td></td>
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<tr>
<td>6. Assess for paresis, and level of paresis</td>
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<td></td>
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<tr>
<td>7. Assess for paresthesia and location/level of paresthesia.</td>
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<td></td>
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<tr>
<td>8. Assess for paralysis and site/level of paralysis.</td>
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<tr>
<td><strong>B.</strong> Primary Management: Immobilization of Head, Neck and Spine with a Seated Patient.</td>
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<tr>
<td>1. Apply gentle, manual traction to the patient's cervical spine, by placing hands on either side</td>
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<tr>
<td>2. Immobilize the cervical fracture with a semi-rigid cervical collar.</td>
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<tr>
<td>3. Gently position the short spine board behind the patient.</td>
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</tr>
<tr>
<td>4. Secure the patient to the board by:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
a. Crossing the shoulder straps across the chest.

b. Apply the leg straps by passing them under the inside of the patient's thigh and up over the outside of the thigh. The straps are placed as close to the groin area as possible.

c. Attach the leg straps in a diagonal fashion with the shoulder straps and cinch up snugly.

d. Place padding, behind the head and neck to provide support between the cervical neck region and the spine board maintaining a neutral, vertical alignment.

e. Secure the patient's head to the board by using cravats or Kerlix. Wrap it snugly around the patient's forehead and board. Avoid use of chin strap.)

5. Immobilize the patient next on a long spine board.

a. Prepare the long board and place it to the patient's side.

b. Pivot the patient (do not use the short board as "handles on the patient" as this causes movement of the spine).

c. Gently lower the patient on the long spine board, keeping the knees and upper legs bent at right angles to the body until the patient is completely on the long board.

d. Slide the patient onto the backboard carefully and release the leg straps with care.

e. Lay the patient's legs down and retighten the short board straps.

f. Secure the patient to the long board with straps.

C. Primary Management: Immobilization of the Head, Neck and Spine with the supine Patient.

1. Prepare the long board with straps.

2. Apply gentle, manual traction to head and apply a semi-rigid cervical collar.

3. Log roll the patient as a unit to either side while maintaining manual traction to the head.
4. Place the long spine board behind the patient.

5. Place padding rolls on the board at the lumbar region, behind the knees, ankles and neck.

6. Roll the patient as a unit onto the long board and secure the patient with strap across the head, chest, thigh and lower legs.

D. Continued Management: Continued re-assessment of the patient’s status.

**INSTRUCTOR’S COMMENTS**

Procedure completed in correct sequence? Yes ___________ No. _______

Instructor's Name: ________________________________
EXTREMITY TRAUMA

Objectives

Upon completion of this topic, the orthopaedic surgeon will be able to identify problems of extremity trauma, principles of management and apply proper immobilization techniques for the initial transport to a definitive care facility.

Specifically, the orthopaedic surgeon will be able to:

A. Identify the types of injuries related to extremity trauma
B. Outline and explain priorities of assessment as related to extremity trauma.
C. Explain the management techniques related to extremity trauma.
D. Demonstrate the ability to assess extremity trauma on a simulated patient, and apply immobilization techniques (application of air and leg traction splints) for initial transportation of extremity trauma patients.

I. INTRODUCTION

Anatomically, extremities are a complex of tissues enveloped in a protective skin layer, supported by bones with joints interposed. Muscles, compartmentalized by fascial planes and neurovascular bundles travel along the entire length.

I. Primary and Resuscitation Surveys

1. Airway with C-spine control
2. Breathing
3. Circulation with hemorrhage control
4. Disability - brief neurological examination
5. Expose - completely undress the patient.

II. Secondary and Definitive Care Surveys.

1. Extremity Trauma - splitting of fractures
2. Evaluation of further injuries
3. Continuous monitoring

II. PATIENT ASSESSMENT

A. History

1. What happened to the patient and what contaminant, if any was found in the wound? (e.g. open fracture, reduced?)
2. Where did the accident happen?
3. When did the accident occur and when did the patient last receive tetanus immunization?
4. How did the accident happen?
5. Any previous injury to the same extremity?

B. Physical Examination

1. Look
   a. Deformities
   b. Swelling
   c. Muscle spasm
   d. Open wounds which may or may not be associated with fractures
   e. Extremity color

2. Feel
   a. Tenderness
   b. Loss of motion
   c. Crepitation
   d. Distal pulse
e. Capillary refilling  
f. Distal neurological sensation.

**C. Mangled extremity severity scores (MESS) variables**

<table>
<thead>
<tr>
<th>Factors</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. Skeletal/ soft tissue injury</strong></td>
<td></td>
</tr>
<tr>
<td>• Low energy (stab, simple fracture, low velocity gunshot wound)</td>
<td>1</td>
</tr>
<tr>
<td>• Medium energy (open or multiple fractures, dislocation)</td>
<td>2</td>
</tr>
<tr>
<td>• High energy (close-range shotgun or high velocity gunshot wound, crush injury)</td>
<td>3</td>
</tr>
<tr>
<td>• Very high energy (above plus gross contamination, soft tissue avulsion)</td>
<td>4</td>
</tr>
<tr>
<td><strong>B. Limb Ischemia</strong></td>
<td></td>
</tr>
<tr>
<td>• Pulse reduced or absent but perfusion normal</td>
<td>1</td>
</tr>
<tr>
<td>• Pulseless; paresthesias, diminished capillary refill</td>
<td>2</td>
</tr>
<tr>
<td>• Cool, paralyzed, insensate</td>
<td>3</td>
</tr>
<tr>
<td><em>Score double for ischemia &gt; 6 hours</em></td>
<td></td>
</tr>
<tr>
<td><strong>C. Shock</strong></td>
<td></td>
</tr>
<tr>
<td>• Systolic blood pressure always &gt; 90 mm Hg</td>
<td>0</td>
</tr>
<tr>
<td>• Hypotension transiently</td>
<td>1</td>
</tr>
<tr>
<td>• Persistent hypotension</td>
<td>2</td>
</tr>
<tr>
<td><strong>D. Age</strong></td>
<td></td>
</tr>
<tr>
<td>• &lt; 30 Y</td>
<td>0</td>
</tr>
<tr>
<td>• 30-50 Y</td>
<td>1</td>
</tr>
<tr>
<td>• &gt; 50 Y</td>
<td>2</td>
</tr>
</tbody>
</table>
Score of 7 points or less in nearly always compatible with salvageable limb.

D. Fracture Assessment

1. Associated Fractures
   a. Assess anterior knee injuries for associated fracture(s) or dislocation of the hip.
   b. Assess wrist injuries for associated injury of the elbow and shoulder.
   c. Assess calcaneal fractures for associated lumbar spine fractures. Fractures of L₁ and L₂ are often seen with this injury.
   d. Assess the hips bilaterally, as a fracture of one hip may conceal a dislocation or fracture of the opposite hip.
   e. Assess for a dislocated hip ipsilateral to a fractured femur.

2. Missed Fractures
   a. Cervical spine fractures, particularly C₆ and C₇
   b. Clavicular fractures.
   c. Fractures of the surgical neck of the humerus and dislocations of the glenohumeral joint.
   d. A fracture of the ulna and radius.
   e. Wrist fractures and/or dislocations.
   f. Ankle fractures.

E. Blood Loss Assessment

1. Closed injury
   Closed extremity injuries can produce enough blood loss, resulting in hypotension.

2. Open injuries
   Open fractures resulting in blood loss at the accident site and into clothing may not be appreciated by the examining Orthopaedic surgeon.
E. **Sprain Assessment**

F. **Dislocation Assessment**

G. **Fracture-Dislocation Assessment.**

Injuries severe enough to cause fracture-dislocations may also cause spinal cord trauma. A high index of suspicion for vascular injury must be maintained, therefore, when dealing with fracture-dislocations.

H. **Neurovascular Bundle Injury Assessment**

1. **Vessel injuries**

   Vessel injuries can result in complete or partial severance. Complete tears of the vessel produce less bleeding than partial tears due to the contractility of the vessel. Partial tears are likely to bleed for a prolonged period of time.

2. **Nerve injuries**

   Nerve injuries may be present as actual division of the nerve or a physiological disruption. Physiological nerve disruption usually occurs in closed injuries unless the nerve is divided by bony fragments. Shock waves created by missiles or stretching of the nerve fibers may cause variable degrees of paralysis, ranging from partial and temporary to complete and permanent.

I. **Closed Space Syndrome (Compartment Syndrome) Assessment**

1. **Pain**

2. **Paresis**

3. **Paralysis**
4. Puffiness or Swelling
5. Pallor
6. Pulselessness

III. EXTREMITY TRAUMA MANAGEMENT

Life-threatening problems (i.e. acute respiratory distress or shock) are managed initially. After these emergencies are controlled, attention can be directed toward the specific extremity injury.

A. Fractures
   1. Open Fractures
   2. Immobilization

B. Joint injuries

Joint dislocations and fracture-dislocations have top priority in extremity management.

C. Splinting extremity injuries

Splinting of extremity injuries should be carried out as soon as life-threatening injuries are controlled. Different types of splints and leg traction splints, may be used including the PASG, especially in the shock patient with lower extremity trauma or pelvic fractures.

1. Leg/Hand/Arm Fractures.

A board or molded splint may be used to immobilize the arm. The splint is padded, applied to the arm and secured with cravat bandages. The inflatable arm splint can also be used. The splint is placed over the applier's hand, and then with proximal and distal traction on the effected extremity, the splint is pulled over the fractured extremity. Traction is maintained until
the air splint is inflated. All jewelry must be removed prior to the application of any splint to prevent pressure areas or circulatory embarrassment.

2. Femoral Fractures

Because of severe muscle spasm associated with femoral fractures, traction leg splints are used to adequately stabilize the fracture. The shoe and stocking are removed to assess peripheral circulation. Distal manual traction is applied and the leg is gently lifted and placed on the half ring of the traction splint.

D. Open Wounds

Open wounds are covered with saline or dry dressings. Bleeding is controlled with direct pressure, pressure dressings, or by the use of anatomical pressure points.

F. NPO/ NBM

G. Tetanus immunization

Attention must be directed toward adequate tetanus prophylaxis in the multiply injured patient, especially if open extremity trauma is present.

1. General Principles

a. Passive immunization with Tetanus Immune Globulin-Human (human T.A.T.) must be considered individually for each patient. The characteristics of the wound, conditions under which it was incurred, its treatment, its age, and the previous active immunization status of the patient must be considered. It is not indicated, however, if the patient has ever received two or more injections of toxoid.
b. To every traumatized patient, give a written record of the immunization provided, instructing him to carry the record at all times, and if indicated, to complete active immunization. For precise tetanus prophylaxis, an accurate and immediately available history regarding previous active immunization against tetanus is required.

c. Immunization in adults requires at least three injections of toxoid. A routine booster of absorbed toxoid is indicated every ten years there after. In children under seven, immunization requires four injections of diphtheria and tetanus toxoids combined with pertussis vaccine. A fifth dose may be administered at four to six years of age. Thereafter, a routine booster of tetanus and diphtheria toxoid is indicated at ten-year intervals.

2. Previously immunized individuals
   a. When the attending Orthopaedic surgeon has determined that the patient has been previously fully immunized and the last dose of toxoid was given within ten years: For tetanus-prone wounds and if more than five years has elapsed since the last dose, give 0.5 ml absorbed toxoid. If excessive prior toxoid injections have been given, this booster may be omitted.
   b. When the patient has had two or more prior injections of toxoid and received the last dose more than ten years previously, give 0.5 ml absorbed toxoid for both tetanus-prone and nontetanus-
prone wounds. Passive immunization is not considered necessary.

3. **Individuals NOT adequately immunized**

When the patient has received only one or no prior injection of toxoid, or the immunization history is unknown:

a. For nontetanus-prone wounds: give 0.5ml absorbed toxoid

b. **For tetanus-prone wounds:**

1) Give 0.5ml absorbed toxoid

2) Give 250 units (or more) of human T.A.T.

3) Consider providing antibiotics, although the effectiveness of antibiotics for prophylaxis of tetanus remains unproved.

4) Administer, using different syringes and sites of injections.

H. **Antibiotics**

I. **Pain Control**

J. **Closed Space Syndrome**

**Note:** For detailed management of extremity trauma see training module on Principles of fracture management and implant surgery.
SKILL STATION III: IMMOBILIZATION TECHNIQUES FOR EXTREMITY TRAUMA

NAME:____________________________________ DATE:__________

EQUIPMENT

1. Live patient model.
2. Air splints - short & or long arm, long leg with foot boot.
3. Leg traction splint.
4. Cardboard splints. (Optional)
5. Blanket.

OBJECTIVES:

1. Upon completion of this station the participant will be able to identify the major neurovascular structures of upper and lower extremities.
2. Performance at this station will allow the participant to practice and demonstrate techniques used to immobilize extremity fractures with the following:
   a. Air splint.
   b. Leg traction splint.

PROCEDURE: APPLICATION OF AIR SPLINT

1. Select the appropriate size and type of air splint.
2. Dress any open wounds
3. Remove and cut open all clothing on the extremity. Remove all watches, bracelets and rings.
4. Apply splint (unzipped, undeflated). Grasp the patient's hand or foot while your assistant holds proximal traction and slide the air splint over your hand onto the patient's extremity. The air splint should be positioned free of wrinkles. The splint should extend one joint above and below the suspected fractures to which air splints

<table>
<thead>
<tr>
<th>SKILLS</th>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
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<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>
are applied. **NOTE:** If the splint is being applied to the arm, it should extend beyond the end of the fingers to prevent a constricting band and subsequent decreased circulation to the fingers.

5. Continue to maintain traction proximally and distally, as your assistant inflates the splint.

6. The splint should be inflated just to the point at which your finger will make a slight dent against the splint.

7. Continue to monitor circulation and check that the splint does not lose pressure.

**Caution:** When the splint is applied in a cold environment and the patient is moved to a warm area, the splint will expand and may constrict. Similar situations occur in air ambulance transfer in non-pressurized cabins.

**INSTRUCTOR'S COMMENTS:**

Patient assessed in proper sequence?  Yes __________  No. __________

Instructor's Name _____________________________________________

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### OBSERVED

#### SKILLS

<table>
<thead>
<tr>
<th>PROCEDURE: APPLICATION OF THE LEG TRACTION SPLINT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. One person should address the injured extremity and one person address the application of the splint.</td>
</tr>
<tr>
<td>2. Measure the unaffected leg with the traction splint.</td>
</tr>
<tr>
<td>a. The upper cushioned ring should be placed right under the buttocks and adjacent to the ischial tuberosity.</td>
</tr>
<tr>
<td>b. Two support straps should be above the knee and two below the knee.</td>
</tr>
<tr>
<td>3. Cut away clothing to expose the injured site. Dress open wounds.</td>
</tr>
</tbody>
</table>

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4. The first assistant supports the leg, while the second assistant removes the shoe and sock to assess distal circulation and pedal pulses.

5. One assistant applies manual traction to the leg, while maintaining support under the fracture and the calf.

6. Reassess the distal pulse after applying manual traction.

7. While the first assistant maintains manual traction on the leg, the second assistant applies the ankle hitch around the patient's ankle and upper foot. The bottom strap should be the same length or preferably shorter than the two upper cross straps.

8. Gently lift the fractured limb, while maintaining support and traction. Slide the splint under the affected leg, with the padded upper ring snugly against the Ischial tuberosity.

9. Gently lay the leg on the splint and extend the leg elevator. Snugly attach the top strap first.

10. While continuing to support the leg and maintain traction, attach the ankle hitch to the traction hook.

11. Apply traction gently to the leg by turning the windlass knob until the extremity appears stable, or in the conscious patient, pain and spasm is relieved.

12. Reassess the distal, pedal pulses.

13. Secure the remaining straps, making sure they are not too light.

14. Continually reassess the circulation to the affected limb.

**INSTRUCTOR'S COMMENTS:**

Patient assessed in proper sequence? Yes __________ No __________

Instructor's Name: ___________________________________________________.
Assessment of fractures and soft tissues

Among polytrauma patients the incidence has risen to about 25% and in the group of traffic-related fatalities a pelvic fracture was detected in as many as 42% of individuals. The evaluation of pelvic injury has to be based on repeated check of the patient’s vital parameters (hemodynamics), a detailed clinical examination, (pelvic stability, concomitant peripelvic injuries, neurology) and a structured radiographic evaluation. Emergency decision can be based on a pelvis AP x-ray. In all situations which are unclear or where a lesion within the posterior pelvic ring is suspected or diagnosed. CT examination is the present diagnostic gold standard.

Decision making: It can be divided into two phases

I. Detection and treatment of life-threatening situations ("emergency algorithm").
II. Diagnosis and detailed classification of the osteoligamentous injury and operative planning and surgery, if required.

TERMINOLOGY AND CLASSIFICATION

The present classification of pelvic injuries based on the AO Muller system comes from the evaluation of mechanism of injury and the resulting "stability/instability" of the pelvic ring.

Grade of stability or instability is the platform for further decision making. For practical reasons and as a basis for indications. Three different degrees of stability/instability are differentiated.
- Mechanical structure of the pelvic ring intact: Type A injury, incidence 50-70% of patients.
- Partial posterior stability, rotational instability: type B injuries, incidence 20-30% of patients.
- Combined anterior and posterior instability, translational instability; type C, incidence 10-20% of patients.

The decision on whether or not the operate can be based on the fracture types:

- Type A injuries: surgical stabilization is only exceptionally indicated
- Type B injuries: stabilization of the anterior pelvic ring alone is sufficient.
- Type C injuries: adequate stabilization of the ring is required, to minimize the risk of secondary displacement.

Primary evaluation and decision making

The primary goal in the assessment of pelvic injuries etc.

- In case of severe "internal" hemorrhage: is this caused by a pelvic fracture?
- The clinical and radiological assessment of the degree of mechanical stability of the pelvic ring.
- The diagnosis of peripelvic soft-tissue and organ injuries.
Emergency algorithm for pelvic injury
Radiological Examination

The AP pelvic view is mandatory and can provide a reliable working diagnosis in about 90% of the cases.

Instability of the pelvic ring combined with hemodynamic instability

In this situations primary therapy has to concentrate on immediate control of pelvic hemorrhage. Several treatment protocols for emergency hemostasis have been published favoring a wide variety of methods. No single method is effective by itself in controlling the bleeding. Only a combination of interventions (early pelvic stabilization followed by surgical hemostasis if necessary) following a priority orientated "algorithm" can have a beneficial impact on the patient's survival. Continued evaluation of resuscitation algorithms is necessary to evaluate their efficiency in saving lives.

Treatment protocol

A standardized protocol for primary clinical treatment is used for all patients being admitted in polytrauma situations. If the pelvic fracture causes hemodynamic instability, this protocol is expanded by a 'Complex pelvic fracture module". This is based on three simple decisions to be made within 30 minutes after admission. If the unstable hemodynamics come from a pelvic instability, emergency stabilization is performed immediately. The pelvic C-clamp or the simple external fixator can allow effective stabilization as early as 10-15 minutes after admission in the shock room.
The unstable pelvic ring in a hemodynamically stable patient

This situation is most frequently encountered. In the hemodynamically stable patients, detailed evaluation of the nature of the pelvic ring injury is required before deciding about indications for and selection of appropriate stabilization techniques.

Indications and decision making

1. Type A ("stable" ring): Stabilization is not normally required.
2. Type B (rotational instability partial dorsal stability): Stabilization of the anterior pelvic ring is usually sufficient.
3. Type C (anterior and posterior instability): Combined stabilization is required.
OPEN FRACTURES

1. Introduction

Open fracture indicates a communication between fracture and external environment. Most severe open tibial fractures associated with vascular injury show documented amputation rates in excess of 50%. Risk of infection, delayed union and non-union are high.

2. Etiology and mechanism of injury

The degree of trauma suffered is related to the impact velocity.

3. Microbiology

Most open fractures are contaminated with bacteria, at or shortly after the time of injury, 60-70% showing positive wound cultures before treatment begins. These bacteria are relatively innocuous skin and environmental contaminants, which rarely cause infection. Most commonly infection follows contamination after arrival at hospital, with pathogenic. Staphylococcus aureus, enterococcus or pseudomonas.

4. Classification

Most widely used the Gustilo and Anderson.

Classification of open fractures

Gustillo type I: Fractures of this type have a clean wound of less than 1 cm in size with little or no contamination. The wound results from a perforation from the inside out by one of the fracture ends. Type I fractures are simple fractures, like spiral or short oblique fractures.
**Gustilo type II**: Injuries have a skin laceration larger than 1 cm, but the surrounding tissues have minor or no signs of contusion. There is no dead musculature present and the fracture instability is moderate to severe.

**Gustilo type III**: open fractures have extensive soft-tissue damage, frequently with compromised vascularity with or without severe wound contamination, and marked fracture instability due to comminution or segmental defects. Because of the many different factors occurring in this group.

**Classification of type III open fractures**

**Type IIIa**: Adequate soft-tissue cover of bone despite extensive soft-tissue damage.

**Type IIIb**: Extensive soft-tissue injury with periosteal stripping and bone exposure. Major wound contamination

**Type IIIc**: Open fracture with arterial injury requiring repair.

5. **Principles of management**

Ultimate goal in the management of the open fracture is the early return to normal function of the injured limb.

**Principles of management**

- Prevention of infection
- Soft-tissue healing and bone union
- Restoration of anatomy
- Functional recovery.
6. **Antibiotics**

   The choice of antibiotic is dictated by the potential bacterial contaminant. Prolonged antibiotic administration is not necessary.

7. **Definitive assessment**

   A tourniquet should be applied, but not inflated unless there is excessive hemorrhage. The concept of "the zone of injury" is important. The skin wound is merely the "window" through which the true wound communicates with the exterior.

   Evaluation of the wound demands a detailed assessment of the true extent of the zone of injury.

**Staged surgical debridement**

   Surgical debridement demands meticulous excision of all dead and devitalized tissues. A "second look" should be routinely performed after 48-72 hours.

**Fracture stabilization**

   Type II and type III open fractures are almost inevitably displaced and unstable. This usually dictates surgical fixation.

   There is experimental evidence to suggest that bacterial proliferation is influenced by fracture stability.

   The benefits of stable fixation must be balanced against the pitfalls of further damage to local blood supply and the risk of complications.

   It is not essential to achieve definitive fixation at the first intervention.
External fixation

External fixators are the device of choice in severely soiled and contaminated wounds.

8. Skin cover and soft tissue reconstruction

Early fracture stabilization and soft tissue reconstruction promote early movement. Delayed union and non-union occur more frequently after open fracture than in closed fractures.

9. Pitfalls and complications

The management of severe open fractures is time consuming and difficult. Infection remains the major risk and follows poor surgical technique, inadequate debridement or delay in skin cover.

Futile attempts at salvage in situations doomed to failure are ill-conceived.

Rehabilitation

The great benefit on an aggressive surgical approach involving early fracture stabilization and early tissue reconstruction is that joint and soft tissue immobilization is avoided and early movement facilitated.

Complication

Infection remains the major risk and almost inevitably follows poor surgical technique, inadequate debridement, or a delay in achieving skin cover.
POLYTRAUMA: PATHOPHYSIOLOGY, PRIORITIES, AND MANAGEMENT

Definition
The term polytrauma mans a syndrome of multiple injuries exceeding a defined severity (ISS > 17) with sequential systemic traumatic reaction which may lead to dysfunction of failure of remote organs and vital systems, which had not themselves been directly injured.

Pathophysiological background
The wound around a fracture is an inflammatory focus, consisting a dead tissue in an ischemic or marginally perfused, hypoxic zone. This focus behaves like an endocrine organ, releasing mediators and cytokines locally no tissue macrophages, as well as into the circulations, thus causing systemic reactions.

By releasing these substances a cascade of local and systemic defense mechanism is activated and immuno defense mechanism is activated and immuno-competent cells are attracted to control, debride, and repair the tissue defects.

Systemic traumatic reactions produce a whole body inflammation or a systemic inflammatory Response syndrome (SIRS). SIRS is associated with a general capillary leak syndrome and high energy consumption demanding a hyperdynamic hemodynamic state (flow-phase) and an increased availability of oxygen. This flow-phase generates an intense metabolic load with significant muscle wasting, nitrogen loss, and accelerated protein
breakdown. This hypermetabolic state is accompanied by increase in core body temperature and a thermal dysregulation.

"Afferent input" in trauma and resulting reflex responses.

Timing and priorities of surgery

The primary objective in the initial care of polytraumatized patients in survival with normal cognitive functions. The first priorities is resuscitation to ensure adequate perfusion and oxygenation of all vital organs. This can be usually accomplished by conservative means such as intubation, ventilation, and volume replacement according to the ATLS protocol. If the response to such measures is not successful, immediate life-saving surgery is necessary:
If there is a positive response to resuscitation, the phase of delayed primary surgery can start. Within the locomotor system the following conditions should be treated with high priority.

- Limb-threatening and disabling injuries.
- Long bone fractures, unstable pelvic injuries, highly unstable large joints, and spinal injuries—they require at least provisional reduction and fixation.

Early fracture fixation in polytrauma is beneficial in terms of mortality and morbidity.

The arguments and experience in favour of early fixation of femoral fractures and unstable pelvic rings injuries are:

- Reduction of the incidence of ARDS, of fat embolism and pneumonia, of MODS, sepsis, and of thromboembolic complications.
• Facilitation of nursing and intensive care: upright chest position, early mobilization, use of less analgesia.

Definitive osteosynthesis as "day-1-surgery" is advisable only when all the endpoints of resuscitation have been accomplished.

**Endpoints of Resuscitation**

• Stable hemodynamics
• No hypoxemia, no hypercapnia
• Lactate < 2 mmol/L
• Normal coagulation
• Normothermia
• Urinary output > 1 ml/kg/hour
• No need for vasoactive or inotropic stimulation

Between the **fifth and tenth day** post trauma there exist an immunological window of opportunity when the phase of hyperinflammation is followed by a period immunosupression and when new cell-recruitment and synthesis de novo at acute-phase protein is taking place.

During this window of opportunity schedule, definitive surgery of long bone fracture - shaft and articular - can be performed in relative safety.
<table>
<thead>
<tr>
<th>Physiological status</th>
<th>Surgical intervention</th>
<th>Timing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Response to resuscitation</td>
<td>Life saving surgery</td>
<td>Day 1</td>
</tr>
<tr>
<td></td>
<td>&quot;Damage control&quot;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Delayed primary surgery</td>
<td></td>
</tr>
<tr>
<td>Hyper inflammation</td>
<td>Second look, only</td>
<td>Day 2-3</td>
</tr>
<tr>
<td>&quot;Window of opportunity&quot;</td>
<td>Schedule definitive surgery</td>
<td>Day 5-10</td>
</tr>
<tr>
<td>Immunosuppression</td>
<td>No surgery</td>
<td></td>
</tr>
<tr>
<td>Recovery</td>
<td>Secondary reconstructive surgery</td>
<td>Week 3</td>
</tr>
</tbody>
</table>

**Priorities and timing of surgery depending on the physiological status**

**General aims and scope of fracture management of polytrauma**

Fractures may have an important impact on the severity of systemic traumatic reactions due to:

- Hemorrhage:
- Contamination
- Dead, ischemic tissue with a marginally perfused hypoxic zone
- Ischemia reperfusion injury: Prolonged hypovolemic and shock compartment syndromes related to fractures without or with vascular injuries are prone to ischemia reperfusion injury with microvascular damage due to oxygen radicals. Blunt tissue contusions may activate xanthine oxidase, ischemia will produce the substrate xanthine/hypoxanthine, and reperfusion will add the co-substrate oxygen. A dangerous triad is thus established.
Mechanism of ischemia-reperfusion injury: "unhappy traid" of providing activated enzyme, substrate, and co-substrate.

Pros and cons of different fixation methods

Nailing is, from the biomechanical point of view, the method of choice for shaft fractures of femur and tibia. However, femoral nailing, reamed as well as unreamed, has an adverse effect due to pulmonary embolization. The main reason is probably that manipulation of the content of the medullary canal by opening, insertion of guide-wire, reaming, and insertion of a nail increases the intramedullary pressure, so that emboli of bone marrow content, fibrin clots, and debris are introduced into the pulmonary circulation. In addition, this embolization causes activation of the coagulation and other cascade systems.

It is important to realize that simple fracture types (transverse and short oblique) in a young patient with a narrow medullary canal and a well-developed muscle envelope, are much more prone to pulmonary
embolization following nailing than complex fractures with extensive fragmentation of the femoral shaft, or fractures in elderly individuals with poorer muscles and a wide medullary canal. There is presently no evidence that nailing without reaming is less dangerous than nailing after reaming.

External fixation minimizes additional surgical trauma. It is a fast and forgiving procedure and allows temporary shortening to avoid compartment syndromes. Rigid protocols related to "timing and choice of implant" should therefore be avoided.

FRACTURE MANAGEMENT UNDER SPECIFIC CONDITIONS

Massive hemorrhage due to crushed or disrupted pelvis

Open or closed crush or disruption of the pelvic ring ("open book", "vertical shear" injuries) can produce exsanguinating hemorrhage into the retroperitoneum, the peritoneal cavity, or to an open or closed (semi) circular degloving injury (Morel-lavalle syndrome). Massive pelvic hemorrhage required immediate reduction and fixation of the pelvic ring by external fixator or C-clamp.

Early fracture fixation in patients with severe brain injury

In trauma brain injury (TBI) it is of paramount importance, both to prevent secondary brain damage due to hypotension and hypoxemia, and to maintain optimal cerebral perfusion. Epidural or acute subdural hematoma require urgent surgical evacuation and hemostasis. Patients with TBI and Glasgow Coma Scale (GCS) < 9 or after craniotomy need ICP (intracranial pressure) monitoring immediately after life-saving surgery. Given a good
response to resuscitation (stable hemodynamics and adequate oxygenation), early fracture fixation has a positive effect in brain-injured patients, by facilitating nursing care, by reducing painful stimuli (afferent input), and by less need for sedation and analgesia.

**Early fixation of femoral shaft fractures in severe polytrauma or polytrauma patients with chest injury**

Several studies have well documented the advantages of early fixation of long bone fractures - especially of femoral shaft in polytrauma. These advantages include facilitation of nursing care, early mobilization with improved pulmonary function, shorter time on the ventilator and reduced morbidity and mortality.

Primary intramedullary nailing of the femur (especially type A and B fractures) can only be recommended for polytraumatized patients without significant chest injury, respectively an ISS $< 25$ points. If the ISS exceeds 40 points, primary stabilization is still essential, but should be done with external fixators only.

This concept of staged surgery in a subset of patients in critical conditions appears to be generally accepted by most authors.

**Summary**

**Polytrauma must be considered as a systemic surgical disease.**

Successful management requires a sound understanding of pathophysiology, complete resuscitation, correct triage and timing, and well orchestrated plans of care.
STABILIZATION AND TRANSPORT

Objectives

Upon completion of this topic, the Orthopaedic surgeon will be able to define and outline general principles as related to stabilization and transportation of trauma patients.

Specifically, the Orthopaedic surgeon will be able to:

A. Identify conditions and general principles as related to transfer of trauma patients from a primary care institution to a trauma critical care facility.

B. Outline procedures to be utilized in preparing and transporting the trauma patient to a trauma critical care facility.

I. INTRODUCTION

It has been the intent of this course that the student become more proficient in his ability to stabilize the patient and prepare him for transportation to another facility should this be required. The need for transfer to another facility will depend on the injuries that have been sustained by the victim and the ability of the Orthopaedic surgeon and his local hospital, including ancillary personnel, to care for those injuries. The decision as to which patient should be transferred and when, is a matter of medical judgement.

The primary principle of trauma management is to do no further harm. Indeed the care of the trauma victim should consistently improve each step along the way from the scene of the accident until he reaches the facility that provides him with the necessary care to properly treat his
injuries. It is mandatory for all of those who treat trauma patients to see that there are no weak links in this chain of treatment. The individual Orthopaedic surgeon must see to it that accidents are reduced by promoting safety measures as part of a local community effort. In addition, the Orthopaedic surgeon must promote public education and training as to: 1) Easy access to an EMS system; 2) Citizens trained in CPR; and 3) Well trained Orthopaedic surgeon surrogates. He must see to it that the emergency room of his hospital has at least the basics in facilities and trained personnel to receive the trauma patient.

II. ANATOMICAL & PHYSIOLOGICAL CATEGORIZATION OF PATIENTS

A. Anatomical Categorization:

The ACS Committee on Trauma has developed an anatomic as well as physiologic categorization and grading scheme of trauma patients to assist local Orthopaedic surgeons in identifying the high risk patients. Patients in the first schema have been categorized on the basis of severity of injury with category 1 as the more severe. Ideally, all Category 1 patients would be taken to a Level 1 or Level 11 hospital depending on the resources of the region. In many instances this may not be possible since all regions do not have equal resources. A category 1 patient may have to be treated temporarily in a Level III facility. Conversely, it may be cost-efficient to treat Category 3 patients from the immediate area in a Level I hospital.
Rigid matching to patient categorization with levels of care may often be impractical and will depend on regional resource and need. Numerical categorization of patients and their injuries does not necessarily imply that they require treatment in the corresponding numbered facility (i.e. Category 3 patients do not necessarily require treatment in a Level III facility).

1. **Category 1 Patients**

Patients with combined system injury, bleeding, open fractures; uncontrolled hemorrhage, severe maxillo-facial injuries, severe head and neck and upper respiratory tract injuries, unstable chest injuries, pelvic fractures, blunt abdominal trauma with hypotension and/or penetrating abdominal wounds, neurological injuries producing prolonged loss of consciousness, posturing, lateralizing signs or paralysis.

2. **Category 2 Patients**

Open or closed fractures, soft tissue injuries with stabilized bleeding, patients with multiple rib fractures without flailed segments, blunt abdominal trauma not producing hypotension, transient loss of consciousness.

3. **Category 3 Patients**

Patients with uncomplicated fractures, no hypovolemia or hypotension, no neurological injuries, no abdominal injuries, soft tissue injuries of moderate degree and chest injuries not producing respiratory distress.
B. **Physiological Categorization of Trauma Patient.**

1. **Field Categorization**

   General considerations refer to derangement of vital physiological functions characterized by:

   (i) **Shock - BP < 90 or**

   (ii) **Respiratory distress - RR > 35 or < 10**

   (iii) **Derangement of conscious level - Glasgow Coma Scale (GCS) - 10 or less.**

   A more subtle and more accurate measure of deranged physiology can be obtained by:

   1. **Measure "Capillary Return"**
      - Normal: Score 2
      - Delayed: Score 0

   2. **Measures Respiratory Effort**
      - Normal: Score 3
      - Shallow: Score 1
      - Retractive: Score 1
      - None: Score 0

   3. **Eye Opening**
      - Spontaneous: Score 3
      - To voice: Score 2
      - To pain: Score 1
      - None: Score 0

   4. **Verbal Response**
      - Oriented: Score 4
      - Confused: Score 3
      - Inappropriate words: Score 2
      - Incomprehensible Words: Score 1
      - None: Score 0

   5. **Motor Response**
      - Obey command: Score 4
      - Withdraws: Score 3
      - Flexion: Score 2
      - Extension: Score 1
      - None: Score 0

Add: Score: If < 7 patients should be treated in Level I facility.
2. **Operational Definitions**

**RESPIRATORY EFFORT:**

- **Shallow**
  - A barely perceptible chest wall movement.

- **Normal**
  - Easily visible chest wall movement.

- **Retractive**
  - Chest wall movement assisted by any accessory muscle, i.e., neck nasal flaring or intercostal retraction.

**CAPILLARY REFILL:**

Assessed by firmly pressing the fingernail bed of the patient with a hard object until the color disappears and the nail bed is white or blanched. The nail bed will be released and the time for the color to return will be assessed. The nurse making the measure will mentally repeat the phrase.

- **Normal**
  - "Capillary refill". If the color has returned to the nail bed by the completion of the phrase it is immediate. If the color did not return prior to

- **Delayed**
  - Completion of the phrase "Capillary refill", it is defined as delayed. If the patient has nail polish - it is acceptable to use the finger pad for assessment.

**EYE OPENING:** Assessment of the stimulus required to induce eye opening.

- **Spontaneous**
  - At this point, with no further stimulation, patient has his eyes open. (Implies arousal mechanism in reticular activating system.)

- **To voice**
  - If a patient's eyes are unopened, his name should be spoken, and then if necessary, it should be shouted, the important point being that it is then a response to stimulation.

- **To pain**
  - If verbal stimulation is unsuccessful in eliciting eye opening, the standard painful stimulus is applied.

**Note:** Document if eyes are closed due to swelling or facial injuries, etc.

- **None**
  - No eye opening.
BEST VERBAL RESPONSE:

Oriented  After arousing the patient, he is asked who he is, where he is, and what the year and month are. If accurate answers are obtained, the patient is recorded as oriented.

Confused  Although the patient is unable to give the correct answers to previous questions, he is capable of producing phrases, sentences, and even conversational exchanges.

Inappropriate words  The patient speaks or exclaims only a word or two (often swear words). Such a response is usually obtained only by a physical stimulation rather than a verbal approach, although occasionally a patient will shout obscenities or call relatives' names for no apparent reasons.

Incomprehensible Sounds  The patient's response consists of groans, moans, or indistinct mumbling and does not contain any intelligible words.

No Verbal Response  Prolonged and, if necessary, repeated stimulation does not produce and phonation.

Note: document if this is due to intubation.

BEST MOTOR RESPONSE:

Obeys Command  This requires an ability to appreciate instructions, usually given in some form of verbal commands but sometimes by gestures and writing. The patient is required to perform the specific movements requested. The command is given to hold up two fingers (if physically feasible); the patient should respond appropriately.

Withdraws  If the patients does not obey commands, a painful stimulus is applied;

-  elbow flexes
-  rapid movement
-  no muscle stiffness
-  Arm is drawn away from the trunk

Flexion response  After painful stimulation:
elbow flexes
- slow movement
- accompanied by stiffness
- forearm and hand held against the body
- limbs assume hemiplegic position.

Extension response After painful stimulation:
- legs and arms extend
- accompanied by stiffness
- internal rotation of shoulder and forearm.

III: TRANSFER RESPONSIBILITIES AND ARRANGEMENTS.

The vast majority of patients will be able to receive their total care in the local hospital and their movement beyond that point will not be necessary. However, a certain percent of patients will have an injury of such a magnitude as to require facilities and personnel beyond those locally available in most hospitals. It is essential for the local Orthopaedic surgeon to recognize this group of patients early, and to arrange for their movement to an institution where optimum care may be provided.

A. Referring Orthopaedic surgeon

The responsibility for the initiation of patient transfer must rest upon the local Orthopaedic surgeon, or in the rural setting where no Orthopaedic surgeon is immediately available, upon the Emergency Department Nurse. There should be direct contact by the referring Orthopaedic surgeon to the receiving Orthopaedic surgeon in order to insure that space and personnel are available for care of the patient.

B. Receiving Orthopaedic surgeon

The specifics of the patient's transfer will normally rest with the receiving Orthopaedic surgeon. He must establish what care should be initiated prior to the patient transfer, how that
transfer is to be established, and what data should accompany the patient.

One of the advantages of established transfer arrangements is that it allows for feedback to the local hospital and Orthopaedic surgeon, suggestions for improving future patient care, and hopefully will result in combined audits with resulting educational benefits to both hospitals and the involved Orthopaedic surgeons.

It should be remembered that the patient selected to be transported to another facility is usually one of the more critically ill patients in the local hospital. Too often this critically injured patient is then transported in a substandard vehicle and cared for by personnel not trained to deal with trauma patients.

IV. PROTOCOLS FOR PATIENT TRANSFER

Where protocols for patient transfer do not exist, or where they have not been established for this type of patient, the following is suggested as an example. This should be reviewed by both the local hospital and its Orthopaedic surgeons and by the transfer center to which the patient is to be received. Approval, with local modifications, should be obtained from the involved Orthopaedic surgeons.

A. The local Orthopaedic surgeon wishing to transfer the patient should talk to the Orthopaedic surgeon accepting the patient at the receiving hospital. This should not be left to the nurse to arrange.
B. Responsibility for arrangements and details of the transfer, including the transportation, are those of the Orthopaedic surgeon at the receiving hospital. Where local ambulances are to be used for moving the patient to the receiving facility, approval of the equipment and personnel involved in that move should be obtained by the local Orthopaedic surgeon from the receiving Orthopaedic surgeon. It is assumed that the referring Orthopaedic surgeon will be intimately involved with the details of such a transfer to insure optimum care of the patient.

C. Proper equipment and trained personnel must be utilized to handle the problems specific to the patient's condition, whether the transfer is by ground or air.

D. Instructions should be given to the personnel transferring the patient by the transferring Orthopaedic surgeon.

E. Information regarding the patient's condition and needs during the time of transfer must be given to the transferring personnel, These should include, but not be limited to:

1. Airway maintenance.
2. Fluid volume.
3. Special procedures that may be necessary.

F. A written record of the problem, treatment given, and status at the time of transfer is essential. It must accompany the patient. Such a record should include:

1. Patient information.
   a. Name
b. Address
c. Hospital number
d. Age.
e. Next of kin (name, address and phone).

2. History of injury and illness.
3. Condition on admission including pertinent physical findings and neurologic status.
   a. Pre-hospital.
   b. During stay in emergency department.
   c. At the time of transfer.
5. Treatment rendered to patient, including medications given en route of administration.
6. Laboratory and x-ray findings - Include films.
7. Fluids given by type and volume.
8. Name of Orthopaedic surgeon referring the patient.
9. Address and phone number of referring Orthopaedic surgeon.
10. Name of Orthopaedic surgeon and hospital to whom patient is to be transferred, as well as name of Orthopaedic surgeon at the receiving institution who has been contacted about the patient.
11. Sample of positive peritoneal lavage specimen.

G. Prior to Transfer

1. Obtain written permission from the patient's family for such a move.
2. Obtain signed permission for surgery (when warranted).
3. Resuscitate and stabilize the patient.
   a. Respiratory.
      1. Insert an airway or endotracheal tube as needed.
2. Determine the rate and method of oxygen administration.
4. Provide mechanical ventilation as needed.
5. Insert chest tube as needed.
6. Insert a nasogastric tube to prevent aspiration.

b. **Cardiac.**
   1. Control external bleeding.
   2. Establish reliable I.V. lines using large bore catheters.
   3. Replace blood volume or begin such replacement and continue replacement during transfer. Consider pneumatic anti-shock trousers.
   4. Insert urinary catheter and connect to closed drainage system.

c. **Central nervous system.**
   1. Proper hyperventilation in head injury.
   2. Mannitol load, if needed
   3. Splint all head injuries for possible associated cervical spine fractures.
   5. Spine board for known thoracic and lumbar spine injuries.

d. **Diagnostic studies as indicated.**
   1. X-ray of chest.
   2. X-ray of spine.
   3. X-ray of extremities.
   4. Hemoglobin, hematocrit and arterial blood gases.
5. ECG.
6. Urinalysis.

e. **Wounds.**
   1. Clean and dress.
   2. Tetanus toxoid when indicated (include Tetanus history).
   3. Antibiotics when indicated.

f. **Fractures.**
   1. Appropriate splitting and traction.
   2. Backboards where indicated.

   a. Continued support of respiratory and circulatory systems.
   b. Continued blood volume replacement.
   c. Monitoring of vital signs.
   d. Use of appropriate medications as ordered by the Orthopaedic surgeon or as provided by written protocol.
   e. Maintain communication with the receiving Orthopaedic surgeon or institution during the transfer.
   f. Maintain accurate records during transfer.
IV. TRANSFER FORM

A. Patient's Name ____________________________________
   Address __________________________________________
   Age ___________ Sex ____________ Weight ____________
   Next of Kin __________________________
   Address __________________________________________
   Phone ______________________________.

B. History of Present Injury or Illness.

C. History of Previous Conditions and Medications.

D. Condition of Admission.
   Blood Pressure _____/_____ Pulse ______ Temperature ____

E. Initial Impressions.

F. Diagnostic Studies.
   1. Laboratory.
      a. CBC.
      b. Urinalysis.
      c. Electrolytes.
      d. Arterial blood gases.
   2. Radiological.

G. Treatment Rendered to Patient.
   1. Medications given with amount and time.
   2. I.V. fluids with type and amount (include patient's blood type).
   3. Other.

H. Status of patient when Transferred.

I. Management during Transport.

J. Name of Orthopaedic surgeon transferring patient.

   __________________________________________________
   Phone __________________________________________

K. Name of Orthopaedic surgeon and Hospital Contacted.

   __________________________________________________
V. SUMMARY:

- The initial principle of trauma management is to DO NO FURTHER HARM.
- None of the basic management guidelines should conflict with this objective.
- Know the indications for transfer.
- Develop arrangements (transfer arrangements) with a Trauma Center or Trauma Program. This will expedite communication and the overall patient care.
- Utilize standing orders and protocols whenever possible.
- Prepare patients for transfer.
- Don't let patients die enroute because of inadequate preparation.
- Transfer with skilled personnel and adequate adjunctive equipment.
Pre course test answer key

1. a
2. e
3. e
4. a
5. c
6. b
7. b
8. b
9. b
10. b
11. b
12. c
13. c
14. e
15. c
16. c
17. c
18. a
19. d
20. d


