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ISCCM Manual of TRAUMA CARE

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2nd Edition

Foreword
Mahesh C Misra

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CHAPTER 8

Musculoskeletal Trauma

Sandeep Sahu, Tapas Kumar Singh

INTRODUCTION

Musculoskeletal injuries/trauma (MSI/MST) involving muscles, tendon/ligaments, and related bones, joints, and neurovascular bundle are a common health problem for young populations. There is need of an effective trauma system that includes strong efforts for prevention of injuries, effective prehospital care, and in-hospital management and complete rehabilitation. Global Burden of Disease 2019 data project approximately 1.71 billion people globally live with musculoskeletal disorders. The incidence of lower extremity vascular trauma has been on the rise because of high-speed motor vehicle accidents in India. Most MSI are relatively minor strain (tendon) or sprain (ligament) that needs conservative treatment including rest, immobilization, analgesic, and local application of analgesic and anti-inflammatory to immediate limb- or life-threatening injuries (crush injury leading to hyperkalemia and myoglobin release leading acute tubular damage and acute kidney injuries, compartment syndrome, pelvic and spine injuries, and vascular injuries). Exsanguination is the most significant cause of death after vascular injury in MST, while neurovascular-related ischemic tissue damage can lead to high rates of amputation. Although advances in surgical techniques of repair of injured structures have minimized the rate of amputation, due to extremity trauma is still a major source of morbidity and mental trauma in trauma patients in developing countries.

Musculoskeletal trauma along with polytrauma is at risk for developing acute systemic complications including prolong intensive care unit (ICU) stay, fat embolism, pulmonary embolism, multiple transfusion-related acute respiratory distress syndrome (ARDS), and other infections along with long-term orthopedic and neurological sequelae. Patient better outcomes depend greatly on initial resuscitative efforts, in prehospital and hospital settings, prompt stabilization and fixation of fractures, and better comprehensive rehabilitation.

PREHOSPITAL MANAGEMENT OF MUSCULOSKELETAL TRAUMA

The cornerstone of prehospital management remains advanced trauma life support (ATLS) prehospital protocol and expedited transport of the patient to appropriate trauma center. The first step in management is primary survey of ATLS protocols to identify any immediate life-threatening conditions involving airway, respiratory, and circulatory functions. Resuscitative efforts of hemodynamically unstable patients should be started at the site

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of accident, intravenous (IV) access is established and IV fluids are given to maintain an adequate circulatory volume, a rapid primary assessment, airway and cervical spine control, appropriate respiratory and cardiovascular assistance focused on bleeding control, gross whole-body fracture immobilization using a backboard, and immediate transport to dedicated trauma hospital/center. Patients, who are not extensively injured and hemodynamically stable, receive full secondary assessment, more care, and fracture immobilization before transport as per local protocol. There is literature supporting use of pneumatic antishock garment (PASG) or medical antishock trouser (MAST) or tourniquet application in prehospital settings. Hence, the primary aim for prehospital management of MST is expedited delivery of patient to trauma center with bleeding control, if possible, provide basic resuscitation or airway, breathing, and circulation (ABC) control with spine and fracture immobilization. Radio communication/trauma alert with MIST (mechanism of trauma, injury sustained, current sign and symptoms of patients, and treatment received and expected) to trauma center helps trauma team to better prepare and sensitize the trauma center team and logistics.

CLASSIFICATION AND TYPE (TRIAGE) OF MUSCULOSKELETAL TRAUMA

Patients may be classified as follows:

- *Isolated, closed injuries* that require surgical intervention, treatment can be done on an elective basis, and trauma team involvement is optional.
- *Multiple fractures of major long bones and/or joints, with ongoing or impending hemodynamic collapse,* which require trauma team resuscitation/exclusion of life-threatening injuries, followed by early fracture stabilization when appropriate. Hip injuries are common after high-energy impact. Fracture treatment can be delayed; however, dislocation injuries require expeditious treatment in order to avoid avascular necrosis of the femoral head and maximize chances for a good functional outcome—these often require either deep sedation or brief periods of general anesthesia, and often paralysis. Pelvic fractures can be lethal, thus they should be identified as soon as possible during primary survey at prehospital or hospital setting and, if necessary, treated immediately. Pelvic bleeding is usually venous in nature and surgically inaccessible, thus the current definitive treatment is by interventional radiology-guided angioembolization [after airway, breathing, circulation, disability, and exposure (ABCDE) and volume resuscitation and external stabilization].

Closed injuries, which are often missed in the primary survey during initial examination, should be further examined when discovered. In particular, the orthopedician is concerned in the vascular and neurologic condition of the limb. Two-thirds of combined orthopedic/vascular injuries in the lower extremity are salvageable. Open injuries are at increased risk of infection and are usually lavage and debrided as soon as possible. This does not have to occur in the operating room, however, and often can be done at the bedside while awaiting triage for more significant injuries.

RESUSCITATION OF MUSCULOSKELETAL TRAUMA—THE ATLS WAY

Any severe MST with degloving or amputation injuries paints a dramatic picture for clinicians

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and healthcare providers alike. Such a visceral picture of insult may distract the clinicians from correct management strategies. It is essential to keep in mind that like any other trauma case the basic approach remains the same the ATLS way—ABCDE. The basic blueprint of MST management remains the primary and secondary survey with awareness of the severity of fracture and blood loss, bones and joints involved, the internal organs at risk, and need for identifying patients with life- or limb-threatening injuries.

While it is vital to recognize the life-threatening injuries causing extensive hemorrhage (internal or external) during primary survey, however, MSI usually are not immediately life-threatening and resuscitation of patient should remain primary focus. However, MSI cannot be ignored; hence, a clinician must strike an optimal balance between patient resuscitation and injury management to ensure best results for patient. Usually, immediate immobilization and splinting of long bone fractures, control of arterial exsanguinations, and compression bandage of open wounds go hand in hand with intravascular balanced hemostatic resuscitation, once patient's airway and breathing are taken care of.

Many musculoskeletal system injuries often appear dramatic, but only infrequently cause immediate threat to life or limb. It has the potential to distract team members from more urgent resuscitation priorities. First, clinicians need to recognize the presence of life-threatening extremity injuries during the primary survey and understand their association with severe thoracic and abdominal injuries. The provider must also be familiar with extremity anatomy to be able to protect the patient from further disability and anticipate and prevent complications. The physical examination of injuries in emergency department (ED) needs simple four steps—IPAN: Inspection (discoloration, swelling, or deformity), Palpation (looking for tenderness and deformity), Assess range of motion (both active and passive) with consideration to the joint above and below the injured part, Neurovascular examination.

Major MSI indicate that the body sustained significant forces and internal injuries because of this. Unstable pelvic fractures and open femur fractures can be accompanied by brisk bleeding. Severe crush injuries cause the release of myoglobin from the muscle, which can precipitate in the renal tubules and result in acute kidney injury. Swelling into an intact musculofascial space can cause an acute compartment syndrome that, if not diagnosed and treated on time, may lead to lasting impairment and loss of the extremity. Fat embolism, an uncommon but highly lethal complication of long bone fractures, can lead to ARDS/pulmonary failure and impaired cerebral function/injury.

Primary Survey

The aim of primary survey is to early identify the immediate life-threatening injuries and simultaneously manage them in form of ABCDE. The blood loss can be apparent in open wound or occult in closed wound or both. Life-threatening injuries include major arterial hemorrhages in open wounds and traumatic amputations, femoral fractures, and pelvic fractures.

Arterial Hemorrhages

The initial step is to apply pressure on open wound or amputation with sterile dressing material followed by compression bandage. If the bleeding does not stop, combat application tourniquet (CAT) category tourniquets use should be considered **(Fig. 1)**. The

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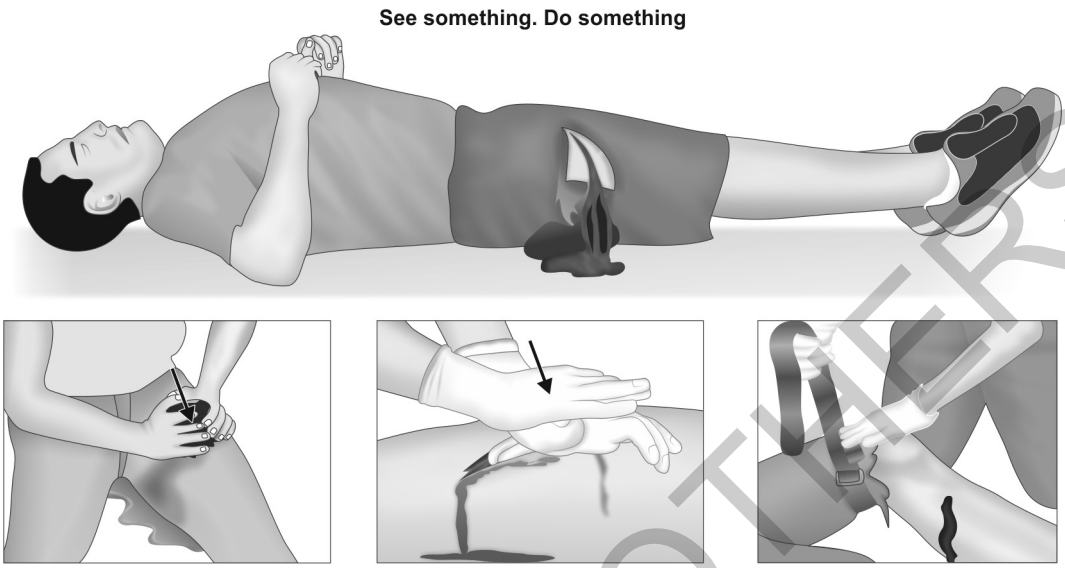

Fig. 1: Methods of stopping the bleed by applying direct pressure, packing the wound, and tourniquet application.

tourniquet application time should be carefully documented. Tourniquet should exert enough pressure to completely occlude arterial inflow otherwise only venous flow will be occluded leading to limb congestion and diffuse bleeding **(Figs. 2A to D)**. The pneumatic tourniquet must be inflated till 250 mm Hg for upper limb and till 400 mm Hg for lower limb. Application of vascular clamps should be done only if the bleeding artery is clearly visible and can be easily accessed for clamping. If the open wound is associated with a fracture, it should be reduced and splinted quickly if possible while trying to maintain pressure on wound. Any patient requiring a tourniquet should get an orthopedic or vascular surgeon consultation as soon as possible. Any investigation like computed tomography (CT) or angiography should be done quickly in hemodynamically stable patients. If patient remains unstable or critical, it is better to consider urgent surgery. Emergency amputation of injured limb should be considered if limb distal to injury is obviously ischemic with no pulse or extensive crush injury is threatening to the patient.

Femoral Fracture

Shaft of femur fractures indicates that injuries are due to considerable impact and are usually found in polytrauma patients. Patient complains of pain and deformity in thigh and leg. A closed femoral shaft fracture might have blood loss around 1,000–1,500 mL. Similarly, a closed tibia shaft fracture will have blood loss around 500–1,000 mL. Open femoral fractures will have lost blood double of this amount. Bilateral femur fracture patients understandably have higher mortality and morbidity than unilateral femur patients. Apart from blood loss, femoral fracture can cause fat embolism syndrome, nerve injuries, compartment syndrome, and crush syndrome.

Crush syndrome is a systemic manifestation of crush injury. It occurs due to release of myoglobin and other intracellular components of a myocyte due to loss of

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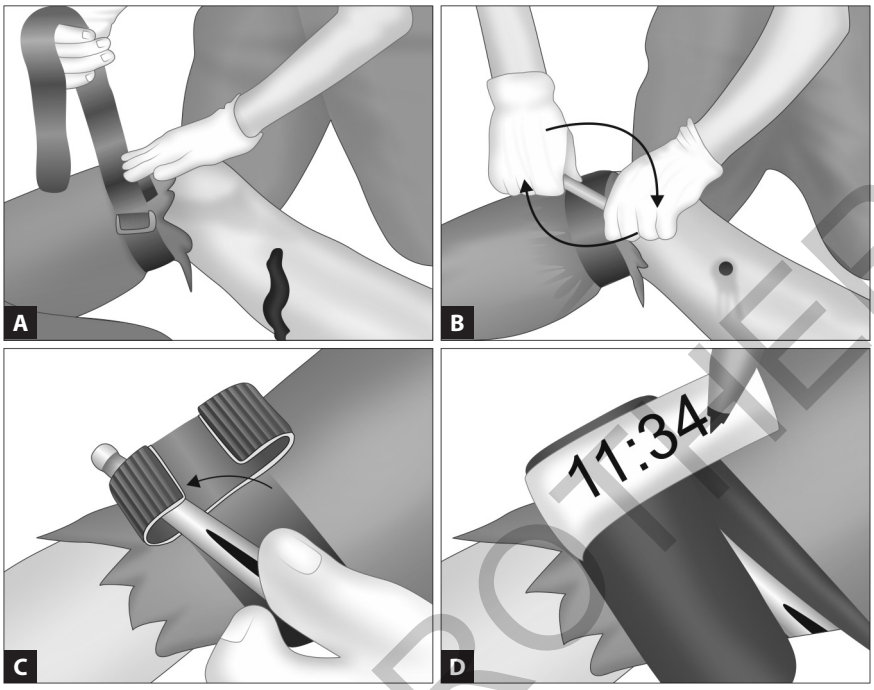

Figs. 2A to D: Steps of applying combat application tourniquet in severe musculoskeletal trauma to stop the bleed.

structural integrity caused by mechanical trauma such as crush injury or cell death due to ischemia. It occurs when a significant amount of muscle mass is affected like thigh or calf muscles. Crush syndrome causes renal failure, metabolic acidosis, disseminated intravascular coagulation, and shock. Management of femoral fracture initially focuses on aggressive volume resuscitation; once patient stabilizes hemodynamically, focus shifts to fracture immobilization with splinting and investigations to identify the extent of damage. Presence of amber-colored urine along with raised serum creatinine assay should alert the clinician to possibility of crush syndrome. Medical management includes aggressive fluid resuscitation along with osmotic diuretics to ensure brisk diuresis, alkalization of urine with sodium bicarbonate, and correction of dyselectrolemia like hyperkalemia and hypocalcemia.

Pelvic Fracture

These are most commonly associated with intra-/retroperitoneal visceral and vascular injuries. The hypotension may or may not be due to pelvic fracture; hence, one must maintain a high index of suspicion for internal injuries. Pelvis has a ring-like structure with ligamentous and cartilaginous supports with no inherent stability without these supports. As trauma forces disrupt these supports, pelvis suffers from vertical and rotational instability. Presence of major vessels and visceral organs such as bladder, bowel, and uterus in pelvic region predisposes fracture in this region to have hemodynamic effects. **Figures 3A to C** illustrate the types of pelvic fractures.

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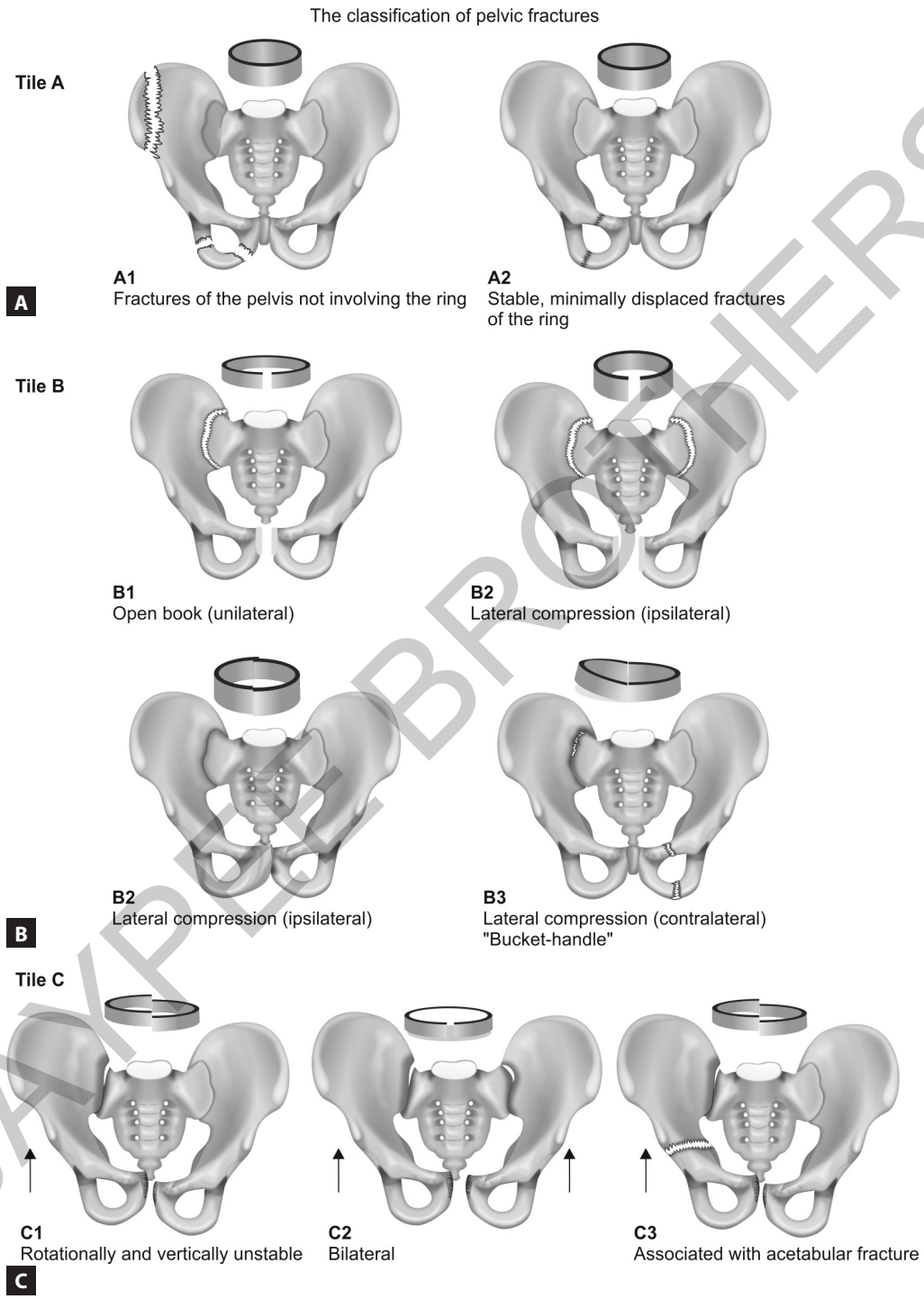

Figs. 3A to C: Types of pelvic fracture.
Source: Adapted from Durrant JJ, Ramasamy A, Salmon MS, Watkin N, Sargeant I. Pelvic fracture-related urethral and bladder injury. BMJ Military Health. 2013;159.

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- *Anteroposterior (AP) compression injury:* An open-book-type fracture, pelvis ring opens, tears up the posterior venous plexus and iliac artery branches. The hemorrhage is severe and life-threatening.
- *Lateral compression injury:* The pelvis is internally rotated due to lateral compression and pubis might damage bladder and urethra. This type of fracture cause severe bleeding usually in elderly only. It is the most common form of pelvic fracture.
- *Vertical displacement injury:* Usually occurs in fall from height. The vertical displacement causes disruption of sacrotuberous and sacrospinous ligaments and causes massive hemorrhage due to damage to iliac vasculature.

The traditional classification systems of pelvic fractures offer little to an emergency physician or clinician, more appropriate for orthopedic/trauma surgeons for definitive treatment. In a practical classification for ED (US-VAGON) proposed by Wang et al. pelvic fracture is initially divided into unstable and stable pelvic fractures.

Unstable pelvic fractures: These present to ED with hypotension. If these patients reach ED early enough, they show only tachycardia, narrow pulse pressure as signs before hypotension is evident due to ongoing blood loss. All patients of suspected pelvic fracture, having unstable vitals or unconsciousness, should be assumed to be with unstable pelvic fracture unless until proved otherwise. The primary survey focuses on ATLS protocols. A base deficit with metabolic acidosis can also be obtained quickly via arterial blood gas analysis, which is useful to determine the severity of hypovolemic shock.

Signs suggestive of pelvic fracture are petechiae in perineum, hematuria or blood at urethral meatus, vaginal or anal bleeding, and high-riding prostate. Rotational deformity of pelvis and legs and lower limb length discrepancies should raise suspicion. Manual compression [or pelvic compression test (PCT)] of iliac wings to check for pelvic instability is highly nonspecific and may worsen the hemorrhage, if performed repeatedly.

Initial management focuses on balanced hemostatic resuscitation to counter massive blood loss and improve oxygenation and coagulation. A base deficit with metabolic acidosis can also be obtained quickly via arterial blood gas analysis, which is useful to determine the severity of hypovolemic shock. The usage of PASG or MAST is controversial. While the studies have shown no protective effect, however, they might be useful for the patient in prehospital settings by compressing the venous volume of lower limbs and maintaining blood pressure. Application of PASG/MAST on the patient may cause more bleeding in pelvic fracture. It might also cause compartment syndrome. However, application of pelvic binder is established as treatment of choice for reducing pelvic volume and reducing hemorrhage. Pelvic binder should be applied at the greater trochanter to provide internally rotating force for splinting of pelvis.

External pelvic binding with makeshift or specialized devices **(Fig. 4)** are only temporary measures and it makes sense to transfer the patient to a specialized advanced trauma center for definitive management as soon as the patient is resuscitated and fracture is immobilized. Intra-abdominal or pelvic hemorrhage can be easily and quickly diagnosed, during primary survey with help of ultrasound done as focused assessment with sonography in trauma patient (FAST protocol). Usually AP X-ray

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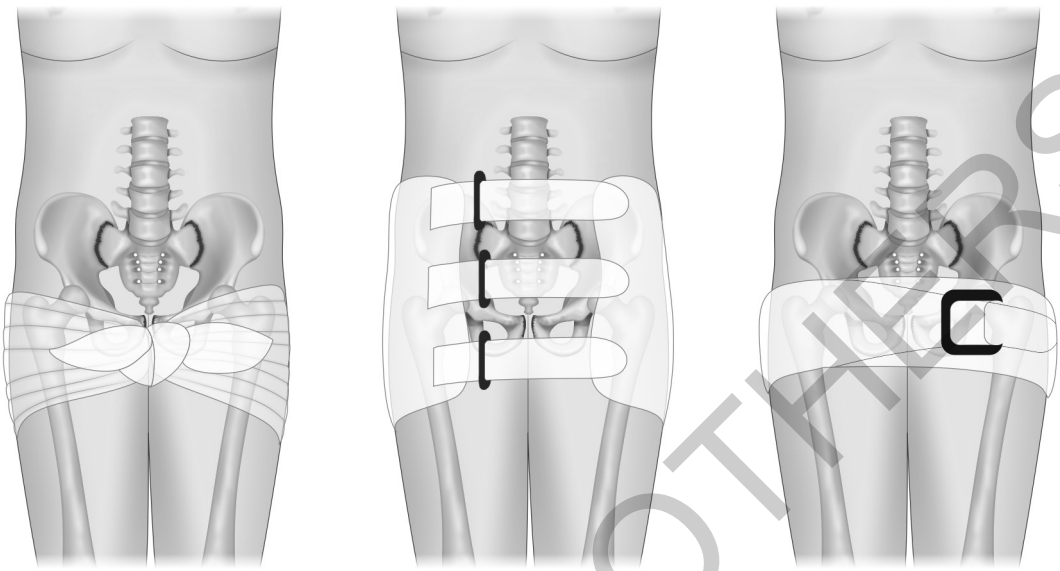
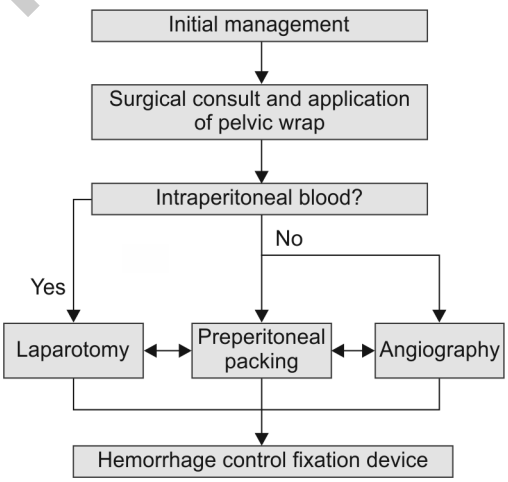


Fig. 4: External pelvic binding with makeshift or specialized devices.

of pelvis is sufficient; however, some orthopedic surgeons might request a CT scan with contrast to identify pelvic fracture and vessel trauma with certainty. Operative management of pelvic trauma usually requires a multidisciplinary team effort of orthopedics, urologists, vascular surgeons, surgical gastroenterologists, interventional radiologists, and anesthesiologists. Hemorrhage control may require both surgical and angiographic control. There are many algorithms available for pelvic fracture management. **Flowchart 1** illustrates the algorithm mentioned in 10th edition of ATLS protocol for management of pelvic fracture with shock.

Stable pelvic fractures: Pelvic fractures which present to ED with stable hemodynamic are classified as stable pelvic fractures. After external fixation, clinician tries to identify the type of pelvic fracture, possibility of hemorrhage, and the possibility of neurological damage. This classification helps emergency physicians to properly workup the patient, identify and prioritize the systems at risk, and seek referrals from other departments.

Flowchart 1: Pelvic fractures and hemorrhagic shock management algorithm.



Source: Henry S, Brasel K, Stewart RM. ATLS®, Advanced Trauma Life Support®. Student Course Manual, 10th edition. United States: American College of Surgeons; 2018. p. 1027.

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Stable pelvic fractures are further classified as:

- *Class 1:* Potential hemorrhagic/vascular complications:
  - Any pelvic fracture with 5 mm or more displacement
  - Open-book injury/pelvic dislocation
  - Open pelvic fracture
- *Class 2:* Potential genitourinary or gastrointestinal complications:
  - Pubic symphysis subluxation
  - Straddle fracture
  - Malgaigne fracture/bucket handle fracture
  - Open-book injury/pelvis dislocation
- *Class 3:* Potential orthopedic complications:
  - Double breaks in the pelvic ring
- *Class 4:* Potential neurologic complications:
  - Sacral fracture
  - Acetabular fracture
- *Class 5:* Uncomplicated
  - Avulsion fractures
  - Single pubic and ischial rami and double unilateral rami fractures
  - Iliac wing fracture (Duverney fracture)
  - Coccyx fracture
  - Ischial body fractures.

Thus, the above classification helps the clinician to decide the urgency and severity of injury to various systems of body and guides the clinician in determining the future course of action.

Secondary Survey

Once we have addressed the immediate risk to patient, we try to ascertain the nature of further damage by obtaining history, examining the patient carefully, and planning investigations.

History

Clinician should try to ascertain the mechanism of injury from the bystanders or family members or first responders. It might help in detection of injuries missed in primary survey. The information about accident environment may help clinician to decide degree and type of bacterial contamination of wound and gain information about exposure to extremes of temperature. Patients' previous medical history, especially comorbid illnesses, medications, allergies, and functional capacity, must be documented. Any observations from first responders or paramedics must be noted regarding the duration since accident, tourniquet application time, perfusion of peripheries, consciousness of patient, and reduction and splinting of fractures, if any.

Physical Examination

Patient must be undressed fully while preventing hypothermia to help in thorough examination. Priority should be given to identify any life- or limb-threatening injuries during primary survey of initial assessment, which once identified, clinician must perform a detailed head-to-toe examination in secondary survey. Each limb and joint must be inspected, palpated for identification of injuries to assess structural, neurological, and vascular integrity, if possible.

Look and ask: Visually assess the extremities for color and perfusion, wounds, deformity, swelling, and bruising. Any pale limb indicates vascular comprise. A swollen, edematous, tense limb with pale pulseless extremities indicates compartment syndrome. A swollen joint indicates dislocation with possible bleeding in joint cavity. If the patient is conscious and cooperating, then it is easy to test for structural integrity of various joints. Full range of motion of a joint implies normal joint.

Feel: Palpate the extremities to ensure normal, neurological, and vascular supply.

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Any sensory deficit indicates nerve injury or compression. Similarly, absent pulses may be due to hypotension or compartment syndrome. Areas of tenderness indicate muscle or soft tissue injury or underlying fracture. Do not attempt to elicit crepitus or demonstrate abnormal motion.

Adjuncts to Secondary Survey

Clinician is much more likely to use adjuncts in secondary survey as things are less critical after primary survey and management.

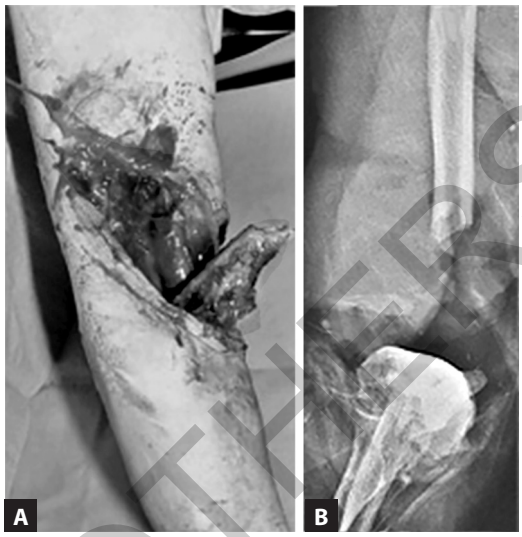
X-rays: If patient is hemodynamically stable, the next logical order is X-rays to obtain an image of various joints. For pelvic fracture, usually an AP view pelvis is sufficient. In cases of polytrauma, clinician should order an AP and lateral view of all four extremities to confirm the obvious and missed fracture. If X-rays cannot be obtained fast enough and there is an obvious deformity threatening the skin and soft tissue overlying the deformity, one should go for reduction of deformity without waiting for the X-ray.

Doppler ultrasonography: It is often difficult to determine if peripheral pulse is absent due to hypotension or compression. Doppler of the extremity documents absence or presence of blood flow in artery.

Open Fractures

Any fracture communicating with environment is termed open fracture **(Figs. 5A and B)**.

If it is bleeding profusely, it is usually dealt in primary survey by immobilization, splinting, compression bandages, and in some cases by application of tourniquet. In secondary survey, open fractures not bleeding profusely are managed. It is vital to administer IV antibiotics depending upon the environment of trauma, within



Figs. 5A and B: Open fracture wound with X-ray.

3 hours to prevent infection. Tetanus prophylaxis is administered. Wound should be made free from gross contamination then fracture must be immobilized, and wound is covered with moist sterile dressing and IV broad-spectrum antibiotics as per local protocols. After investigations, patient is planned for operation to debride the wound and definitively treat the fracture, if needed.

Compartment syndrome: Compartment syndrome is a very painful condition caused by the increased intracompartmental pressure (ICP) within a closed osteofascial compartment. ICP higher than 30 mm Hg of diastolic blood pressure is significant of compartment syndrome. Compartment syndrome can occur wherever muscle is contained within a closed fascial space. Common areas for compartment syndrome include the lower leg, forearm, foot, hand, gluteal region, and thigh **(Figs. 6 and 7)**. Pressure rises in compartment due to increase in mass in the closed space (hematoma in bleeding or muscle swelling of

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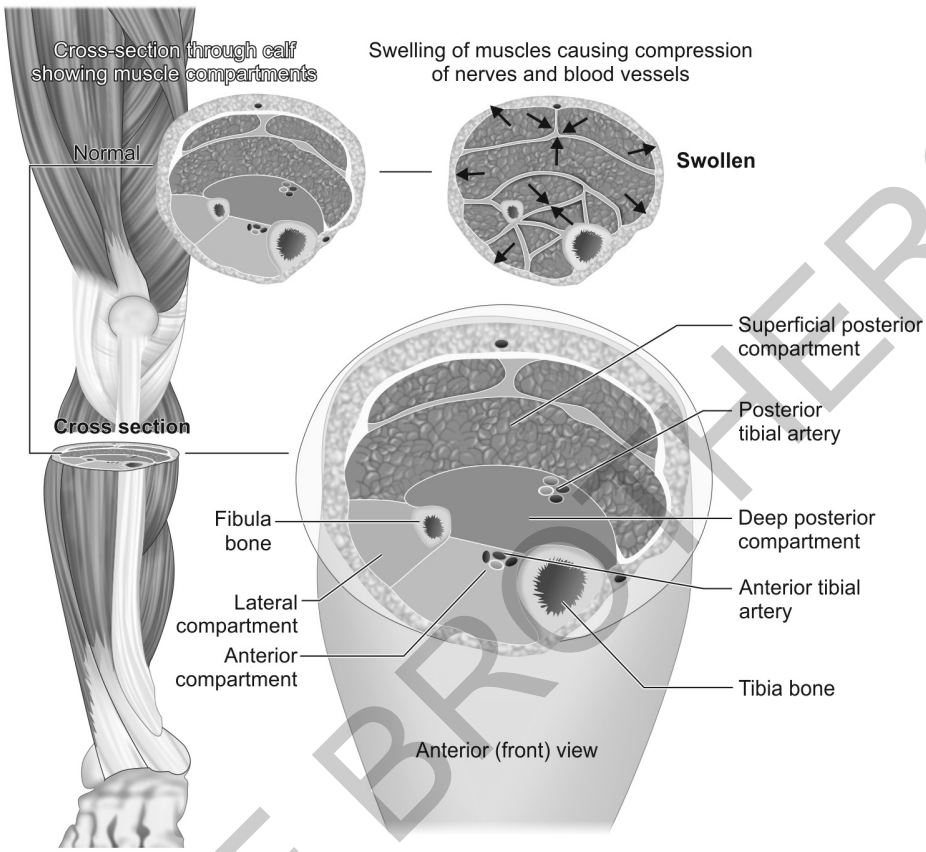

Fig. 6: Cut section anatomy of leg with typical arrangements of structures in an osteofascial compartment.



Figs. 7A and B: Typical compartment syndrome with its surgical management as fasciotomy wound.

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ischemic muscle due to reperfusion injury) or due to reduction in size of compartment (compression due to accident or occlusive bandage). Compartment syndrome is a surgical emergency. Immediate surgical consultation should be done, and all pressure bandages should be removed. It requires urgent fasciotomy.

Neurological injury in trauma: These commonly occur due to joint dislocation or bone fracture or compression bandage. If during examination any neurological deficit is reported by patient or elicited, nerve supplying the region should be presumed compressed and the size of neurological deficit should be mapped with time.

Occult Skeletal Injuries

It has been stressed enough to perform a thorough extensive examination of patient as per ATLS way. However, it is possible to miss certain injuries, which get revealed later on. Therefore, it is crucial to reassess the patient repeatedly and to communicate with the other members of trauma team to rule out the possibility of occult skeletal injuries.

PSYCHOLOGICAL EFFECT OF MUSCULOSKELETAL TRAUMA

Musculoskeletal trauma leads to persistent daily pain, opioid and related drug demand and its dependence, disability, related anxiety and depression, and symptoms of post-traumatic stress disorder that persist even many months after injury, when primary injury had been taken care of. Management includes improving social support, self-efficacy via cognitive behavioral therapy, and mindfulness training to help people to return back to their daily routine normal life.

SUMMARY

Knowledge of the mechanism of injury and history of the injury-producing event can guide clinicians to suspect potential associated injuries. MSI may pose threats to both life and limb. The initial assessment of MST is to identify those injuries that cause a great threat to life and/or limb. Although uncommon, life-threatening MSI must be promptly assessed and managed. A staged approach to hemorrhage control is utilized by applying direct pressure, packing, splints, and tourniquets. Early splinting of fractures and dislocations can prevent serious complications and late sequelae. Careful neurovascular examination must be performed both prior to and after application of a splint or traction device. Most of the extremity injuries are appropriately diagnosed and managed during the secondary survey. A thorough history and careful physical examination, including completely undressing the patient, is essential to identify missed MSI. It is essential to recognize and manage arterial injuries, compartment syndrome, open fractures, crush injuries, and dislocations in a timely manner.

MULTIPLE CHOICE QUESTIONS

1. Priority in MST:
   a. Is same like any trauma patient in sequence of ABCDE
   b. Is different like any trauma patient in sequence of BCDEA
   c. Is same like any trauma patient in sequence of CDEAB
   d. Is same like any trauma patient in sequence of DEABC

Ans. a

2. Musculoskeletal trauma is:
   a. Limb-threatening

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Key Features

- Covers all aspects of trauma including prehospital management in rural and remote areas
- Evidence-based and updated protocols have been used in easy-to-read format with flowcharts and diagrams
- Dedicated chapter on trauma and ICU scores will be helpful in objective assessment of trauma patients
- Written by experts with enormous clinical expertise
- This manual will serve as a handbook for postgraduates, DNB students, intensivists, physicians and those who are involved in acute care of injured patients.

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