Chapter 25, Trauma Overview

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1. Introduction to Trauma and Energy Concepts

Traumatic injuries are the **leading cause of death** for people younger than 44 years old in the United States [6]. **Trauma emergencies** happen because of physical forces on the body [7]. Understanding the **mechanism of injury (MOI)** helps predict serious unseen injuries [7]. This awareness is called **index of suspicion** [7].

Traumatic injury happens when body tissues are exposed to energy beyond their tolerance [9]. MOI describes the forces causing the injury [10]. Three key energy concepts related to injury are **potential energy, kinetic energy, and work** [11]. Energy cannot be created or destroyed, only changed [13].

- **Work** is force over distance [13]. Forces that bend or compress tissues cause injury [14].
- **kinetic energy** is the energy of a moving object [14]. It relates to the object's mass (weight) and velocity (speed) [15].
- **potential energy** is related to the mass and gravity [15]. It's mostly linked to falling objects [15].

Energy Type	Description	Relation to Injury

Potential Energy	Energy of falling objects	Product of mass, gravity, and weight [15]
Kinetic Energy	Energy of a moving object	Relationship between mass and velocity [15]
Work	Force acting over distance	Bending or compressing tissues causes injury [13]

2. Mechanisms of Injury: Blunt and Penetrating Trauma

Traumatic injuries are categorized as **blunt trauma** or **penetrating trauma** [18].

- **blunt trauma** is caused by force without penetrating tissues or organs [18]. Common examples include motor vehicle crashes and falls [22]. Skin discoloration and pain might be the only signs [23]. It's important to have a high index of suspicion for hidden injuries [7].
- **penetrating trauma** occurs when objects pierce the body's surface [19]. This damages soft tissues, internal organs, and body cavities [19].

Both types can happen from various MOIs [20].

Trauma Type	Characteristics	Common Mechanisms	Assessment Clues
Blunt Trauma	Force without penetrating tissues or organs [18]	Motor vehicle crashes, falls [22]	Skin discoloration, pain, unseen injuries [23]
Penetrating Trauma	Objects pierce or penetrate body surface [19]	Knives, bullets [67]	Entrance/Exit wounds, trajectory, cavitation [70]

3. Motor Vehicle Crash Mechanisms and Associated Injuries

A motor vehicle crash typically involves **three collisions** [23]. The vehicle's condition can indicate the MOI [24].

- **First collision:** Vehicle against an object (e.g., a tree) [23].
- **Second collision:** Passenger against the car's interior [24]. kinetic energy is converted to work of stopping the body [24]. Common injuries include lower extremity fractures, rib fractures, and head trauma [25].
- **Third collision:** Passenger's internal organs against body structures [26]. Internal injuries may be life-threatening but not obvious externally [26].

Significant MOIs in crashes include:

- Death of an occupant [27].
- Severe vehicle deformity or intrusion [27].
- Moderate lateral intrusion or severe rear damage [27].
- Crashes with rotation involved [27].
- Ejection from the vehicle [27].

Different crash types cause specific injury patterns:

- **Frontal crashes:** Evaluate restraint systems and airbag deployment [28]. Seat belts and airbags prevent the second collision's severity [29]. Airbags decrease deceleration injuries to chest, face, and head [30]. Suspect extremity and internal organ injuries despite airbags [31]. Improper restraints can cause injuries; seat belts too low cause hip dislocations, too high cause internal injuries, and lumbar spine fractures are possible [33].
- **Rear-end crashes:** Known for **whiplash** injuries, especially without a proper headrest [36]. Acceleration injury to the brain is possible [38]. Rear passengers with only a lap belt may injure the thoracic and lumbar spine [38].
- **Lateral crashes:** Common cause of death [40]. Vehicle rocks away from the impact side [41]. Passenger sustains a whiplash-type injury [41]. Substantial intrusion suggests lateral chest and abdominal injuries, lower extremity and pelvis fractures, or rib fractures and organ damage [42].
- **Rollover crashes:** Large trucks and SUVs are prone due to high center of gravity [43]. Injuries depend on restraint use [44]. Ejection is the most common life-threatening event [45]. Severe injuries can occur even when restrained [46].
- **Rotational crashes (spins):** Similar to rollovers [47]. Vehicle spinning can strike objects like utility poles [48].

Crash Type	Mechanism	Common Injuries

Frontal	Vehicle strikes object head-on	Lower extremity fractures, ribs, head trauma (passenger vs interior) [25], extremity/internal organ injuries (despite airbags) [31]
Rear-end	Vehicle struck from behind	Whiplash, acceleration brain injury [36], thoracic/lumbar spine injury (lap belt only) [38]
Lateral	Vehicle struck from the side	Whiplash, lateral chest/abdominal injuries, lower extremity/pelvis fractures, rib/organ damage [41]
Rollover	Vehicle rolls over	Ejection (most common life-threat) [45], severe injuries even when restrained [46]
Rotational	Vehicle spins	Injuries from striking objects during spin [48]

4. Other Blunt Trauma Mechanisms: Pedestrian, Bicycle, Motorcycle, and Falls

Other blunt trauma mechanisms also cause significant injuries.

- **Car versus Pedestrian:** Injuries are often graphic and obvious [49]. Serious unseen injuries are also possible [49]. Key factors include vehicle speed, if the patient was thrown and how far, where they landed, and if they were pulled under the vehicle [50]. Evaluate the striking vehicle for damage [51]. ALS should be called for significant MOI [52].
- **Car versus Bicycle:** Evaluate similarly to car versus pedestrian crashes [53]. Assess bicycle damage and position [53]. Inspect the helmet for damage [53]. Presume spinal cord injury until ruled out at the hospital [53]. Spinal immobilization is crucial [53].
- **Car versus Motorcycle:** Helmets offer protection but not against severe cervical injury [54]. Leather or abrasion-resistant clothing protects against road abrasion but not blunt trauma [55]. Boots protect feet [55]. When assessing, look for motorcycle deformity, side of most damage, skid distance, damage to other objects, and helmet deformity [56]. There are four types of motorcycle impacts:
  - **Head-on:** Motorcycle stops, rider continues forward [57].
  - **Angular:** Motorcycle strikes object at an angle; rider's lower extremity is crushed [58].

    - **Ejection:** Rider travels at high speed until stopped by an object or road drag [59].
    - **Controlled crash:** Rider separates from the motorcycle before impact (laying the bike down) [60].
- **Falls:** Injury potential relates to the fall height [62]. Greater height means greater potential energy [62]. A fall over 20 feet is significant [63]. Internal injuries are the greatest threat [63]. Landing on feet may lessen internal injuries but cause serious lower extremity and pelvis injuries [64]. Spinal injuries are possible [64]. Consider fall height, surface struck, body part that hit first, and energy displacement path [64].

5. Penetrating Trauma: Low, Medium, and High Velocity

penetrating trauma is the second leading cause of death after blunt trauma [66]. It can be caused by low, medium, or high energy impacts.

- **Low energy penetrating trauma:** Caused by objects like knives or ice picks [67]. Injuries are from sharp edges moving through tissue, close to the object's path [68]. Knives moved internally can cause more damage than external wounds suggest [69].
- **Medium and high velocity penetrating trauma:** Usually caused by bullets [70]. The bullet's path can be unpredictable; it may flatten, tumble, or ricochet [71]. The path is called the **trajectory** [72]. **Fragmentation** increases damage [72]. **cavitation** results from rapid tissue/fluid pressure changes [72].
    - **Temporary cavitation:** Tissue stretching from pressure changes [73].
    - **Permanent cavitation:** Injury closer to the bullet path that remains after passage [73].

The distance and injury severity depend on the weapon type [74]. Air resistance (drag) slows the projectile, reducing penetration depth and energy [75]. The damaged area from medium/high velocity projectiles is much larger than the projectile's diameter [76]. Exit wounds are often larger than entrance wounds for this reason [77]. Energy's ability to cause damage is more about speed than mass [78]. The type of tissue the projectile passes through significantly impacts injury seriousness [79].

Velocity	Characteristics	Damage Mechanism
Low Velocity	Objects like knives or ice picks [67]	Sharp edges moving through tissue [68]

Medium/High Velocity	Usually bullets [70]	Trajectory, fragmentation, cavitation (temporary and permanent) [72]

6. Blast Injuries: Mechanisms and Affected Tissues

Blast injuries are seen in civilian settings from explosions in mines, shipyards, chemical plants, and terrorist activities [81]. There are **four mechanisms** of blast injuries [82].

- **Primary blast injuries:** Caused entirely by the blast's pressure wave [83].
- **Secondary blast injuries:** Damage from flying debris hitting the body [84].
- **tertiary blast injuries:** Victim is thrown by the explosion force against a stationary object [85].
- **Quaternary blast injuries:** Burns from hot gases, respiratory injury from toxic gas, crush injury from building collapse, suffocation, poisoning, or other medical emergencies/contamination [86].

Most survivors have a combination of these four injury types [88]. **Tissues containing air** are most susceptible to pressure changes, like the middle ear, lungs, and GI tract [89].

- The **ear** is the most sensitive [90].
- **pulmonary blasts** are lung trauma from close exposure to detonations [91]. **pneumothorax** is common and may need field decompression [92]. **arterial air emboli** are concerning pulmonary blast injuries, occurring when air enters lung blood vessels, potentially causing vision issues, behavioral changes, consciousness changes, or neurological signs [93].
- **Solid organs** are somewhat protected but can be injured by secondary missiles or being thrown [94].
- **Neurologic injuries and head trauma** are the most common causes of death from blast injuries [94]. **Extremity injuries**, including traumatic amputations, are also frequent [95].

Blast Mechanism	**Description**	**Example Injuries**
Primary	Pressure wave from explosion [83]	Ear damage, pulmonary blast injuries [90]

Secondary	Struck by flying debris [84]	Penetrating wounds, fractures [84]
Tertiary	Victim is thrown against object [85]	Fractures, head trauma, internal injuries [85]
Quaternary	Burns, toxic inhalation, crush injury, etc. [86]	Burns, respiratory issues, suffocation, poisoning [86]

7. Multi-System Trauma and Pre-hospital Care Principles

multi-system trauma involves injury to more than one body system [96]. Examples include head/spine trauma, chest/abdomen injuries, or chest/multiple extremity injuries [97]. Patients with multi-system trauma have high morbidity and mortality [98]. Rapid transport and medical control contact are important [97].

The **golden principles of pre-hospital trauma care** guide management [98]:

- Ensure **safety**: Your safety first, then crew safety, then patient safety [98].
- Determine the need for additional personnel and equipment [100].
- Evaluate the mechanism of injury [100].
- Identify and manage **life threats** [101].
- Focus on patient care [101].
  - **Hemorrhage control** is the highest priority [101].
  - Access and manage the **airway**, including ventilatory support and high-flow oxygen [102]. Maintain spinal restriction [102]. This is the second priority [102].
  - Ensure other **shock therapy** is completed [102].
  - Protect the spine and proceed with spinal immobilization if indicated [102].
- **Transport** the patient immediately to the appropriate facility [103]. Definitive care for multi-system trauma often requires surgery [104]. **Scene time should be 10 minutes or less** [104].
- During transport, obtain a **SAMPLE history** and complete the secondary assessment [105].
- Consider **advanced life support (ALS) intercept** or **air medical transport** [105].

8. Patient Assessment and Injury Patterns by Body Region

For patients with a significant MOI and serious/critical condition, perform a **rapid physical exam** [107]. Focus on the chief complaint while assessing the whole patient [108]. Common injury patterns are seen in different body regions.

- **Head injuries:** Disability and unseen brain injury can occur [110]. Bleeding or swelling inside the skull is often life-threatening [111]. Include frequent **neurologic examinations** [111]. Signs and symptoms may appear minutes or hours later [111].
- **Neck and Throat injuries:** Airway problems can quickly become life-threatening [112]. Frequent physical exams, including **DCAP-BTLS** (Deformities, Contusions, Abrasions, Punctures/Penetrations, Burns, Tenderness, Lacerations, Swelling), are essential [113]. Assess for **jugular vein distension** and **tracheal deviation** [114]. Swelling can impede blood flow to the brain [114]. Crushing injuries to the upper neck can fracture airway cartilage [115].
- **Chest injuries:** The chest contains the heart, lungs, and large vessels [116]. Many life-threatening injuries are possible [116].
  - Broken ribs can hinder breathing [117].
  - Bruising to the heart can cause irregular rhythms [117].
  - Torn large vessels can cause massive unseen bleeding [117].
  - Air collection between the lung and chest wall is a **pneumothorax** [118].
  - Blood collection in the chest is a **hemothorax** [118].
  - A penetrating chest wound is an **open chest wound** [119].

If untreated, shock may occur [120]. Assess the chest every five minutes [120]. Assessment includes DCAP-BTLS, lung sounds, and chest rise/fall [121].

- **Abdomen injuries:** The abdomen holds vital organs with high blood flow [122].
  - **Solid organs** (liver, spleen, pancreas, kidneys) can tear, lacerate, or fracture, causing serious bleeding [123].
  - **Hollow organs** (stomach, intestines, bladder) can rupture, leaking toxic digestive chemicals and causing life-threatening infection [125].

Ruptured blood vessels can cause serious unseen bleeding [126].

Body Region	Key Assessment Points	Common Injury Patterns

Head	Neurologic exams, check for bleeding/swelling [110]	Unseen brain injury, bleeding/swelling inside skull [110]
Neck and Throat	DCAP-BTLS, jugular vein distension, tracheal deviation [113]	Airway problems, impeded blood flow to brain, fractured cartilage [112]
Chest	DCAP-BTLS, lung sounds, chest rise/fall, assess every 5 minutes [120]	Broken ribs, heart bruising, torn vessels, pneumothorax, hemothorax, open chest wound [117]
Abdomen	Assess for signs of solid/hollow organ injury, bleeding [122]	Solid organ tears/lacerations/fractures (bleeding), hollow organ rupture (infection) [123]

9. Transport Decisions and Trauma Center Levels

Scene time survival is critical for trauma patients [127]. On-scene time for critically injured patients should be less than 10 minutes [127].

Criteria for identifying a **critically injured patient** include:

- Dangerous mechanism of injury [128].
- Decreased level of consciousness [129].
- Threats to the airway, breathing, or circulation [129].
- Very young or very old patients, or those with chronic illness [129].

Trauma centers are classified into levels one through four [130].

- **Level one:** Provides every aspect of trauma care, most resources [131].
- **Level two:** Provides initial definitive care [132].
- **Level three:** Provides assessment, resuscitation, emergency care, and stabilization [133].
- **Level four:** Provides advanced trauma life support [133].

Criteria for using **emergency air medical services** for trauma patients:

- Extended time to access or extricate a remote/trapped patient [135].
- Distance to a trauma center is more than 20-25 miles [135].

- Patient needs advanced care, and no ALS ground ambulance is available [135].
- Traffic or hospital availability makes ground transport to a trauma center unlikely [136].
- Multiple trauma patients overwhelm nearby hospitals [137].
- EMS system requires transport to the nearest hospital instead of bypassing to a trauma center, delaying definitive surgical care [138].
- Mass casualty event [139].

Trauma centers are categorized as adult or pediatric, not necessarily both [140]. **Modes of transport** are ground or air [141]. Ground units are staffed by EMTs and paramedics [142]. Air or critical care units are staffed by critical care nurses and paramedics [142]. Special considerations during transport include staying calm, completing a thorough assessment, correcting life-threatening injuries, doing no harm, and contacting ALS backup or medical control if needed [142].