401071 – Traumatic and Environmental Emergencies

Week 1 – Mechanisms of Injury:

Mechanism of Injury:

- **Mechanisms of injury (MOI)** is the set of specific biomechanical forces acting on the human body to produce a particular injury or injuries.
- **Kinematics** is the study of physics/mechanics involved in the motion of objects.
- A pattern of injury may be seen in patients who are subject to the same MOI.
- Paramedics are in a unique position in that they often get to assess MOI on scene. Other health professionals providing treatment for the patient later rely on paramedics' accurate assessment and description of the MOI.
- The forces that result in blunt trauma are most commonly due to rapid deceleration or acceleration.
- Penetrating injury causes damage as it passes through the body or tissue, and with sufficient force may also affect surrounding tissues.

Kinematics:

- Kinematics is the process of evaluating an event and determining the injuries that are likely to occur, given the motion involved.
- This includes evaluation of aspects such as position, angle and speed
- There are four particular laws of physics that are relevant to mechanism of injury:
    1. **Newton's first law of motion:** A body at rest remains at rest and a body in motion remains in motion unless acted on by an outside force.
        - Stationary objects = pedestrians hit by vehicle, gunshot victims
        - Moving objects = falling from height, vehicle hitting stationary object
    2. **The law of conversation of energy:** Energy is neither created nor destroyed, but changes form.
        - As a car decelerates, the energy of motion (acceleration) is converted to friction (thermal energy)
    3. **Newton's second law of motion:** The force that an object exerts on another object is equal to the mass of the object multiplied by its acceleration. This gives the force of impact absorbed by the object stopping it. F = ma
    4. **The law of motion:** Kinetic energy (E_k) is the energy associated with motion and reflects the connection between weight (mass) and speed (velocity).
        - $$KE = \frac{1}{2}mv^2$$
    5. **Newton's third law of motion:** For every action there is an equal and opposite reaction

Injury Concepts:

- Injury occurs when an external source of energy dissipates more rapidly tan the body's ability to tolerate it.
- Energy originates from several sources, including kinetic, chemical, electrical, thermal and radiation sources.

- Absence of heat and oxygen may cause injury also; e.g. drowning
- A basic component in producing injury is absorption of kinetic energy.

Blunt Trauma:

- Blunt trauma results from acceleration, deceleration, compression, shearing or direct forces.

Acceleration Injuries	Occur when a moving object strikes a stationary or slower-moving body
Deceleration injuries	Occur when a moving body hits a solid or slower-moving object
Compression injuries	Occur with squeezing inward pressure applied to tissues
Shearing injuries	Occur when two oppositely directed parallel forces are applied to tissue

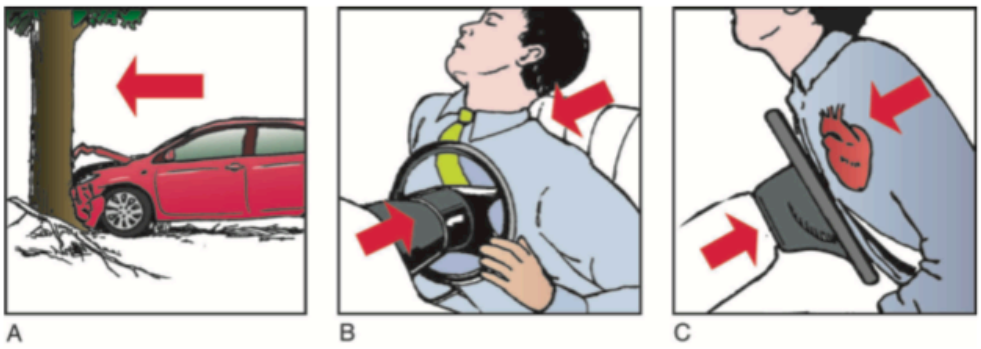
Falls:

- The mechanism of injury is **vertical deceleration**
- Falls of > 3m are considered significant due to gravitational potential energy.
- Increased fragility and co-morbidities lead to a greater risk associated with relatively minor falls.
- Falls in children – have a relatively larger head which increases momentum and risk of head injury
- Head injuries may occur from:
  - Impulsive loading: movement of the brain within the skull
  - Impact loading: skull fracture or scalp lacerations
- If a person lands on their feet the energy transferred from deceleration causes calcaneus fractures and compression fractures in the femur, vertebral column and base of the skull.
- Spinal injuries can occur from compression or axial loading injuries where vertebral bodies are compressed and wedged, producing vertebral fragments that can pierce the spinal cord.

Motor Vehicle Collisions:

- Phases of deceleration:
  1. When the vehicle impacts with another object – the motion of the vehicle continues until the kinetic energy is dispatched through damage to the vehicle or until the restraining force of the object is removed.
  2. Deceleration of the occupant then occurs – can result in compression or shearing trauma
  3. When internal structures continue to move until they collide with another internal structure, or vasculature – muscles and ligaments restrain them
- Pre-hospital information:
  - Patient position in vehicle
  - Restraint devices – did airbags deploy, were they wearing a seatbelt
  - Area of impact, e.g. front, side, rear
  - Details of impact – stationary or moving vehicle
  - Damage evident – steering wheel, windscreen

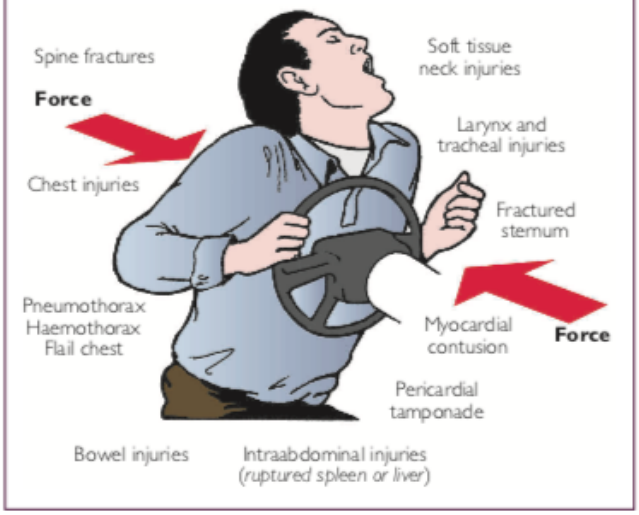
FIGURE 43.1 The three phases of a motor vehicle collision.



A, Car hits tree. **B**, Body hits steering wheel, causing fractured ribs and sternum. **C**, Heart strikes chest wall, causing myocardial contusion.

- **Frontal Impact:** Occurs when the front of the vehicle impacts another object, resulting in damage to the front of the vehicle.
- **Down and under:** After frontal impact the occupant continues to forward movement downwards into the steering column or dashboard. The knees impact the dashboard and upper legs absorb most of the energy. This causes knee-femur-hip injury
- **Up and over:** Forward motion from frontal collision carries the unrestrained occupant so the chest and abdomen hit the steering wheel. Head injuries can occur when the head strikes the steering wheel or dashboard, such as compression. Cervical spine damage can also occur (spider-web windscreen).

FIGURE 43.2 Steering wheel injuries.



- **Rear impact:** When the vehicle suddenly accelerates, hyperextension of the neck may occur.
- **Side impact:** Generally, occupants receive injuries on the same side of their body as the impact and are subjected to compression and deceleration forces.
- **Rotational impact:** When the corner of the vehicle collides with another – the part that is hit on the second vehicle stops forward motion, but the rest rotates until the energy is transformed. Injuries are a combination of frontal and lateral impacts.
- **Vehicle rollover:** Occupants tend to have injuries in the same body areas where damage occurs to the vehicle. The chance for axial loading injuries is increased.
- **Ejection:** May sustain injuries from impact, during flight or landing – increased mortality
- **Restraints:** Allow occupants to decelerate at the same rate as the vehicle. Seatbelt bruising patterns imply significant energy exchange. Injuries include spinal from flexion and extension, thoracic – soft tissue injuries and abdominal – crushing forces.
- **Vehicle safety devices:** Airbags are designed to protect occupants in frontal and lateral deceleration collisions by cushioning the head and chest

Motorbike Collisions:

- Injuries are dependent on the amount and type of kinetic energy and the body part that sustains impact.
- Motorcyclists are more likely to sustain severe thoracic injuries and head, neck and extremity injuries.
- **Head-on impact:** Motorbike impacts an object that stops the bike's forward motion, so the rider travels over the handlebars – bilateral femur fracturs can occur if the feet are trapped.
- **Angular impact:** When a motorbike is hit at an angle and collapses on the rider, the angular impact injures the side that is crushed between the rider and the ground.
- **Ejection:** Injuries occur to whatever body part is struck at the time of impact and when the body lands.

Pedestrian Trauma:

- The initial impact occurs when the bumper of the vehicle impacts the lower extremities.
- Following this, the head, chest and abdominal injuries occur as the pedestrian hits the bonnet or windscreen
- The pedestrian may then fall to the ground, resulting in further head, chest and upper extremity injuries.
- Waddell's triad for paediatrics – femur, thoracic, head

Crush Injuries:

- Most common mechanism is blunt trauma where there is sudden compression of the chest or upper abdomen – e.g. being wedged, children reversed over
- Crush injuries can cause traumatic asphyxia – characterised by cyanosis, oedema of the face, subconjunctival haemorrhage and petechial haemorrhage of the face.

Hanging and Strangulation:

- Severity of injuries are associated with the height of the fall, the type and position of the neck ligature used and whether the body is fully or partially suspended.
- Associated injuries are hypoxia, unconsciousness, arterial spasm due to carotid pressure, arterial dissection and vagal collapse.

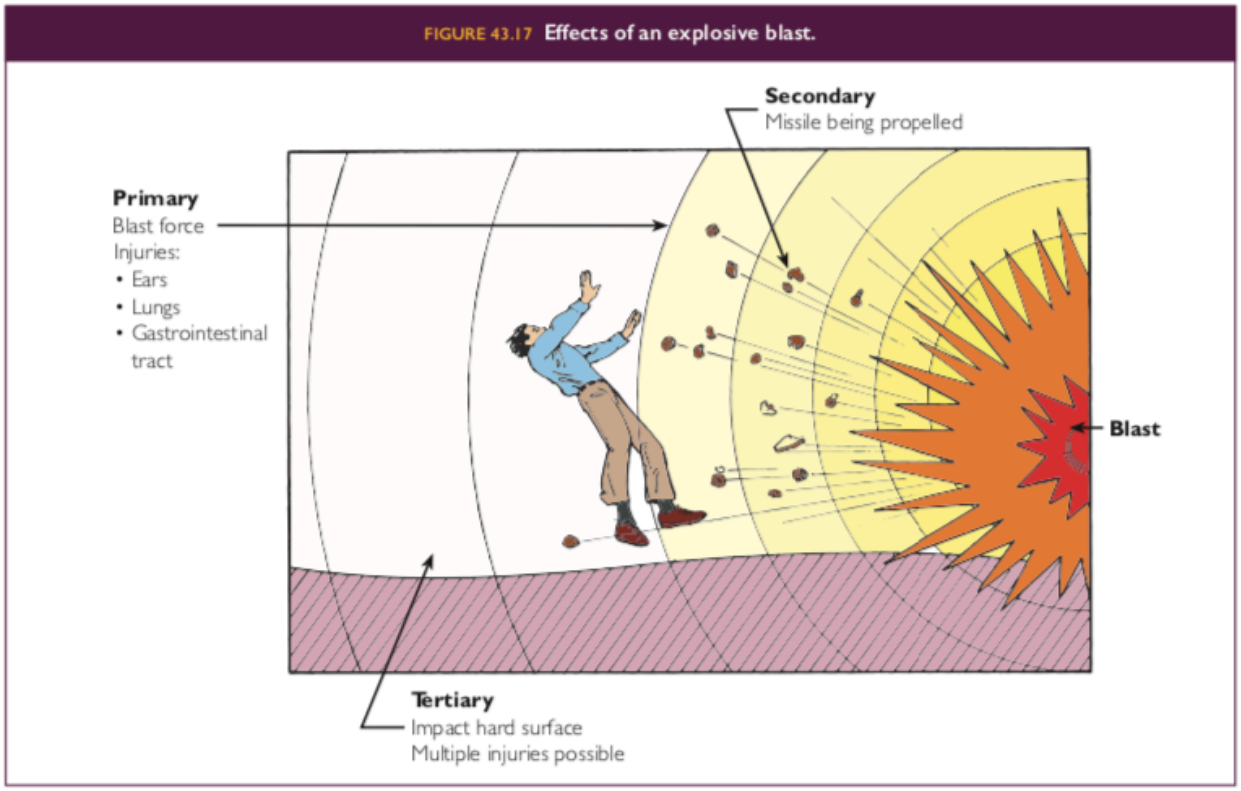
Penetrating Trauma:

- Refers to injuries caused by a foreign object penetrating or entering the body.
- Low-velocity injuries most commonly include stab wounds and impalements
  - It is beneficial to have insight into the size and length of the object.
  - It is important also to consider the victims position at the time of penetration
  - Impaled objects should be secured in position until the patient is in a controlled environment where surgical support is immediately available.
- High-velocity injuries refer to gunshot wounds
  - Gunshot wounds are further categorised into low and high velocity
    - Low velocity = handguns, travel at 300 to 900 m/s, cavity 3-6x
    - High velocity = assault rifles, travel at > 900 m/s, cavity 30-40x

- The transfer of energy from a weapon to the object it strikes causes particles to be moved out of position – **cavitation**.
  - Permanent cavitation – hole remains after energy has dissipated
  - Temporary cavitation – Tissue particles may return to their original location
- Bullet profile, the yaw, tumble and fragmentation can determine the extent of injury
  - Yaw = deviation of the nose of the bullet from a straight path
  - Tumbling = change in rotation of the bullet as it hits the body (somersault)
  - Fragmentation = bullet breaks apart on impact – damage to more areas
- Entry and exit wounds can help determine the pathway of the bullet and indicate potential organs the bullet has come in contact with.

Blast Injuries:

- Refers to any substance that has the ability to cause decomposition by the sudden release of gas and thermal energy in a limited space.
- There are three main phases – primary, secondary and tertiary
  - **Primary:** Associated with the effects of the pressure waves – the degree of damage is related to the power behind the blast and duration
  - **Secondary:** Involves the projection of bomb fragments and debris
  - **Tertiary:** Result from the person being displaced either onto the ground or into other objects
  - **Quaternary:** Miscellaneous injuries – building collapse, burns from fire
  - **Quinary:** Associated with hyperinflammatory states manifested by hyperpyrexia, low central nervous pressure and a positive fluid balance



Week 2 – Trauma Overview:

Overview:

- Trauma is the leading cause of death in those 1-44 years in the developed world.
- Internationally, motor vehicle collisions are the primary cause of traumatic mortality in the young generation.
- In Australia, the leading causes of non-fatal injury are falls (40%), other unintentional causes (32%) and transport crashes (12%).

Trauma Systems:

- A trauma system is an organised, coordinated effort in a defined geographic area that delivers the full range of care to all injured patients and is integrated with the local public health system.
- In the optimal trauma system, the right patient is transferred to the right hospital in the right time.
- Improvements in the systematic approach to trauma care have resulted in significant reductions in mortality and morbidity.

Interventions:

- The systematic primary survey approach **CABCDE** needs to be applied consistently and in a treat-as-you find fashion.
- Hypoxia should be assumed in all patients suffering major trauma.
- Effective airway management, ventilation and oxygenation are essential.
- Haemorrhage control is a priority in the patient with significant bleeding and should be accomplished swiftly.
- On-scene time should ideally not exceed 10mins

Week 2 – Trauma Lecture:

Epidemiology:

- Trauma is the leading cause of death in those 1-44 years of age in the developed world.
- Internationally, motor vehicle collisions are the primary cause of traumatic mortality in the young generation.
- In Australia, the leading causes of death are falls (40%), other unintentional causes (32%) and transport crashes (12%).
- Hospitalised injuries in Australia = 484,000 patients – 1:1, males: females
- Number of cases of injury by age ground and sex:
  - Younger men are more likely – risky behaviour
  - Older females are more likely – osteoporosis etc.
- Most common causes of injuries
  - Falls = 198,575 (41.1%) – 112,075 females and 86,500 males
  - Crashes = 58,591 (12.1%) – 38, 947 males and 19, 643 females
- **Injury severity:**
  - High threat to life = 1 in 6 cases (predicted mortality risk of >6%)

- Average length of stay (LOS): 4 days (484,000 patients x 4 days = > 1.7 million days)
- ICU stay: 2% (approx. 9,680) – for an average of 82 hours per case

- Deaths in Australia:
  - Leading underlying causes of death, by age group 2014-2016

Age group	1st	2nd	3rd	4th	5th
Under 1	Perinatal and congenital conditions	Other ill-defined causes	SIDS	Spinal muscular atrophy	Accidental threats to breathing
1–14	Land transport accidents	Perinatal and congenital conditions	Accidental drowning and submersion	Brain cancer	Other ill-defined causes
15–24	Suicide	Land transport accidents	Accidental poisoning	Assault	Other ill-defined causes
25–44	Suicide	Accidental poisoning	Land transport accidents	Coronary heart disease	Other ill-defined causes
45–64	Coronary heart disease	Lung cancer	Suicide	Breast cancer	Colorectal cancer
65–74	Lung cancer	Coronary heart disease	COPD	Cerebrovascular disease	Colorectal cancer
75–84	Coronary heart disease	Dementia and Alzheimer disease	Cerebrovascular disease	Lung cancer	COPD
85 and over	Coronary heart disease	Dementia and Alzheimer disease	Cerebrovascular disease	COPD	Heart failure

  - Chronic diseases feature more prominently among people over 45, while the leading causes of death among people aged 1-44 are external causes, such as accidents and suicide

Global Perspective:

- More than 5 million people die each year as a result of injuries
- This accounts for 9% of the world's deaths, nearly 1.7 times the number of fatalities that result from HIV/AIDS, tuberculosis and malaria combined.
- Approx. 1 in 4 of the 5 million deaths from injuries are the result of suicide and homicide, while road traffic injuries account for nearly another quarter.
- Other main causes of death from injuries are falls, drownings, burns, poisoning and war