Mechanism of injury
Assessment of the trauma patient

Humaryanto
3. It could happen to you?
3. It could happen to you?

- Show jumping
- Wearing helmet
- Burst # C1, Hangman’s # C2
- Resuscitated
- Quadriplegic, ventilator-dependent
• Categories of trauma
• Kinetics
• Injury severity score
• Common mechanism of injury
• How not to miss an injury
Why is it necessary to determine the mechanism of injuries?

Important for the diagnosis, rehabilitation and prevention of injuries
The Injury

Is the pivotal event - result of the interaction between an individual, an activity and the environment that produces the injury.

The nature of the injury determines the outcome for the person and for society.
Mechanism of injury

The forces and the energy dissipated to cause an injury

- thermal in the case of burns
- or kinetic in the case of RTC & falls
Injury Mechanism

• Depends persons perspective
• Mechanism often acts in combination
• Establish cause and effect relationship

• Sport medicine classification
  – Contact or impact
  – dynamic overload
  – overuse
  – structural vulnerability
  – inflexibility
  – muscle inbalance
  – rapid growth
Mechanical Loading

• Loads greater than physiological lead to injuries
• Chronic injuries
  – cumulative trauma
  – repetitive stress
• Acute injuries
Contributing factors

- Age
  - acute injuries: young
  - chronic: older
- Gender
- Genetics
- Fitness level
- Nutrition
- Psychological
- Human interaction
- Fatigue
  - physical & mental
- Environment
- Equipment
  - protective
  - contributes to injuries
- Previous injury
- Disease
- Drugs
- Rehabilitation
- Anthropometrics
- Skill level
- Experience
- Pain
Gymnast off balance, falling forward

Internal rotation of the femur

Genu valgum

External rotation of the tibia

Genu valgum and ACL tear

External rotation of the tibia
Kinetic energy

Kinetic energy is the energy of motion. Function of an object’s mass and velocity.

As speed increases, there is an even larger increase in kinetic energy.

Energy is classified as blunt or penetrating forces.
Mechanisms of Injury:

Kinetics of Trauma:
Mechanism of Injury:

• How the person was injured.
  – MVA
  – Fall
  – Blunt Trauma
  – Penetrating Trauma
Kinetics of Trauma:

- Science of analyzing mechanism of injury.
- Helps to predict:
  - Extent of injuries.
  - Priority decision.
  - Type of assessments.
  - Treatment.
  - Transport.
Kinetic Energy:

• The energy contained in a moving body.
Mass and Velocity:

• The two factors of kinetic energy.
  – Mass (weight).
  – Velocity (speed).

• Formula
  – Kinetic energy = \( \frac{\text{mass} \times \text{velocity}^2}{2} \)
Kinetic Energy

- Energy of Motion
- Kinetic energy = \( \frac{1}{2} \) mass of an object \( X \) \((velocity)^2\)
- Injury doubles when weight doubles but quadruples when velocity doubles
So...

When a moving body is acted on by an outside force and changes its motion, then kinetic energy must change to some other form of energy.

If the moving body is a human being and the energy transfer occurs too rapidly, then trauma results.
Blunt Force Trauma

- Force without penetration
- “Unseen injuries”
- Cavitation towards or away from the injury
Penetrating Trauma

- Piercing or penetration of body with damage to soft tissues and organs
- Depth of injury
Head on Collision:

• The kinetic energy of two moving bodies that collide will be combined.
  – 2 vehicles traveling at 30 mph will impact with the same force as one traveling at 60 mph. Colliding with a tree.
Law of Inertia:

• A body at rest will remain at rest, and a body in motion will remain in motion, unless acted upon by an outside force.

• “Newton’s first Law”
Acceleration and Deceleration:

- **Acceleration:**
  - Rate at which body in motion increases its speed.

- **Deceleration:**
  - Rate at which a body in motion decreases its speed.
Acceleration and Deceleration:

• A faster rate of speed results in more force exerted.

• Example:
  – 2 cars same weight and speed.
  – Car #1 braked to a gradual stop.
  – Car #2 stopped suddenly by tree.

• Which vehicle exerted more force?

• Whiplash injuries.
Deceleration Injury

- Aortic tear
  - Fixed descending aorta
  - Mobile arch
- Acute subdural brain hematoma
- Kidney avulsion
- Splenic pedicle
MECHANISMS OF INJURY
Impacts:

• MVA (involves 3 Collisions).
  – Vehicle collision.
  – Body collision.
  – Organ collision.
Vehicle Collisions:

• High index of suspicion:
  – Death of another occupant of vehicle.
  – Unresponsive patient or patient with altered mental status.
  – Spider webbed windshield.
  – Ejection.
Classification of MVA’s:

• Frontal.
• Rear-end.
• Lateral.
• Rotational.
• Rollovers.
Head-On Collision
Frontal:

• Driver continues to travel forward at the same speed as the vehicle.

• Up and over injuries:
  – head, neck, chest, abdomen and possible ejection.

• Down and under injuries:
  – knees, femurs, hips, acetabulum, and spine.
Head-on Collision

• Vehicle stops
• Occupants continue forward
• Two pathways
  – Down and under
  – Up and over
Frontal Collision

• Down and under pathway

  – Knees impact dash, causing knee dislocation/patella fracture
  – Force fractures femur, hip, posterior rim of acetabulum (hip socket)
  – Pelvic injuries kill!
Frontal Collision

• Down and under pathway
  – Upper body hits steering wheel
    • Broken ribs
    • Flail chest
    • Pulmonary/myocardial contusion
    • Ruptured liver/spleen
Frontal Collision

• Down and under pathway
  – Paper bag pneumothorax
  – Aortic tear from deceleration
  – Head thrown forward
    • C-spine injury
    • Tracheal injury
Frontal Collision

• Up and over pathway
  – Chest/abdomen hit steering wheel
    • Rib fractures/flail chest
    • Cardiac/pulmonary contusions/aortic tears
    • Abdominal organ rupture
    • Diaphragm rupture
    • Liver/mesenteric lacerations
Frontal Collision

• Up and over pathway
  – Head impacts windshield
    • Scalp lacerations
    • Skull fractures
    • Cerebral contusions/hemorrhages
  – C-spine fracture
Rear-end Collision
Rear-end Collision

- Car (and everything touching it) moves forward
- Body moves, head does not, causing whiplash
- Vehicle may strike other object causing frontal impact
- Worst patients in vehicles with two impacts
Rear-End Impacts:

• Whiplash
  – Stretching or tearing of anterior
• Coup-contracoup.
Lateral Collision
Lateral Impacts:

- Intrusion into the side of a vehicle impinging upon the occupants.
- Injuries:
  - Head, shoulder, lateral chest, lateral abdomen, lateral pelvis, and femur.
Lateral Collision

- Car appears to move from under patient
- Patient moves toward point of impact
- Increased potential for “shearing” injuries
  - Increased cervical spine injury
Lateral Collision

- Chest hits door
  - Lateral rib fractures
  - Lateral flail chest
  - Pulmonary contusion
  - Abdominal solid organ rupture
- Suspect upper extremity fractures and dislocations
Lateral Collision

- Hip hits door
  - Head of femur driven through acetabulum
  - Pelvic fractures
- C-spine injury
- Head injury
Rotational Collision
Rotational Collision

- Off-center impact
- Car rotates around impact point
- Patients thrown toward impact point
- Injuries combination of head-on, lateral
- Point of greatest damage = point of greatest deceleration = worst patients
Rollover
Roll-Over

- Multiple impacts each time vehicle rolls
- Injuries unpredictable
- Assume presence of severe injury
- Justification for Transport to Level I or II Trauma Center
Restrained vs Unrestrained Patients

- Ejection causes 27% of motor vehicle collision deaths
- 1 in 13 suffers a spinal injury
- Probability of death increases six-fold
Restraint Injuries:

• Seat belts.
  – Not worn properly can cause various injuries.
  – Even worn properly, do not protect against side impacts.

• Airbags.
  – Works best for first impact.
  – Powder burns.
  – Suffocation for infants and children.
Considerations for Infants & Children:

• Look for possible neck injuries even if child is restrained in a car seat.
• Use the car seat to immobilize the infant.
Restrained with Improper Positioning

• Seatbelts Above Iliac Crest
  – Compression injuries to abdominal organs
  – T12 - L2 compression fractures
• Seatbelts Too Low
  – Hip dislocations
Restrained with Improper Positioning

- **Seatbelts Alone**
  - Head, C-Spine, Maxillofacial injuries
- **Shoulder Straps Alone**
  - Neck injuries
  - Decapitation
Predictable injuries with restrained driver

- # clavicle
- # sternum
- Cardiac injuries
- Diaphragmatic rupture

- Bruising/laceration liver, spleen, pancreas
- Pelvic # and injuries
- Bruising of lower abdomen, breast, shoulder
Figure 7-1  Potential injury sites of unrestrained driver.
Predictable injuries in unrestrained driver

- Head injuries
- Facial injuries
- # larynx
- # clavicle
- #Sternum
- Cardiac contusion

- Lacerated liver or spleen
- Lacerated greater vessels
- # patella and femur
Figure 7-2 Potential injury sites of unrestrained passenger in front seat.
Pedestrian Injuries

Figure 7-10 Potential primary injury sites of adult pedestrian.
Vehicle-Pedestrian Collision Child:

• Child turns toward oncoming vehicle.
  – Frontal injuries.
    • Femur, chest, abdomen, and head.

• Low center of gravity.
  – Usually thrown in front of the vehicle.
    • May be run over by the same vehicle.
Pedestrian vs. Vehicle

• Child
  – *Faces oncoming vehicle*
  – *Waddell’s Triad*
    • *Bumper* → *Femur fracture*
    • *Hood* → *Chest injuries*
    • *Ground* → *Head injuries*
Vehicle-Pedestrian Collision Adult:

• Turns away from vehicle causing most impacts to side of the body.

• Injuries:
  – Lower leg tib-fib., back, chest, shoulders, arms, and abdomen.
  – Possible head and facial injuries from windshield.
Pedestrian vs. Vehicle

• Adult
  – Turns from oncoming vehicle
  – O’Donohue’s Triad
    • Bumper → Tib-fib fracture
    • Knee injuries
    • Hood → Femur/pelvic
Motorcycle Impacts:

- Head on.
- Angular.
- Ejection.
- Lying the bike down.
- ATV’S
Motorcycle Collisions

- Rider impacts motorcycle parts
- Rider ejected over motorcycle or trapped between motorcycle and vehicle
- No protection from effects of deceleration
  - Limited protection from gear
Head-First Falls:

• Hyperextension of the head.
• Compression of the cervical spine.
• Chest, lower spine and pelvic injuries are also common.
Feet-First Falls.

• Compression travels up the spinal column.
• Falls greater than 20ft. possible affect on internal organs.
• Foreword falls look for Colles’ or silver fork fractures of the wrist.
• Thrown backwards look for injuries to head, back, and pelvis.
Penetrating Injuries:

- The amount of kinetic energy transferred to the tissue is the greatest indicator of potential danger.
- Knife vs. gun.
Stab Wounds

• Damage confined to wound track
  – Four-inch object can produce nine-inch track

• Gender of attacker
  – Males stab up; Females stab down

• Evaluate for multiple wounds
  – Check back, flanks, buttocks
Stab Wounds

• Chest/abdomen overlap
  – Chest below 4th ICS = Abdomen until proven otherwise
  – Abdomen above iliac crests = Chest until proven otherwise
Stabbings

• Always maintain high degree of suspicion with stab wounds

• Remember: small stab wounds do **NOT** mean small damage
Assaults

• Same principles as stabbings
  - acknowledge the anatomy that lies beneath damaged soft tissue

• Find out how the weapon used in the assault
  - fists, 4x2, baseball bat, boots - how many people
Gunshot Wounds

• Damage **CANNOT** be determined by location of entrance/exit wounds
  – Missiles tumble
  – Secondary missiles from bone impacts
  – Remote damage from
    • Blast effect
    • Cavitation
Penetrating Injuries - Gunshots

- Kinetic energy of missile depends more on the velocity rather than the mass.

- Length of barrel is important
- Type of missile used is important

- Check for an entry and an exit wound
Low-Velocity Injuries:

• Damage to immediate area of impact.

• Length of the weapon used.
  – Pneumothorax, Hemopneumothorax.

• Length of object in stabbing should be included when reporting to the hospital staff.
Medium and High Velocity Injuries:

• Projectiles are generally pellets or bullets.
• Medium velocity.
  – Most shotguns or handguns.
• High velocity.
  – M-16, 30-30 Winchester.
Damage depends on two factors.

- Trajectory-path or motion of projectile during its travel.
- Dissipation of energy-way energy is transferred to the body.

• Affected by:
  - Drag-wind resistance.
  - Profile-impact point of bullet.
  - Cavitation-pathway expansion.
Fatal Gunshot Wounds:

- 49% occur to torso.
- 42% occur to head.
- 9% occur below the waist.
Head Wound:

• No room for expansion.
• Projectile enters the skull.
  – Skull fragments.
• Face.
  – Major airway threat.
  – Difficult to manage airway.
Chest Wounds:

- Pneumothorax.
  - Air in the chest cavity.
- Hemothorax
  - Blood in the chest cavity.
- Hemopneumothorax.
  - Both air and blood.
- Sucking chest wound.
- Fractured ribs.
- Consider abdominal injuries also.
- Depends on inhalation or exhalation.
Abdominal Wounds:

- Usually secondary injury from chest injury.
- Contains fluid-filled (bladder), air-filled (stomach), solid (spleen), and bony structures (pelvis).
- Both air-filled and fluid filled are more tolerant than solid filled organs.
Extremities:

- Contain bone, muscle, blood vessels, and nerves.
- Circulation, motor and sensory function may be compromised.
Blast Injuries:

• Explosion phases.
  – Primary phase.
    • Pressure wave of the blast.
  – Secondary phase.
    • Flying debris from blast.
  – Tertiary phase.
    • Patient thrown away from blast.
Assessment:

• “Golden Hour”
  – Time from injury to surgical intervention.
• “Platinum 10 Minutes”
  – On scene time.
• Maintain a high index of suspicion.
• Rely on the mechanism of injury in your priority decision.
Assessment:

• Scene-size up.
• Initial assessment.
• Rapid trauma/focused history or physical exam.
• SAMPLE if possible.
• Detailed physical exam.
• Ongoing assessment.
Significant Mechanism of Injury:

- Ejection from vehicle.
- Death or altered mental status in same passenger compartment.
- Extrication time of greater than 20 minutes.
- Falls greater than 20 feet.
- Rollover.
- High speed auto crash
  - Initial speed >40 mph.
  - Major auto deformity > 20 inches.
  - Intrusion into passenger compartment > 12 inches.
- Auto-pedestrian/auto bicycle with significant (>5 mph) impact.
- Pedestrian thrown or run over.
- Motorcycle crash > 20 mph. Or with separation of rider from bike.
Commonly missed injuries include

- # or sprains of extremities - upper & lower

- Lacerations to scalp or mouth/ tongue

- # vertebrae - L1 and L2

- # teeth
92% of injuries admitted to Auckland Hospital were as a result of blunt injury - 35% as a result of RTC
Falls

40% of injuries admitted to Auckland Hospital occur as the result of a fall.
Fall of 3 metres or more is a mandatory Trauma Call at Auckland Hospital
FALLS

• Major determinant of injury and the chance of death is directly proportional to the height fallen.

• At impact the decelerating forces are determined by the individual’s mass, the nature of the landing surface and the body’s orientation on landing.
Falls

• Critical Factor
  – Height
    • Increased height + Increased injury
  – Surface
    • Type of impact surface increases injury
  – Objects struck during fall
  – Body part of first impact
    • Feet
    • Head Buttocks
    • Parallel
Falls

• Assess body part that impacts first, usually sustains the bulk of injury

• Think about the path of energy through body and what other organs/systems could be impacted (index of suspicion)
Falls onto Head/Spine

- Injuries may not be obvious
- C-spine precautions!
- Watch for delayed head injury S/S
Falls onto Hands

- Bilateral colles fractures
- Potential for radial/ulna fractures and dislocations
Fall onto Buttocks

- Pelvic fracture
- Coccygeal (tail bone) fracture
- Lumbar compression fracture
Fall onto Feet*

- Don Juan Syndrome
  - Bilateral heel fractures
  - Compression fractures of vertebrae
  - Bilateral Colles’ fractures
Trauma in Pregnancy

Figure 7-6 Proper positioning of lap-shoulder belt during pregnancy.
Common injury patterns in pregnant woman

- Severity of injury parallels severity of damage to car
- Intra-peritoneal haemorrhage and hypovolaemic shock
- Likelihood of foetal death is proportional to severity of maternal injury
- Pelvic fractures are associated with high incidence of placental separation and foetal injury
Figure 7-7  Potential movement of child restrained with adult lap belt during motor vehicle crash.
Figure 7-5  Potential injury sites of child held by adult.
Trauma in the Elderly

No elderly trauma patient should be considered "just trauma".
Goals of assessment for the older person are:

To discover or rule out injury or a medical cause of symptoms

Identify the degree of clinical compromise that may be masked by physiologic changes associated with ageing.
Trauma in the Elderly

- Trauma screening and scoring methods may be unreliable
- Medical conditions should be accounted for during the assessment
- Usual hearing, visual and mobility abilities should be acknowledged
INJURY BIOMECHANICS AND ACCIDENT PREVENTION

• The magnitude of an injury is related to energy transferred to the victim during the event, the volume/area of tissue involved and the time taken for the interaction
Injury Scaling System

General measure of disease severity based on current physiologic measurements age and previous health condition.
The score can help in the assessment of patients to determine the level and degree of diagnostic and therapeutic intervention.
Classification of Injury Scale

• Impact of injury depend on
  – Extent of tissue damage $\rightarrow$ Anatomic Score
  – Physiological Response to injury $\rightarrow$ Physiologic Score
  – Host factor
Classification of Injury Scoring Scale

• Anatomic Score:
  ➢ Organ Injury Scale
  by American Association for the surgery of Trauma
  ➢ Abbreviated Injury Scale (AIS)
  ➢ Injury Severity Scale (ISS)
## Organ Injury Scale

### Liver Injury Grading Scale

<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
<th>ICD-9</th>
<th>AIS-90</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Capsular tear &lt; 1 cm in depth</td>
<td>864.02</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>864.12</td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>Capsular tear 1-3 cm in depth</td>
<td>864.03</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>&lt; 10 cm length</td>
<td>864.13</td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>Capsular tear &gt; 3 cm in depth</td>
<td>864.04</td>
<td>3</td>
</tr>
<tr>
<td>IV</td>
<td>Parenchymal disruption 25-75% of hepatic lobe or 1-3 Couinaud’s segments within a single lobe</td>
<td>864.04</td>
<td>4</td>
</tr>
<tr>
<td>V</td>
<td>Parenchymal disruption &gt; 75% of hepatic lobe or &gt; 3 Couinaud’s segments within a single lobe</td>
<td>864.14</td>
<td></td>
</tr>
</tbody>
</table>
# Abbreviated Injury Scale (AIS)

## AIS Scale

<table>
<thead>
<tr>
<th>AIS</th>
<th>Head</th>
<th>Thorax</th>
<th>Abdomen and pelvic contents</th>
<th>Spine</th>
<th>Extremities bony pelvis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>headache</td>
<td>single rib fracture</td>
<td>abdominal wall superficial lacer.</td>
<td>acute strain (no fracture)</td>
<td>toe fracture</td>
</tr>
<tr>
<td>2</td>
<td>unconscious &lt; 1 hour</td>
<td>2-3 rib frax</td>
<td>spleen, kidney or liver laceration</td>
<td>minor frax. no cord involvement</td>
<td>tibia, pelvis or patella frax</td>
</tr>
<tr>
<td>3</td>
<td>unconscious 1-6 hours</td>
<td>&gt;4 rib frax or frax and hemo.</td>
<td>spleen or kidney major laceration</td>
<td>ruptured disc &amp; nerve root dmg</td>
<td>knee dislocation femur fx</td>
</tr>
<tr>
<td>4</td>
<td>unconscious 6-24 hours; open fx.</td>
<td>flail chest</td>
<td>major liver laceration</td>
<td>incomplete cord cord syndrome</td>
<td>amputation or crush above knee</td>
</tr>
<tr>
<td>5</td>
<td>unconscious &gt; 24 hours; partial transec-tion</td>
<td>aorta lacer. partial transec-tion</td>
<td>kidney, liver or colon rupture (open)</td>
<td>quadriplegia</td>
<td>pelvis crush</td>
</tr>
</tbody>
</table>
Injury Severity Scale (ISS)

- 6 body regions:
  1. head/neck
  2. face
  3. chest
  4. abdomen / pelvis content
  5. (6) extremities

- Maximum AIS for three regions

- \( \text{ISS} = \text{AIS}_1^2 + \text{AIS}_2^2 + \text{AIS}_3^2 \)

- Maximum ISS 75

- Any AIS=6 result in ISS= 75
Example: AIS-90 Codes for one patient

- **Chest**
  - 2-3 rib fractures with pneumothorax, 450222.3 (right)
  - **Bilateral lung contusion, 441410.4**

- **Abdomen and Pelvic Contents**
  - Liver (minor) laceration, 541822.2
  - Spleen (minor) laceration, 544222.2
  - Lumbar (L-1) spine fracture, transverse process, 650620.2
  - Lumbar (L-2) spine fracture, transverse process, 650620.2

- **Extremities and Pelvic Girdle**
  - Supracondylar femur fracture, 851822.3 (right)
  - Tibia fx, open/displaced/ comminuted (medial malleolus), 853414.2 (right)
  - Tibial tendon laceration (and other leg tendons), 840804.2 (right)
  - **Other lower extremity arteries, major laceration, 821008.3**
  - Femoral/tibial nerve contusion, 830602.2
  - Tibia plateau fracture (proximal), 853406.2 (left)
  - Talus fracture, 853200.2 Calcaneus fracture, 851400.2 (right)
  - Muscle tear, 840600.2
  - Lower extremity, skin laceration, minor, 810602.1
  - Lower extremity, skin abrasion, 810202.1
  - Radius fracture, open/displaced/ comminuted, 752804.3 (left)
  - Ulna fracture, open/displaced/ comminuted, 753204.3 (left)
  - Upper extremity, skin abrasion, 710202.1

**ISS = 4 + 2^2 + 3^2 = 29**
Classification of Injury Scoring Scale

- Physiologic Score
  - Glasgow Coma Scale
  - Revised Trauma Score (RTS)
  - Acute Physiology and Chronic Health Evaluation (APACHE)
Application of Injury Scale System

- Objective description of injury
- Help for decision making for clinician
- Prediction of patient outcome
- Evaluation the performance of care center
- Search for unexpected death
Summary

- Use knowledge of anatomy & physiology to understand the mechanism of injury

- Investigate any symptoms that the patient reports at the time following the initial assessment

- Assess, report, and investigate any symptoms that the patient complains of while in hospital
Remember ...

A # arm caused by a fall is vastly different from a # arm caused by a motor bike versus car.

And

Bruce Willis uses stunt doubles and the fight sequences are actually dance routines.
DANGER AHEAD
FASTEN SAFETY BELTS
AND REMOVE DENTURES

GEVAAR VOOR
MAAK GORDELS VAS
EN VERWYDERS KUNSTANDE