Trauma

Initial Assessment and Management

Airway and Ventilatory Management

Shock

Thoracic Trauma

Abdominal Trauma

Head Trauma

Spine and Spinal Cord Trauma

Musculoskeletal Trauma

Injuries Due To Burns And Cold

Paediatric Trauma

Trauma in Women

Transfer to Definitive Care
Initial Assessment and Management

Preparation
Pre-hospital
Minimize scene time
Priorities
Airway maintenance
Control external bleeding and shock
Immobilization
Immediate transport to the closest appropriate facility
Obtain information for hand over
Criteria for transfer to trauma centre
GCS <14, RR <10 or >29, systolic <90 mmHg, RTS <11, PTS <9
Flail chest, >2 proximal long bone fractures, amputation proximal to wrist or ankle, penetrating trauma proximal to elbow or knee, limb paralysis, pelvic fracture, trauma with burns
Consider trauma centre for
Ejection from car, death in same compartment, pedestrian thrown or run over, high speed crash, extrication time >20 min, fall >6 m, roll over, pedestrian struck at >8 km/h, motorcycle crash at >32 km/h or with separation of bike and rider
Age <5 or >55, pregnancy, immunosuppression, cardiac or respiratory disease, diabetes, cirrhosis, morbid obesity, coagulopathy

In hospital
Resuscitation area
Airway equipment, warm IV solutions, monitoring
Means to summon medical help, means to summon diagnostic services
Transfer agreement with trauma centre
Universal precautions to be observed

Triage
Revised Trauma Score
Respiratory rate
>29  4
10-29  3
6-9  2
1-5  1
0  0
Systolic BP
>89  4
76-89  3
50-75  2
1-49  1
0  0
GCS
13-15  4
9-12  3
6-8  2
4-5  1
<4  0
Paediatric Trauma Score

Weight
- <20 kg  2
- 10-20 kg  1
- <10 kg  -1

Airway
- Normal  2
- O₂  1
- Intubated  -1

Systolic BP
- >90  2
- 50-90  1
- <50  -1

Consciousness
- Awake  2
- Any LOC  1
- Coma  -1

Fracture
- None  2
- Single closed  1
- More / open  -1

Skin
- Intact  2
- Lac. <7 cm  1
- More  -1

Score >8 should have zero mortality.

Priorities
Multiple casualties are treated in order of severity.
Mass casualties (exceeding capacity of available facilities) are treated in order of probability of survival with least expenditure of resources.

Primary Survey
Examination and management take place simultaneously

Airway maintenance with cervical spine protection
Assess patency of the airway: fractures, foreign bodies
Establish a patent airway
Definitive airway is usually required if GCS ≤ 8
Cervical spine must be immobilized in any multi-system trauma
Deterioration of conscious state may demand reassessment of airway

Breathing and ventilation
Requires function of lungs, chest wall and diaphragm
Examine the chest for acute causes of impaired ventilation
   Tension pneumothorax, open pneumothorax, flail chest with pulmonary contusion, massive haemothorax
Intubation may worsen pneumothorax
Chest x-ray is required as soon after intubation as practical
Circulation and haemorrhage control

Haemorrhage is the commonest cause of post-injury death treatable in hospital
Volume status is assessed by conscious state, skin colour and pulse rate and strength
Hypotension is caused by hypovolaemia until proved otherwise
Bleeding is controlled by local pressure
Occult haemorrhage occurs into the chest or abdomen, retroperitoneum following pelvic fracture or soft tissues following long bone fracture
Blood pressure is not a good indicator of volume status

Disability (neurologic evaluation)

Rapid assessment of GCS or AVPU status
Impaired consciousness after correction of hypoxia and hypovolaemia is usually due to CNS trauma
Drugs may confuse examination findings
Frequent reassessment is required

Exposure and environmental control

Complete exposure is required for examination
Prevention of hypothermia is required, using warming blankets, warmed IV fluids and early control of haemorrhage

Resuscitation

Airway
Definitive airway if there is doubt about the patient’s ability to maintain an airway
Application of a hard collar for cervical spine immobilization

Breathing and ventilation
All patients should receive supplemental oxygen

Circulation
Two large IVs should be inserted
Blood taken for crossmatch, baseline bloods and pregnancy test
IV fluid administration, initially warmed Hartmann’s 2-3 l
Hypovolaemic shock is treated with operative intervention to stop bleeding and continued fluid resuscitation, not pressors, steroids or bicarbonate

Adjuncts to primary survey and resuscitation

ECG monitoring
Signs of cardiac injury, pulseless electrical activity, hypoxia or hypoperfusion

Urinary and gastric catheters
Urine output provides an indication of volume status
Catheter should not be inserted if the urethra might be injured
Blood at meatus, perineal ecchymoses, blood in scrotum, high riding prostate, pelvic fracture
Gastric catheter reduces the risk of regurgitation and aspiration, but does not eliminate it
Nasogastric insertion is contraindicated if the cribriform plate might be disrupted

Other monitoring
Ventilatory rate and ABGs
CO₂ confirmation of ETT placement
Pulse oximetry
Blood pressure
Diagnostic studies
CXR and pelvis x-ray can guide resuscitation but must not cause delay
Lateral cervical spine x-ray is useful if it shows an injury
Further tests during secondary survey

Consider need for transfer
However life saving interventions should start at the time the problem is identified

Secondary survey
Begins when resuscitation is underway and vital signs are normalizing

History
Allergies, medications, past illnesses or pregnancy, last meal, events related to the injury (mnemonic: AMPLE)

Physical examination

Head
Complete examination for soft tissue or bony injury
Eye examination for acuity, pupils, hyphaema, penetrating injury, contact lenses, lens dislocation, muscle entrapment
Facial bones for fractures

Cervical spine and neck
Head or face injury implies cervical spine injury until it is excluded
Penetrating injuries should be explored in theatre
Cervical spine injury should be excluded as soon as convenient and hard collar removed

Chest
Inspection and palpation of the entire thorax
Auscultation for heart sounds and breath sounds
Bony or soft tissue injury makes visceral injury likely
Children have a more compliant chest wall which may hide deeper injuries

Abdomen
Specific diagnosis is not as important as recognizing that an injury exists
Repeat examination for changing signs may be necessary
If injury is suspected
Ultrasound or lavage
CT if stable

Perineum
Inspection, PR, PV, urinary catheter

Musculoskeletal
Limbs must be inspected and palpated
Pelvis integrity should be assessed
The back must be examined
Soft tissue injury may be difficult to detect in an unconscious patient

Neurological
Assess conscious state (and reassess)
Examine for peripheral signs of nerve or cord injury
Prevent abrupt rises in ICP in head-injured patients
Specialized diagnostic tests (as indicated)

X-rays
- CXR, pelvis, cervical spine, thoracolumbar spine, sites of injury

CT
- Head (±MRI), chest, abdomen, spine

Contrast studies
- Urography, angiography

Ultrasound
- Abdomen, gynaecological, transoesophageal

Endoscopy
- Bronchoscopy, gastroscopy

Tests requiring transport demand a stable patient

Reevaluation
- Continuous monitoring of vital signs
  - ECG, BP, SpO₂, conscious state, urinary output, ABG, E₅CO₂

Analgesia

Definitive care
- Surgical intervention
- Transfer to an appropriate facility

Documentation
- Essential for continuity of medical care and evidence in case of medicolegal problems
- A dedicated record-taker is needed in the resuscitation setting
- Consent should be obtained before procedures if possible
- If criminal involvement is likely, evidence must be preserved
Airway and Ventilatory Management

Airway

Problems
Maxillofacial trauma, neck trauma, laryngeal trauma

Signs
Talking patient: airway is patent and not compromised
Agitation, obtundation, cyanosis, rib retraction, accessory muscle use
Noisy breathing, stridor, hoarseness, confusion (hypoxia)
Palpable larynx and trachea

Ventilation

Problems
Airway patency, chest and lung integrity, innervation, CNS function

Signs
Chest movement
Breath sounds
Oximetry

Management
All require protection of cervical spine if injury is suspected
Airway maintenance
Chin lift, jaw thrust, Guedel airway, nasopharyngeal airway

Definitive airway
“A tube present in the trachea with the cuff inflated, the tube connected
to some form of oxygen-enriched assisted ventilation, and the airway
secured in place with tape.”

Orotracheal, nasotracheal, surgical options

Indications
Apnoea, inability to maintain a patent airway, protection from
aspiration, impending or potential airway compromise, closed head
injury (GCS ≤8), inadequate oxygenation with face mask
ventilation

Intubation
Method depends on practitioner's experience, usually orotracheal
Cervical immobilization, preoxygenation, cricoid pressure, drugs (if
required), laryngoscopy, ETT placement, auscultation, CO₂ analysis, CXR
Nasotracheal intubation is only used in spontaneously breathing patient
Induction agents typically suxamethonium and benzo.

Surgical Airway

Needle cricothyroidotomy
12g or 14g cannula inserted through cricothyroid membrane
Intermittent jet O₂ insufflation (1 s on 4 s off)
Contraindicated in glottic obstruction (→ barotrauma)
Provides 30-45 minutes oxygenation (limited by PCO₂)

Surgical cricothyroidotomy
Palpate thyroid notch and sternal notch, find cricothyroid
Local anaesthetic if required, prepare skin
Stabilize trachea with one hand, transverse incision through skin
and cricothyroid membrane
Insert scalpel handle or artery and dilate opening
Insert cuffed tube (5-6 mm), inflate cuff and check ventilation
Secure tube
Oxygenation

All patients require supplemental oxygen
Oximetry should be used where available
unreliable with poor peripheral perfusion, anaemia, abnormal Hb

Ventilation

Bag-valve-mask is best performed with two operators
Ventilation is required during prolonged attempts at intubation
Pressure-limited ventilation is required post-intubation
Shock

Assessment

Signs
- Peripheral vasoconstriction, tachycardia, narrowed pulse pressure
- Hypotension is a late sign (>30% volume loss)
- Haemoglobin is not a measure of volume status

Causes
- Haemorrhagic: Present in most patients with multiple injuries, responds to filling
- Non-haemorrhagic: Cardiogenic, tension pneumothorax, neurogenic, septic

Haemorrhagic shock
- Haemorrhage is the acute loss of circulating blood volume
- Normal blood volume is 70 ml/kg in adults (80-90 ml/kg in children)

Classification
Class I
- Loss up to 15% of blood volume
- Usually fully compensated
- Recovers by transcapillary refill within 24 hours

Class II
- 15%-30% blood volume lost
- Tachycardia, tachypnoea, reduced pulse pressure, anxiety
- Urine output 20-30 ml/h
- Responsive to crystalloid filling

Class III
- 30%-40% blood volume lost
- Marked tachycardia, tachypnoea, hypotension, mental changes
- Urine output low 5-15 ml/h
- Will require transfusion

Class IV
- More than 40% blood volume lost
- Immediately life-threatening
- Minimal urine output
- Requires immediate transfusion and usually surgery

Soft-tissue haematoma may consume litres of blood.

Management

Examination
- ABCDE
- Gastric decompression
- Urinary catheter insertion

Vascular access
- Large peripheral IVs initially (16g or 14g short)
- Cut-down if required depending on level of experience
- Intraosseous infusion if under 6 years and no other access
- CVC insertion is not the best choice for rapid infusion
- Blood taken for crossmatch, investigations including ßhCG, ABG

Initial fluid therapy
- 20 ml/kg Hartmann’s as a bolus
- Further therapy guided by response to initial bolus and on-going losses

Response
- Urine output, conscious state, peripheral perfusion, CVP
Evaluation of resuscitation

Normalization or improvement of HR, BP and pulse pressure
Urine output >0.5 ml/kg/h (1 ml/kg/h in children, 2 ml/kg/h in infants)
CVP or PAOP or CO (if PA catheter inserted)
ABG
  Initial respiratory alkalosis followed by metabolic acidosis
  Persistent metabolic acidosis if peripheral perfusion is inadequate

Response to initial therapy
Rapid response
  Haemodynamic normalization with bolus fluid
Transient response
  Deterioration following initial response to bolus fluid indicates
  inadequate resuscitation or ongoing losses
  Likely requirement for transfusion and surgery
Minimal or no response
  Likely exsanguinating haemorrhage requiring surgery, or
  Non-haemorrhagic cause for shock
  Differentiate using CVP or echocardiography

Choice of fluid
Blood
  Usually packed cells
  Used to replace oxygen carrying capacity
  Not the first choice for volume replacement
  Type-specific or O negative can be used in extreme urgency
  Component therapy for coagulopathy as indicated by pathology tests
Crystalloids
  Hartmann’s or normal saline
  Heated to 39°C

Special considerations
Use of vasopressors is contraindicated in haemorrhagic shock

↑ SVR, ↓ CO → “death spiral”
Elderly have reduced physiological reserve
Tachycardia may be a poor sign if on β-blockers or pacemaker or in athletes
Hypothermia may prevent a response to fluid
Always suspect ongoing haemorrhage if response is poor
Under-resuscitation is far more common than fluid overload
CVP can guide fluid therapy
Thoracic Trauma

Primary Survey

Airway
Assess air movement at nose and mouth, inspect oropharynx, observe for intercostal retraction
Laryngeal injury or posterior dislocation of sternoclavicular joint can obstruct the airway

Breathing
Expose chest, observe, palpate and auscultate
Tension pneumothorax
Decompress with large Jelco in second intercostal space in midclavicular line followed by chest tube in the fifth intercostal space between the midaxillary and anterior axillary lines
Open pneumothorax
Flap-valve dressing, surgical closure and chest tube
Flail chest
Underlying pulmonary contusion is usually the major concern
Administer oxygen, limit IV fluids unless shock is present, analgesia
May require intubation and ventilation

Circulation
Assess pulse, blood pressure, JVP
Monitor ECG and SpO₂
Massive haemothorax
Rapid accumulation of more than 1500 ml in the chest cavity, usually manifest as shock with absent breath sounds and dullness on one side of the chest
Rapid IV fluid administration, decompression with a chest tube, thoracotomy likely if >1500 ml or >200 ml/h evacuated or persistent transfusion requirement or penetrating injury medial to nipple or scapula
Cardiac tamponade
15-20 ml in pericardial space is enough to cause haemodynamic compromise
Difficult to diagnose acutely, echocardiography may help
IV fluid may produce transient improvement
Pericardiocentesis may be performed without definitive diagnosis
Open pericardiotomy may be required to evacuate clot and inspect the heart

Resuscitative thoracotomy
May be helpful in penetrating chest injury with pulseless electrical activity
Only performed by an appropriate surgeon

Secondary survey
Further examination
Upright CXR, ABG, SpO₂, ECG
Simple pneumothorax
Decreased breath sounds, resonant percussion
Chest tube inserted in fifth intercostal space, underwater seal drain,
CXR to confirm lung re-expansion all required before IPPV or air transport
Haemothorax
Usually due to laceration of intercostal or internal thoracic arteries, bleeding is usually self-limiting
Chest tube allows drainage of blood and monitoring ongoing loss
Thoracotomy for severe bleeding

Pulmonary contusion
Most common potentially lethal chest injury, gradual respiratory failure
$P_{O_2}$ >65 mmHg or $SpO_2$ <90% demands intubation and ventilation
Repeated assessment of ABG, ECG and $SpO_2$

Tracheobronchial tree injuries
Most injuries are within 2.5 cm of the carina and cause death at the scene
Haemoptysis, subcutaneous emphysema or tension pneumothorax
Large air leak after chest tube insertion, two chest tubes may be required
Diagnosis confirmed at bronchoscopy, may require double lumen tube, may require urgent surgical repair

Blunt cardiac injury
Pain, hypotension with ↑ CVP, wall motion abnormality, conduction abnormalities (PVCs, ST, AF, RBBB, STΔ)
Treatment of arrhythmia as indicated, ECG monitoring

Traumatic aortic disruption
Common cause of death after severe deceleration injury
Survivors to hospital have contained haematoma
Signs on CXR: widened mediastinum, obliterated aortic knob, tracheal deviation to right, no space between aorta and PA, depressed left main bronchus, deviation of oesophagus to right, widened paratracheal stripe, widened paraspinal interfaces, apical cap, left haemothorax, fractures of first or second rib or scapula
Diagnosed at angiography or TOE

Traumatic diaphragmatic injury
Commonly missed, may be diagnosed on CXR with NGT or contrast, or by drainage from chest tube of DPL fluid, or at thoracoscopy or laparotomy
Treated by direct repair

Mediastinal traversing wounds
Penetrating injury crossing from one hemithorax to the other or with metallic fragment lodged in the mediastinum
50% unstable, 20% mortality
Early surgical consultation
Injury to great vessels, tracheobronchial tree, oesophagus, heart, spinal cord and lung must be considered
Chest tubes may be required bilaterally, early operation if unstable
Stable patients require angiography, contrast swallow, gastroscopy, bronchoscopy, CT or echocardiography

Associated problems
Subcutaneous emphysema
Crush injury
Rib, sternum and scapula fractures
Rib 1-3 protected by upper limb; fracture suggests great vessel injury
Rib 4-9 most commonly injured, require greater force in the young
Rib 10-12 fracture suggest hepatic or splenic injury
Analgesia is required for good ventilation
Blunt oesophageal rupture
Due to forced expulsion of gastric contents with oesophageal tearing or instrumentation
May present as left pneumothorax without rib fracture, particulate matter in chest tube
Required operative repair to prevent mediastinitis and sepsis

CXR examination
Confirm ID of film
Trachea and bronchi
Interstitial or pleural air, pneumomediastinum, pneumothorax, subcutaneous or interstitial emphysema, pneumoperitoneum
Pleural space and lung parenchyma
Lung infiltrate, consolidation or haemothorax
Mediastinum
Altered cardiac silhouette, signs of aortic rupture (above)
Diaphragm
Elevation, disruption, obscured, mass above or air below
Bony thorax
Clavicle, scapula, ribs, sternum fractures or dislocation
Soft tissues
Tubes and lines
Abdominal Trauma

Assessment

History
- Mechanism of injury: e.g. vehicle crash, speed, direction, position in car etc. or weapon and range in penetrating trauma
- Location of pain and referral of pain

Examination
- Inspection
  - Including posterior abdomen and chest and perineum
- Auscultation, percussion
- Palpation
  - Guarding, pregnancy

Evaluation and local exploration of penetrating wounds
- Dependent on surgical experience
- 25%-33% of anterior stab wounds do not penetrate peritoneum

Assess pelvic stability

Perineal, penile/vaginal and rectal examination
- Signs of pelvic fracture or urethral injury

Gluteal examination

Intubation
- Insertion of NGT, urethral catheter (if no indication of injury)

Blood and urine sampling

Imaging
- Screening x-rays: cervical spine, CXR, pelvis
- Supine and erect AXR (lateral decubitus if can’t be sat up)

Contrast studies
- Urethrography, cystography if injury suspected
- IVP only if contrast CT unavailable
- GI contrast studies if injury suspected and patient stable

Special investigation

Diagnostic peritoneal lavage
- 98% sensitive for intraperitoneal bleeding

Indications
- Haemodynamically abnormal, multiple blunt injuries
- Altered conscious state
- Spinal cord injury
- Equivocal abdominal examination
- Prolonged “loss of contact” with abdomen expected (e.g. CT)
- CT or US not available

Relative contraindications
- Previous surgery, morbid obesity, cirrhosis, coagulopathy
- Lavage catheter inserted and aspirated
- If no aspirate, 1000 ml Hartmann’s used for lavage
- Positive if ≥100,000 RBC/mm³, ≥500 WBC/mm³ or gram stain +ve

Ultrasound
- As good as DPL or CT in experienced hands
- Gives views of pericardium, hepatorenal fossa, splenorenal fossa, pelvis
- Repeat scan at 30 minutes to detect slow bleeding

Computed tomography
- Time-consuming, only for stable patients
- Most specific test for injury
- Will miss some diaphragmatic, bowel and pancreas injuries
Special investigation in penetrating trauma
  Lower chest wounds
    Serial examination and imaging, laparoscopy, thoracoscopy
  Anterior abdominal stab wounds
    Serial examination or DPL help to detect asymptomatic penetration of peritoneum
  Back or flank stab wounds
    Serial examination or contrast CT or DPL plus follow up beyond 24 hours if asymptomatic

Indications for laparotomy
  Blunt trauma with
    Positive DPL or ultrasound
    Hypotension despite resuscitation
  Peritonitis
    Penetrating trauma with
      Hypotension
      Bleeding from GI or urogenital tract
      Gunshot wounds
  Evisceration
    AXR with free air, diaphragmatic defect or retroperitoneal air
    CT with ruptured viscus, injury to bladder, renal pedicle or other viscus

Pelvic fractures
  Classification
    Anteroposterior compression injury
      Commonly sacral fracture or dislocation
      Haemorrhage from posterior venous or internal iliac vessels
    Lateral compression injury
      Pubis commonly injures bladder or urethra
      Haemorrhage less common
    High energy shear force injury
      Disrupts sacrospinous and sacrotuberous ligaments
      Major instability
  Assessment
    Inspection for bruising, lacerations, urethral injury, PR
    Manual test of mechanical stability
    X-ray
  Management
    Exsanguination
      ABCDE, PASG, operate if open or DPL positive, post-op fixation
      Angiography if unstable and DPL negative
    Stable following resuscitation and unstable fracture
      ABCDE, PASG, operate if DPL positive, post-op fixation, angiography if still unstable
      Normal BP
      ABCDE, PASG if hypotension develops, treat other injuries, fix
  DPL technique
    Urinary catheter, NGT
    Prep, local below umbilicus
    Vertical incision to fascia, peritoneal incision (alternatively Seldinger tech.)
    Insert catheter, advance into pelvis
    Aspirate, irrigate, agitate, drain after 5-10 min
    Send sample for RBC, WBC counts and gram stain

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Head Trauma

Classification
Mechanism: blunt or penetrating (dura)
Severity: by GCS: severe 3-8, moderate 9-13, mild 14-15

Morphology
Usually determined at CT scan
Skull fractures
   Vault: linear or stellate, open or closed, depressed or not
   Basilar: with or without CSF leak, VII nerve palsy
Intracranial lesions
   Focal
      Extradural haematoma
         9% of comatose head injuries
         Lenticular lesion, usually arterial
   Subdural haematoma
      30% of severe head injuries
      Cover entire hemisphere, usually venous
   Intracerebral haematoma or contusions
      Usually frontal and temporal and associated with subdural
   Diffuse “concussion”
      Mild, classical and diffuse axonal injury

Management
Mild
   80% of head-injury presentations
   All require CT scan if any LOC, amnesia or headache
   Skull x-rays only for penetrating injury
   Usual cervical spine x-rays, blood tests etc.
   Avoid narcotics
   12 hours of observation (can be at home) even if normal CT
   Discharged only if asymptomatic, uninjured, living nearby and in the company of a responsible adult

Moderate
   10% of head-injury presentations
      10 - 20% will deteriorate
   History
   Examination
   Investigations
      CT head (40% abnormal), baseline bloods
   Surgery if indicated (8% on CT scan)
   Admission for observation
      Repeated examination and CT if any deterioration
Severe

10% of head-injury presentations

ABCDE

Hypotension and hypoxia are associated with 75% mortality

Require rapid resuscitation

- Early intubation, moderate hyperventilation (PCO₂ 25-35 mmHg)
- Maintenance of cerebral perfusion pressure
- Management of other injuries as indicated
- Priority of CT versus DPL/US depends on response to fluid resuscitation: poor response → DPL/US first

High incidence of other injuries

- Long bone or pelvic fracture 32%
- Mandible or maxillary fracture 22%
- Major chest injury 23%
- Thus detailed secondary survey

Neurologic examination

- GCS and pupils at least prior to relaxation
- Serial examinations over time, recording best responses on each side

Diagnostic procedures

- Emergency CT scan unless precluded by instability
- Looking for lesions and midline shift

Medical management of head injury

- 36% mortality for severe head injury
- IV fluids: maintain euvoalemia with saline or Hartmann’s (not glucose)
- Maintain perfusion pressure ≥70 mmHg
- Moderate hyperventilation: PCO₂ 25-35 mmHg
- Mannitol for oedema if normotensive
- Frusemide and anticonvulsants with surgical consultation
- Steroids and barbiturates probably not beneficial

Surgical management

- Scalp laceration without underlying fracture
  - Closed after shaving and irrigation
- Depressed fracture
  - Elevated surgically if depressed more than the skull thickness
- Mass lesions
  - Transfer to neurosurgical unit
  - Emergency burr holes by a non-specialist are rarely justified
Spine and Spinal Cord Trauma

Epidemiology

450 spinal injuries per year in Australia, 2% mortality

Level of injury

<table>
<thead>
<tr>
<th>Level</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>C4-7</td>
<td>48%</td>
</tr>
<tr>
<td>T3-6</td>
<td>13%</td>
</tr>
<tr>
<td>T10-12</td>
<td>18%</td>
</tr>
<tr>
<td>Other</td>
<td>21%</td>
</tr>
</tbody>
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Classification of injury

Level

The most caudal segment with normal sensory and motor function

Dermatomes

- C5: deltoid
- C6: wrist extension
- C7: elbow extension
- C8: middle finger flexion
- T1: finger abduction
- L2: Hip flexion
- L3: Knee extension
- L4: Ankle dorsiflexion
- L5: Toe extension
- S1: Ankle plantar flexion

Myotomes

Disters from bony level of injury

Severity

- Complete, incomplete

Cord syndromes

Central cord

- Anterior spinal artery compromise
- Usually cervical extension injury
- Upper limb weakness > lower limb

Anterior cord

- Anterior spinal artery infarction
- Pain and temperature sensation loss, paraplegia
- Intact vibration, proprioception

Brown-Sequard

- Cord hemisection
- Ipsilateral motor and vibration/proprioception loss
- Contralateral pain and temperature loss two segments lower

Morphology

- Fracture, fracture dislocation, SCIWORA, penetrating injury
- Stable or unstable (all assumed to be unstable)

X-ray evaluation

Cervical spine

- Must see BOS to T1
- May require lateral and swimmer’s views: 85% sensitivity for fractures
- Addition of AP and open-mouth views: 92% sensitivity
- Addition of oblique views: slight ↑ in sensitivity
- CT scan if unable to see low vertebrae or injury suspected
- 10% of cervical spine fractures have a second vertebral fracture
- To detect spinal cord compression: MRI or CT myelography

Thoracic and lumbar spine

- AP views routine
- Lateral or CT if injury suspected

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Management

Rules for cervical spine

Paraplegia or quadriplegia suggests cervical instability.
Alert, normal and pain-free patients can be cleared if full-range voluntary movement is pain-free.
Alert, normal patients in pain need lateral, AP and open-mouth films. If a flexion lateral film is also of good quality and clear there is no need for CT.
Unconscious or confused or uncommunicative patients require AP, lateral and, if possible, open-mouth films before assessment by a surgeon before being cleared.
If there is doubt, the collar should be left on.
Neurosurgical or orthopaedic referral is required for all suspected injuries.
Paralyzed patients should be removed from a backboard as soon as practicable.
Never force the neck.
If operation is required prior to clearing the neck, the collar should be left on.
Assess the cervical spine x-rays for
  Bony deformity
  Fracture of the vertebral body or processes
  Loss of alignment
  Increased distance between spinous processes
  Narrowing of the canal
  Increased prevertebral soft-tissue shadow

Immobilization

A semirigid collar does not ensure immobilization.
A collar, backboard, tape and straps should be applied before definitive transfer.
Sedation, paralysis and intubation may be required to maintain immobilization.
Two-handed technique for cricoid may reduce cervical spine movement

Steroids

Not used in Australia for spinal cord injury
Musculoskeletal Trauma

Primary survey
- Occur in 85% of trauma patients
- Major importance in primary survey is haemorrhage
  - Control with local pressure

Fracture immobilization
- Aim to reduce fracture, minimize pain and bleeding
  - Not more important than ABCDE

X-rays
- Obtained when convenient
  - AP pelvis is indicated early in multi-trauma

Secondary survey

History
- Detail of mechanism of injury: time, force...
- Environment: temperature, poison, fragments, contamination
- Preinjury status: AMPLE...
- Prehospital observations

Physical examination
- Complete exposure
- Detection of life-threatening, limb-threatening and other injuries
- Systematic examination: skin, neuromuscular, circulation, skeletal and ligamentous
  - Look, feel, pulses/circulation, x-ray

Potentially life-threatening extremity injuries

Major pelvic disruption with haemorrhage
- Falls, motorcycle or pedestrian accidents are associated with ring-opening injuries: sacroiliac disruption and major haemorrhage
- Motorcar accidents are associated with lateral force injuries with genitourinary injury and less incidence of haemorrhage

Signs
- Progressive swelling or bruising
- Failure to respond to fluid resuscitation
- Signs of urethral injury
- Mechanical instability
- X-ray findings

Management
- Haemorrhage control with immobilization ± PASG
- Rapid fluid resuscitation
- Early surgical consultation

Major arterial haemorrhage
- Penetrating or blunt injury with fracture or dislocation
- Signs of ischaemia or haematoma

Management
- Direct pressure
- Fluid resuscitation
- Surgical consultation

Crush syndrome
- Prolonged crush injury to muscle causes rhabdomyolysis
- Signs: dark urine, hypovolaemia, acidosis, hyperkalaemia, hypocalcaemia, DIC
- Management fluid loading, osmotic diuresis, urinary alkalination
Limb-threatening injuries

Open fractures and joint injuries
Communication between external environment and bone
Management sterile dressing, examination of soft-tissue, circulatory and neurological involvement, surgical consultation
Tetanus prophylaxis

Vascular injuries, traumatic amputation
Suggested by circulatory insufficiency associated with limb trauma
May result from circumferential dressings or casts
Urgent surgical revascularization
Replantation is indicated only in isolated limb injuries, not in patients requiring intensive resuscitation
Amputated part is washed in Hartmann’s, wrapped in penicillin-soaked gauze and transported on crushed ice

Compartment syndrome
Caused by injury within a closed fascial space or external compression
Compartment pressure exceeds perfusion pressure
High risk: tibial and forearm fractures, tight dressings or casts, severe crush injuries, interstitial oedema due to reperfusion, increased capillary permeability or exercise
Signs
Unexpectedly severe pain, worse with stretching
Dysfunction of nerves in the compartment
Tense swelling
Weakness and loss of pulses are late signs
Compartment pressure >35-45 mmHg
Management
Removal of dressings or casts
Fasciotomy if no improvement over 30-60 min.

Neurologic injury secondary to fracture dislocation
Assessment of nerve function requires a cooperative patient
Documentation of progression of disability and repeat examination is important, especially after reduction manoeuvres (table below)

Other extremity injuries
Contusions and lacerations
Examine for associated injury
Superficial injury from crushing or degloving may be minor
Tetanus risk increased: >6 h old, abraded, >1 cm deep, due to burn, cold or missile, contaminated

Joint injuries
May not be associated with fractures
Hyperextension or hyperflexion soft tissue injury
Examine for associated nerve or vessel damage
Immobilize

Fractures
Usually associated with soft tissue injury
Clinical examination to make diagnosis, accompanied by x-rays in two planes
Joint above the injury must also be x-rayed
Examine for associated nerve or vessel injury
Immobilize
<table>
<thead>
<tr>
<th>Nerve</th>
<th>Motor</th>
<th>Sensation</th>
<th>Injury</th>
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</thead>
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<tr>
<td>Ulnar</td>
<td>Index finger abduction</td>
<td>Little finger</td>
<td>Elbow injury</td>
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<tr>
<td>Median (distal)</td>
<td>Thenar opposition</td>
<td>Index finger</td>
<td>Wrist dislocation</td>
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<tr>
<td>Median (anterior interosseous)</td>
<td>Index tip flexion</td>
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<td>Supracondylar fracture of humerus</td>
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<tr>
<td>Musculocutaneous</td>
<td>Elbow flexion</td>
<td>Lateral forearm</td>
<td>Anterior shoulder dislocation</td>
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<tr>
<td>Radial</td>
<td>Thumb, finger MCP extension</td>
<td>1st dorsal web space</td>
<td>Distal humeral shaft, anterior shoulder dislocation</td>
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<tr>
<td>Axillary</td>
<td>Deltoid</td>
<td>Lateral shoulder</td>
<td>Anterior shoulder dislocation, proximal humerus fracture</td>
</tr>
<tr>
<td>Femoral</td>
<td>Knee extension</td>
<td>Anterior knee</td>
<td>Pubic rami fractures</td>
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<tr>
<td>Obturator</td>
<td>Hip adduction</td>
<td>Medial thigh</td>
<td>Obturator ring fractures</td>
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<tr>
<td>Posterior tibial</td>
<td>Toe flexion</td>
<td>Sole of foot</td>
<td>Knee dislocation</td>
</tr>
<tr>
<td>Superficial peroneal</td>
<td>Ankle eversion</td>
<td>Lateral dorsum of foot</td>
<td>Fibular neck fracture, knee dislocation</td>
</tr>
<tr>
<td>Deep peroneal</td>
<td>Ankle/toe dorsiflexion</td>
<td>Dorsal 1st to 2nd web space</td>
<td>Fibular neck fracture, compartment syndrome</td>
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<tr>
<td>Sciatic</td>
<td>Plantar flexion</td>
<td>Foot</td>
<td>Posterior hip dislocation</td>
</tr>
<tr>
<td>Superior gluteal</td>
<td>Hip adduction</td>
<td></td>
<td>Acetabular fracture</td>
</tr>
<tr>
<td>Inferior gluteal</td>
<td>Gluteus maximus hip extension</td>
<td></td>
<td>Acetabular fracture</td>
</tr>
</tbody>
</table>

Physical Examination

Look

- Age, sex
- Wounds, deformity, position
- Colour of extremities
- Spontaneous activity: evidence of pain or paraplegia
- Urine colour

Feel

- Palpate pelvis for instability
- Peripheral pulses and capillary refill
- Muscle compartment palpation
- Joint stability
- Neurological examination: sensory and motor
Injuries Due To Burns And Cold

Immediate management

ABCDE

Airway

Immediate intubation if inhalational injury likely
Facial burns, eyebrows or nasal hair singed, acute inflammation or carbon deposits in mouth, carbonaceous sputum, history of confinement in burning environment, explosion with burns to head or torso, COHb > 10%

Stop the burning process
Remove all clothing, chemical residue
Rinse with water

Intravenous access
Required if burns > 20% of BSA
Large bore, upper limb preferable, unburned area preferable

Assessment

History
AMPLE history, tetanus status

Examination
Area burned
“Rule of nines” for adults, modified for children
Adult: head, arm, half of leg, quarter of torso = 9%
Infant: head = 18%, half of leg = 7%
Palm excluding fingers = 1%

Depth of burn
First degree
Erythema, pain, no blisters e.g. sunburn
Second degree, partial thickness
Red or mottled, blisters, weeping, hypersensitive
Third degree, full thickness
Dark and leathery, painless, dry

“Major” burns
>10% full thickness or >25% partial or inhalational injury

Stabilization

Airway
Early intubation if any suggestion of inhalational injury

Breathing
Injury mechanisms
Thermal injury
Upper airway oedema, obstruction
Inhalation of smoke and toxins
Tracheobronchitis, oedema, pneumonia
CO poisoning
< 20% COHb asymptomatic
20-30% headache and nausea
30-40% confusion
40-60% coma
> 60% death
Treat with high FiO₂ (hyperbaric if pregnant)

Circulation
IV access and IDC required for management
Aim for urine output 1 ml/kg/h in children, 30-50 ml/h in adults
Initial fluids
Hartmann’s 2-4 ml/kg/%burn over 24 h

Trauma & Resuscitation 3.J.1.23 James Mitchell (December 24, 2003)
Half given in 8 hours, half in next 16
Plus acute losses and fasting requirements
Adjust according to urine output, vital signs

Examination
- Document extent and depth of burns
- Assess for associated injuries
- Weigh patient

Investigations
- FBE, XM, ABG (COHb), glucose, U&E, ßhCG if indicated

Adjuncts to initial management
- Assessment of limbs with circumferential injury for circulatory compromise, escharotomy if necessary
- NGT insertion for gastric stasis and nausea initially
  Later may be required for hyperalimentation
- Analgesia with IV narcotic or ketamine
  Small graduated doses, as circulation is centralized in shock
  May worsen hypotension, hypoxia if not adequately resuscitated
- Dress burns with clean linen
- Prevent hypothermia

Special burns
- Chemical injury
  Alkali, acid or petrochemical burns
  Alkali burns are generally the most serious
  Remove all traces of chemical and irrigate
  Burns to the eye may require continuous irrigation

- Electrical burns
  Frequently small entry and exit burns with extensive deep tissue injury underlying
  Rhabdomyolysis common
  Manage the same except
  High index of suspicion of rhabdomyolysis, cardiac injury
    ECG monitor, urine colour observation
    Osmotic diuresis ± alkalinization of urine
Trauma in Women

Alterations in pregnancy

Uterus
- Intrapelvic until week 12, thick-walled, embryo well cushioned
- At umbilicus by week 20
- At costal margin at week 34-36, thin-walled, vulnerable to injury
- Protects bowel from blunt trauma
- High risk of placental abruption with trauma

CVS
- ↑ blood volume, ↓ Hb, ↑ WCC (15-25,000 mm$^3$), ↓ albumin (22-28 g/l)
- ↑ CO (by 1-1.5 l/min), ↑ HR (10-15/min), ↓ BP (5-15 mmHg), ECG LAD

Resp
- ↑ MV, ↓ PCO$_2$, ↓ RV, FRC

Other
- ↑ gastric emptying time
- ↑ RBF, GFR, uterine compression of ureters
- ↑ pituitary size
- ligamentous laxity

Assessment and management

Primary survey and resuscitation

Mother
- Usual ABCDE
- Except left lateral tilt with uterine displacement unless spinal injury suspected
- Vigorous fluid resuscitation to prevent uterine vasoconstriction and fetal hypoxia
- Indicated x-rays must be performed, risk to fetus is low

Fetus
- Good maternal resuscitation is good fetal management
- Assessment by abdominal examination
  - Signs of uterine rupture
  - Signs of abruption
- Fetal heart sounds, ultrasound, CTG

Secondary survey
- Usual, including DPL or ultrasound
- Except DPL must be above the umbilicus
- Additional attention to uterine contraction, obstetric pelvic examination
- Admission and fetal monitoring is required for even minor injuries

Specific conditions

Uterine rupture
- Massive haemorrhage and shock if severe
- Abnormal fetal position, extended limbs, free intraperitoneal air
- Laparotomy required if rupture suspected

Abruption
- Leading cause of fetal death after trauma
- Vaginal bleeding, pain, uterine rigidity, shock
- 30% show no external bleeding

Amniotic fluid embolism
- Hypotension, hypoxia, DIC

Fetomaternal haemorrhage
- Fetal anaemia and death
- Maternal isoimmunisation (use anti-D even if Kleihauer negative)

Perimortem Caesarean section
Indicated after 4-5 minutes of failed acute resuscitation