

## Epidemiology

### *Trimodal trauma mortality time-line:*

- Immediate-1hr peak - 50% e.g. brain, SC, laceration major vessel or heart
- Second peak - 30% early, around 3hrs, e.g. blood loss, may be preventable with early resuscitation and definitive operative intervention
- Third peak - late (3 wks), 20% e.g. sepsis, multi-organ failure, ARDS, diffuse brain injury
- ~5% of all deaths (MVA & trauma suicide biggest contributors)

### *Poor prognostic predictors in elderly:*

- Base excess < -6 assoc with 66% mortality
- GCS<8 for 72h
- Trauma score<7
- Admission resp rate<10/min

### *Prevention*

- Seat belts (by law) & air bags
  - 3 point belt and airbag 50% reduction in mortality
  - 3 point belt 45% reduction in mortality
  - Airbag alone 13% reduction in mortality
    - NB Air-bag injuries: 95% minor (blunt trauma/burns to face, arm, chest)
    - RF Air-bag injuries: children, short-stature, forward positioned seat
- Reduce young, inexperienced or elderly drivers
  - Higher driving test age
  - Retest older drivers
  - Longer P plates
- Reduce EtOH & drugs - RBT, stronger penalties, public campaigns
- MBA helmet
  - 40% decrease in fatal head injuries,
  - 15% reduction in non-fatal head injuries
- Bicycle helmet
  - 63-85% reduction in risk of severe head, brain injury

### *Gender*

- Male>Female

## Mechanisms

### *Commonly:*

- Road related: MVA, MBA, Pedestrian vs MV
- Fall from height
- Assault

### *Patterns of injury*

#### *MVA Frontal impact*

- Face # lac, C-spine, chest ant flail, pneumo, aorta, myocardial contusion, abdo liver and spleen, pelvis post dislocation hip

#### *MVA Side impact*

- Face #, c-spine lateral elements, chest lateral flail, pneumo, abdo liver and spleen, pelvis # esp acetabulum

## MVA Rear

- C-spine hyperextension

## MVA Ejection

- All

## Pedestrian vs MV

- Head, chest, abdo, pelvis, lower limb

## Fall from height

- 50% survival 15m (4 storeys), 10% survival 30m

## Landing on feet

- Calcaneal, thoraco-lumbar, retroperitoneal, intracranial

## Trauma Team

### Medical

Trauma team leader

Airway doctor

Breathing/Proc doctor

Circulation doctor

### Nursing

Nursing Team leader

Airway nurse

Circulation nurse

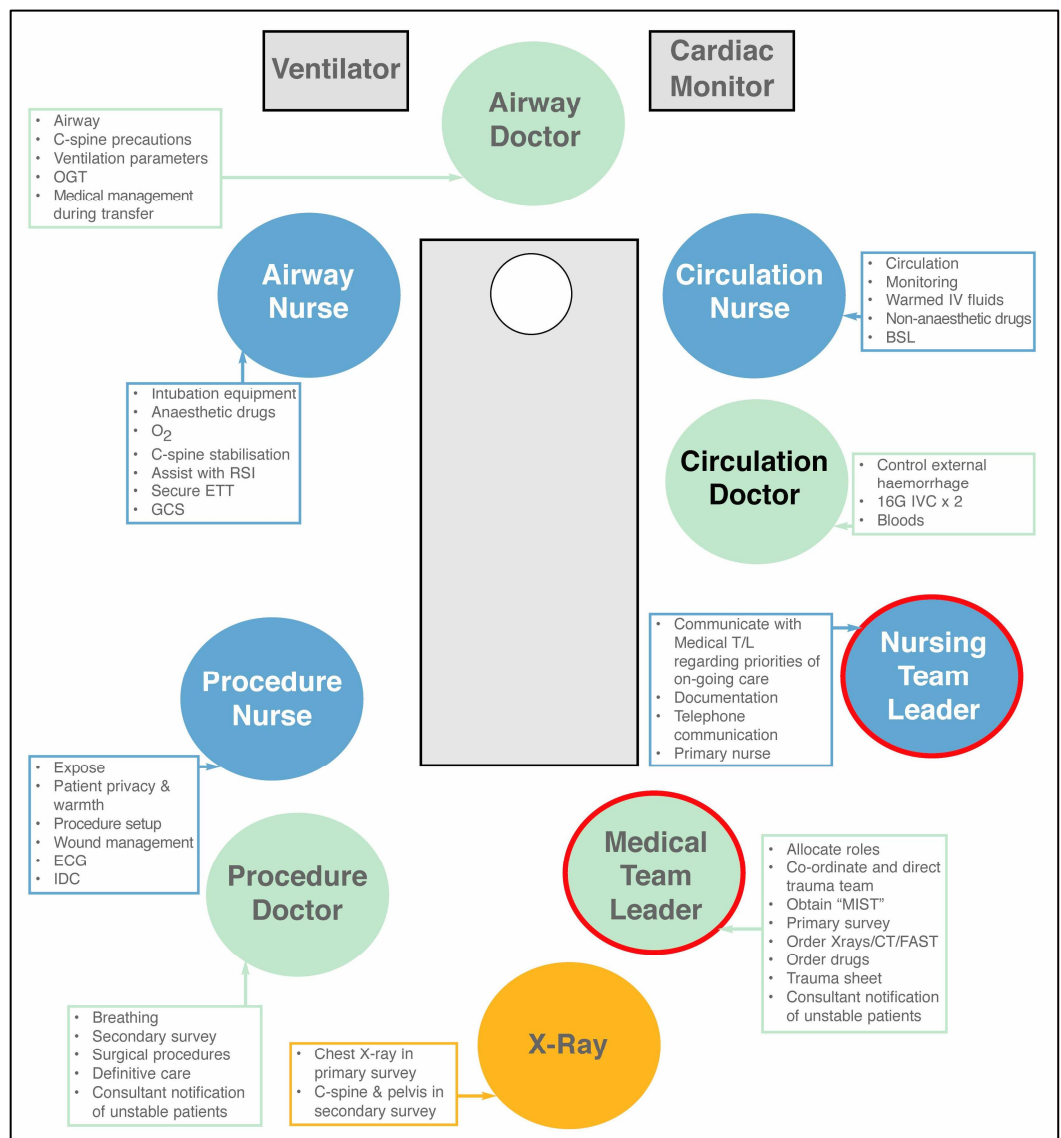
Procedure nurse

Scribe

### Other

Radiographer

±Social worker



## Activation

May be single tier or two tier systems (e.g. Alert vs Respond). Criteria institution-dependent.

- Potentially life threatening injuries
- Multiple or complex injuries
- Injuries requiring urgent or immediate surgery

## Mechanism

- MVA + ejection, roll-over, fatality, MV major deformity, >60km/h, extrication >30min
- MBA, bicycle, pedestrian >20km/h
- Fall 3m (child ?1m)
- Inter-hospital trauma transfer
- Other: explosion, hanging, drowning

## Injuries

- Any evidence of airway obstruction or compromise
- Penetrating injury
- Flail chest
- Suspected spinal cord injury
- Multiple body region injuries
- Multiple long bone or pelvic fractures
- Severe maxillofacial injuries
- Traumatic amputation or crush injury to torso or limb proximal to wrist or ankle
- Burn greater than 20% BSA associated with trauma

## Signs

- GCS <14 (<15 if >65y) or fitting,
- RR <10 or >29
- BPsys<90(<100 if >65y)
- HR>130 or <50

## Demographics

- High risk demographic
  - Age <5 or >55, pregnant, immuno-suppressed, cardiac, resp, liver, diabetes, obesity

## Trauma Centres

- In USA, state based trauma systems associated with improved outcomes across pop - Not in Aus as lower pop, rel large distance to hospital and different mechanism frequency
- Care at trauma centres theoretically is better than smaller hospitals due to better staff and facilities but this is difficult to measure
- ATRAX - Australia wide trauma database

## Advantages

Staff: Higher case load, experience, increased interest, surgical reg in hospital, trauma surgeon/ director, trauma CNC

Equipment: ED USS, trauma beds, maintained trauma resources - difficult airway, ICC, cut down, Philadelphia collars, paed equipment, ventilators, helipad

Drugs: Blood products, novo-seven

Procedures: FAST, DPL, cut down, paed airway

Services: Radiology - XR, CT, angio, MRI  
OT - neurosurg, cardiothoric, paed  
HDU/ ICU

Protocols: Trauma team activation, trauma team roles, disaster, chain of command

Education: Trauma meeting, M and M, trauma data collection, quality assurance

## Disadvantages

Pre-hospital: Increased times to trauma centre, patients may arrive by private transport to non-trauma centre, less available hospitals to see trauma in disaster, needs pre-hospital system to care for patient for longer time period

Staff: Less deskilled staff at non-trauma hospitals, because low case volume

Equipment: Diversion of resources away from non-trauma

Patient: Patient further from family, lack of community consultation

## Management Principles

### Pre-arrival preparation

- Trauma Team activation
- Other notifications:
  - Trauma Surgeon if GSW torso or  $\geq 3$  simultaneous trauma activations
  - Neurosurg Reg if sev HI
  - OT & Cardiothracic Reg if penetrating chest trauma,
  - Security if psychotic, violent behaviour
- Resuscitation bay cleared & prepared (Bair hugger, fluid warmer, airway & IVC trolleys)
- All Trauma Team members wearing PPE (gowns, gloves, goggles), TTL in lead gown
- TTL briefs Team of expected patient details and anticipated course of action
- Team members allocated roles, appropriately identified and introduced

### Arrival

- Patient transferred to the trauma bed on arrival
- TTL takes handover from CDA in MIST format (<60seconds allowed)
  - Time of injury
  - Mechanism
  - Injuries
  - Signs & Symptoms - vitals
  - Treatment so far incl drugs, fluids
- *If patient unstable then Primary survey takes precedence over CDA handover.*

### Primary Survey

#### Priorities:

- Seek & treat life-threatening ABC conditions
  - e.g. cardiac arrest, airway obstruction, tension pneumothorax, haemorrhagic shock
- Perform resuscitative measures
  - A - ETT, B - CXR, chest drain, C- direct pressure, stapling of bleeding scalp wounds, Pelvic X ray, FAST, pelvic sling, arrange OT, resusc thoracotomy
- Determine need for urgent operative or angiographic intervention and summon the appropriate expertise
  - Chest injury - thoracotomy if penetrating injury, gross deformity, haemothorax, or widened mediastinum
  - Abdomen - laparotomy if penetrating injury, distension, tenderness and bruising
  - Pelvis - pelvic embolisation or external fixation if grossly unstable, scrotal or perineal haematoma

#### Primary Survey commences immediately as Nursing staff cut off clothes & attach monitoring

- A: check clear/patent, O<sub>2</sub>, collar. May need Guedel, in-line control, ETT/surg airway, vent.
- B: check for difficulty breathing, trachea central, air entry, chest wall. May need needle thoracostomy, drain, open pneumo dressing.
- C: direct pressure dressings, 2x16IVC, bloods, EtOH level, fluids. May need pelvic sling.
- D: GCS/AVPU, pupils, gross peripheral motor function, BSL

#### Outcomes:

- Primary Survey results to TTL
- Resuscitative procedures initiated
- Severe HI: intubated <10min or immediately+mannitol/phenytoin if asymmetric pupils
- TTL determines initial Mx plan (by 15min) and any orders for XR, OT, blood bank

## Decisions:

- ?Haemodynamic unstable (pale/sweaty or SBP<90mmHg or HR>130bpm or needs bld prod)
- Classic classes of shock (may not be as useful for assessing loss as once thought):

Shock Class/Grade	0	1	2	3	4	Moribund
Blood loss (%)	0	<15	15-30	30-40	>40	>50
~Vol for adult (ml)	0	<750	750-1500	1500-2000	>2000	>2500
Fluid bolus	Not req	Unlikely to be req	Req + good response	Req recurrent	Unresp to boluses	Unresp
Surgical intervention	Not req	Not req	Not req	Likely req	Immed req	?ED thoracotomy
HR	Normal	<100	>100	>120	>140	>140 or brady
sysBP	Normal	Normal	Normal	Decreased	Decreased	Falling
Pulse pressure	Normal	Normal or ↑	Decreased	Decreased	Decreased	Decreased
RR	12-18	14-20	20-30	30-40	>35	>35
Mental state	Calm	Sl. Anxious	Mild anxiety	Anxious, confused	Confused, lethargic	Moribund

- Try to avert the lethal triad of hypothermia, coagulopathy and acidosis
- ?Trauma Surgeon - notified if, at any time:
  - SBP <90mmHg measured in the resuscitation bay
  - Requiring blood products during resuscitation
  - Gunshot wound to the torso or neck
  - Three or more simultaneous trauma activations
  - Consensus not achieved with regards to definitive care or ongoing management
- ?Blood bank - if clearly needs blood products for O neg and urgent XM x6 + 4xFFP
- ?OT
  - SBP<70mmHg
  - Penetrating neck wound with airway compromise or arterial extravasation
  - Penetrating chest wound to cardiac box & haem unstable
  - Any chest injury with initial drain output >1.5L or >200mL/hr
  - Sig penetrating or haem unstable/FAST +ve blunt abdominal trauma
  - Any gunshot wound to the abdomen/chest
  - Blunt abdominal injury + hypotension unresponsive to the initial bolus of IV fluid
- ?CT will be needed
  - Head - altered mental state, GCS<15, evidence of major external head injury
  - C-spine - High risk, inadequate XR, having urgent head CT
  - Chest - unexplained central CP, multiple rib fractures, haemothorax, abnormal CXR, patients going for head and abdominal CT
  - Abdominal/Pelvic - AP/tenderness, gross haematuria, major pelvic #, seat belt sign, penetrating flank, groin or UQ injuries, (ant penetrating injuries most likely require OT) and multiple orthopaedic injuries
    - Give contrast by NG or PO if alert and won't delay scan.
    - Oral contrast not abs req to Dx haemoperitoneum, active intravenous contrast extravasation, & solid organ injury.
    - Hollow viscus injury rare & difficult to Dx even with oral contrast.
  - Head/C-Spine/Chest/Abdomen/Pelvis - alert or intubated patients with multiple system injuries, haem unstable & intubated, significant mechanism

## Initial Imaging

- Radiographer completes necessary Trauma X ray series
- TTL performs a FAST
- All done within 30min of arrival time



## Secondary Survey

### Aims

- Document abdominal & superficial injuries
- Determine the need for further imaging
- Determine adjunctive treatment
  - Analgesia
  - Limb splinting
  - ADT
  - Antibiotics for open fractures
  - Indwelling catheter and NG tubes
  - Core temperature if haemodynamically unstable
- AMPLE history if available
- Full exposure & log roll
- Rectal exam - only +ve in 6% and if not >65y or urethral meatal blood or abnormal neurology then <1% are true +ve - consider if ?SCI, pelvic#, urethral disruption
- Surgical Registrar completes secondary survey
- TTL briefs ALL Trauma Team members with definitive management plan

### Disposition

- X rays & other blood invs completed and checked
- Cervical spine clearance and further assessment if indicated
- Appropriate supportive care and adjuncts are given -e.g. analgesia, ADT, antibiotics
- Clock should be <45min from arrival
- Patient prepared for transfer to Radiology Department for CT or definitive care
  - OT not CT if Grade 4 shock (SBP <70-80mmHg bleeding unresponsive to fluid Rx).
  - Grade 3 shock (hypotension responsive to recurrent fluid boluses) may go in consultation with Trauma Surgeon if full support and monitoring available.
- TTL determines when individual team members can leave
- Management plans to patient and family members
- Documentation completed

## Massive Transfusion Protocol

### Principals:

- Send XM, Coags, FBC, VBG
- 1:1:1 PRBC:plt:FFP per 6h
- Early tranexamic acid
- Cryoppt every 2<sup>nd</sup> PRBC
- Rare use of factor VIIa
- Maintain:
  - T >35°C
  - pH >7.2
  - BE >-6
  - lactate <4
  - iCa<sup>2+</sup> >1.1mmol/L
  - Plt ≥50 × 10<sup>9</sup>/L
  - INR <1.5
  - APTT <1.5x Norm
  - Fibrinogen ≥ 1.0g/L

Suggested criteria for activation of MTP									
<ul style="list-style-type: none"> <li>• Actual or anticipated 4 units RBC in &lt; 4 hrs, + haemodynamically unstable, +/- anticipated ongoing bleeding</li> <li>• Severe thoracic, abdominal, pelvic or multiple long bone trauma</li> <li>• Major obstetric, gastrointestinal or surgical bleeding</li> </ul>									
<b>Initial management of bleeding</b> <ul style="list-style-type: none"> <li>• Identify cause</li> <li>• Initial measures:               <ul style="list-style-type: none"> <li>- compression</li> <li>- tourniquet</li> <li>- packing</li> </ul> </li> <li>• Surgical assessment:               <ul style="list-style-type: none"> <li>- early surgery or angiography to stop bleeding</li> </ul> </li> </ul>	<b>Resuscitation</b> <ul style="list-style-type: none"> <li>• Avoid hypothermia, institute active warming</li> <li>• Avoid excessive crystalloid</li> <li>• Tolerate permissive hypotension (BP 80-100 mmHg systolic) until active bleeding controlled</li> <li>• Do not use haemoglobin alone as a transfusion trigger</li> </ul>								
<b>Specific surgical considerations</b> <ul style="list-style-type: none"> <li>• If significant physiological derangement, consider damage control surgery or angiography</li> </ul>	<b>Special clinical situations</b> <ul style="list-style-type: none"> <li>• Warfarin:               <ul style="list-style-type: none"> <li>• add vitamin K, prothrombinex/FFP</li> </ul> </li> <li>• Obstetric haemorrhage:               <ul style="list-style-type: none"> <li>• early DIC often present; consider cryoprecipitate</li> </ul> </li> <li>• Head injury:               <ul style="list-style-type: none"> <li>• aim for platelet count &gt; 100 × 10<sup>9</sup>/L</li> <li>• permissive hypotension contraindicated</li> </ul> </li> </ul>								
<b>Cell salvage</b> <ul style="list-style-type: none"> <li>• Consider use of cell salvage where appropriate</li> </ul>	<b>Considerations for use of rFVIIa<sup>b</sup></b> <p>The routine use of rFVIIa in trauma patients is not recommended due to its lack of effect on mortality (Grade B) and variable effect on morbidity (Grade C). Institutions may choose to develop a process for the use of rFVIIa where there is:</p> <ul style="list-style-type: none"> <li>• uncontrolled haemorrhage in salvageable patient, <u>and</u></li> <li>• failed surgical or radiological measures to control bleeding, <u>and</u></li> <li>• adequate blood component replacement, <u>and</u></li> <li>• pH &gt; 7.2, temperature &gt; 34°C.</li> </ul> <p>Discuss dose with haematologist/transfusion specialist</p> <p><sup>b</sup>rFVIIa is not licensed for use in this situation; all use must be part of practice review.</p>								
<b>Dosage</b> <table border="0"> <tr> <td>Platelet count &lt; 50 × 10<sup>9</sup>/L</td> <td>1 adult therapeutic dose</td> </tr> <tr> <td>INR &gt; 1.5</td> <td>FFP 15 mL/kg<sup>a</sup></td> </tr> <tr> <td>Fibrinogen &lt; 1.0 g/L</td> <td>cryoprecipitate 3-4 g<sup>a</sup></td> </tr> <tr> <td>Tranexamic acid</td> <td>loading dose 1 g over 10 min, then infusion of 1 g over 8 hrs</td> </tr> </table> <p><small>a Local transfusion laboratory to advise on number of units needed to provide this dose</small></p>	Platelet count < 50 × 10 <sup>9</sup> /L	1 adult therapeutic dose	INR > 1.5	FFP 15 mL/kg <sup>a</sup>	Fibrinogen < 1.0 g/L	cryoprecipitate 3-4 g <sup>a</sup>	Tranexamic acid	loading dose 1 g over 10 min, then infusion of 1 g over 8 hrs	
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# Major Traumatic Haemorrhage

*Haemorrhagic Shock Classes are not always reliable as:*

- Compensation varies for different types of injuries (e.g. blunt versus penetrating trauma)
- Age (e.g. blunted physiological responses in the elderly)
- Comorbidities
- Medications (e.g. beta-blockade may conceal shock by preventing tachycardia)

*Goals in major haemorrhage:*

- Stop bleeding
- Rapid and effective restoration of blood volume
- Maintain blood function: haemostasis, O<sub>2</sub> carrying capacity, oncotic pressure & biochem

*Sources of bleeding*

- **S**calp
- **C**hest
- **A**bdomen
- **L**ong bones (especially femurs)
- **P**elvis
- **E**xternal sources
- **R**etroperitoneum

*Haemorrhage control*

- Find the cause (**SCALPER**)
  - Initial measures, such as: Direct pressure/elevation, adrenaline soaked gauze/haemostatic dressings, reduce/splint long bone and pelvic #, tourniquets.
- Invasive measures, such as:
  - Sutures, tamponade (packing or Foley catheter), tie/clamp off vessels, cautery
  - Interventional radiology
  - Damage control surgery
- Correct coagulopathy

*The lethal triad is:*

- Hypothermia
- Coagulopathy
- Acidosis

*Prevent and treat hypothermia with the following:*

- Aggressive resuscitation with blood products
- Use warmed fluids (e.g. Level 1 Fluid Warmer)
- Bair Hugger or warm blankets
- Minimise exposure
- Increase ambient temperature
- Continuous temperature monitoring

*Further address lethal triad with Damage Control Resuscitation:*

- Permissive hypotension (aka minimal normotension) **if no traumatic brain injury**
  - BPsys 80-100mmHg to avoid excessive fluid administration (with assoc crystalloid hemodilution [Hb, coag factor dilution, cooling, hyperCl acidosis], fluid overload & clot disruption). Alt targets MAP >65mmHg + good radial pulse/SaO<sub>2</sub> waveform.
  - If BP too high, use **fentanyl** 25mcg IV aliquots for sympatholysis + analgesia.
- Early haemostatic resuscitation & massive transfusion protocol
  - See above
- Damage control surgery
  - Limited surgical interventions that control haemorrhage and minimize contamination until the patient able to have definitive interventions.

# Assessment and Management of Major Trauma

## Bat Call

### Preparation

- Activate trauma page
- Inform triage and nursing team leader
- Clear resuscitation bay
- Check equipment - airway trolley, chest drain set, IV trolley, fluid warmer, FAST machine turned on
- Protective gear - blue gown, goggles and gloves on all team members
- Lead gowns on TTL and anaesthetics registrar
- Team members introduced and briefed
- Ensure any necessary early notifications - Trauma surgeon on call, ED consultant, Blood bank, Radiology

### Ambulance Handover (Time Zero)

- If stable, to conduct handover first with other ambulance officer undoing buckles on stretcher. Team to stand back and listen to handover and TTL to start documenting at the end of the bed
- If unstable, immediate transfer onto bed with formal handover after primary survey
- Ambulance officers to remain until at least the completion of primary survey

### Primary Survey (1 Minute Mark)

- Airway - relieve airway obstruction
- Breathing - Start oxygen, auscultate and commence high flow oxygen
- Circulation - Measure BP, pulse. Obtain IV access and bloods, commence IV fluids if haemodynamic instability
- Log roll patient off spine board if patient condition allows, obtain chest and pelvis X rays and get C spine series if indicated as well
- Delegate someone to order the bloods and trauma series
- If patient likely requires intubation or chest drain then inform the radiographer that likely needs repeat X rays

### Ask For Primary Survey Summary

- Definitive measures (3-10 minutes mark)
  - Airway - intubation
  - Breathing - CXR, chest drain, arrange urgent thoracotomy
  - Circulation - Pelvic X ray, pelvic slings, compression, wound stapling, FAST, arrange urgent OT. FAST to be performed during or after X rays

### Ask For Primary Survey Progress And Outline Management Plan To The Team

### Ask The Important Questions And Start Making Telephone Calls (10-15 Minute Mark)

- Is the patient haemodynamically unstable?
- Who do I call for help?
- Should this patient go directly to OT or Interventional Radiology/Angiography?
- What should I scan?



### Transfer To Urgent Definitive Care (15 Minutes Mark)

- Transfer to operating theatres, interventional angiography if urgently required needs to be arranged at this point

### Secondary Survey (15 Minute Mark)

- Performed by the surgical registrar
- Discussion and documentation of findings
- Arrangements for further imaging
- Start documenting in Trauma Assessment Form

*Ask For Secondary Survey Summary And Handover Patient To Surgical Registrar If Requiring Trauma Admission*

### Adjuncts

- Analgesia
- Limb splinting
- Limb X rays
- ADT
- Antibiotics for open fractures
- Indwelling catheter and NG tubes
- Core temperature if haemodynamically unstable
- Check all initial X rays and blood test results, in particular INR - coagulopathy should be identified early and corrected
- Ensure blood alcohol is sent and note serial number in notes
- Notify patient and family of management plan and progress
- Documentation and clinical handover to the general surgical registrar and ICU

### Transfer To CT Scan (45 Minutes Mark)

- Ensure the following are present if any evidence of haemodynamic instability
  - Anaesthetics or ICU registrar
  - Senior Registered Nurse
  - Airway equipment
  - Oxygen tank
  - Monitoring devices and pulse oximetry
  - IV access patent
  - O Negative or X matched blood if available
  - Documentation

### Clinical Handover (60 Minute Mark)

- Documentation of all findings, discussions
- Check results of all imaging and initial blood tests
- Handover to surgical and intensive care registrar
- Ensure all relevant people notified of changes

# Overview of Trauma Drill for Patients in Grade III -IV Shock

## Patients in this category include

- Blunt trauma with multiple torso and limb injuries with frank hypotension SBP <70mmHg and or pre arrest
- Penetrating torso injury with frank hypotension or pre arrest

## Drill

- Protective gowns, gloves, goggles and lead gown
- Notify Trauma Surgeon on call, Operating Theatres and Blood Bank
- Penetrating Chest wounds - contact Cardiothoracics Registrar
- Identify Team roles
- Brief your team about what the plan will be (aim for immediate IV access, X match, O negative blood, X rays performed with bloods and FAST scan)
- On arrival, immediate transfer to the trauma trolley (zero minutes)
- Assess and clear ABC - Clear and protect airway, identify tension and obtain IV access, measure BP and place monitoring leads and start blood transfusion with O negative blood if required
- Maintain SBP 85-90mmHg
- Ensure X match for 10 units of blood and 4 units FFP sent and Blood Bank contacted
- Perform Chest X ray (and pelvic X ray if blunt trauma) (5 minute mark)
- Perform FAST during X rays
- Establish and confirm definitive airway
- If significant chest deformity, pneumothorax or penetrating wound, Surgical Registrar/ICU registrar to insert chest tubes (bilateral if required) and call Cardiothoracic Registrar
- While X rays are being performed decide where the bleeding is most likely to arise from:
  - Chest - haemothorax, penetrating wound in cardiac box, widened mediastinum
  - Abdomen - penetrating wound, distension or bruising, FAST positive
  - Pelvis - gross instability, perineal haematoma
- Contact Trauma Surgeon on call with this information
- Inform entire team and patient of management plan (10 minute mark)

## Decide whether transfer to Operating theatres, CT or Angiography

- Contact Neurosurgical Registrar if severe head injury or vertebral fracture
- Review the X ray results and decide if patient needs further chest tubes or pelvic slinging
- After secondary survey, warm patient with Bair Hugger, space blankets and fluid warmer. Get core temperature and IDC (if time available)
- Establish monitoring, oxygen and other equipment necessary to transfer this patient urgently to definitive care. (15minute mark)
- Check INR and handover all clinical details to the Surgical Registrar, ICU Registrar and Anaesthetics Registrar

## Algorithm for Unstable Trauma Patients

