Contents

General

Crush Injury

- see massive tissue destruction ⟹
  - ↓Ca
  - ↑phosphate
  - ↑K
- Need to treat high potassium
- Avoid Ca - high PO4 will bind Ca ⟹ Ca precipitate in tissues

Neck & Chest

Neck Trauma

Priorities include:

1. securing definitive airway
2. protecting c-spine - esp in blunt trauma
3. diagnosing and managing life threatening injuries

History – AMPLE

Examination
- any neck pain - ?clinical rule out?
- what position has he adopted (sitting up leaning forward, unlikely to be able to lie flat)
- gentle inline immobilisation (probably will not tolerate hard collar)
- examine airway –
  - mouth opening,
  - blood,
  - haematoma,
  - stridor ?getting worse,
  - anatomical landmarks for airway blocks for anaesthesia,
- Neck & Chest exam

Investigations – if time permits
- chest xray
- lateral c-spine xray:
  - Indications:
    - GCS <15
    - >65yr old
    - dangerous mechanism ie 3 feet, collision, high speed, axial load
    - peripheral neuro symptoms
    - normal movement in rotation not possible
- nasal fiberoptic examination
- CT scan

Management
- keep patient breathing!
- call for help (anaesthetic technician, senior anaesthetist, ENT specialist, maxillo-facial specialist, cardiothoracic specialist, intensive care specialist, general surgeon, theatre personnel)
- allow patient to adopt comfortable position
- apply high flow O2
- nebulised adrenaline + IV dexamethasone may buy some time
- transfer patient to theatre (preferably with cardiac bypass available, call perfusionist)

- anti-reflux medications; ranitidine, metoclopramide, Na+ citrate
- glycopyrulate IV to decrease secretions
- surgeons scrubbed and ready to site emergency tracheostomy if airway obstruction occurs
- while preparing to secure airway get someone to insert a femoral vascath for possible femoral-femoral bypass

Securing Airway

Often default = DL with best efforts & earlier surgical airway if needed

1. awake percutaneous crico-thyroid puncture with insertion of an endotracheal tube – anatomy may be too abnormal

- examine neck and attempt to palpate
- apply anti-septic
- infiltrate LA
- make a punch stab through crico-thyroid membrane
- dilate with handle of scapel
- insert a size 6 or 7 cuffed ETT into trachea

2. awake tracheostomy – ENT surgeon may not be comfortable or experienced with this technique, patient will probably not be able to

3. awake direct laryngoscopy after topicalisation – to facilitate intubation, then allow fiberoptic examination of defect, can advance ETT pass the lesion

- topicalise airway with 10% lignocaine (5 sprays)
- insert bite block
- perform laryngoscopy
- topicalise trachea with 4mL of 4% ligocaine with cannula injection
- intubate or place LMA to avoid instrumenting trachea

4. awake fiberoptic intubation – topicalise with LA as you go, cannulate trachea, assess whether trachea normal with bronchoscope, intubate passed defect, may need remifentanil for analgesia, may be limited by blood and debris

- if able use nasal approach
- topicalise with co-phenylcaine forte (5 sprays to each nostril while inspiring)
- 5 sprays of 10% lignocaine to oro-pharynx
- trans-tracheal injection via cannula to crico-thyroid membrane
- insert successive nasopharyngeal airways up to #7.0
- insert fiberoptic scope into naso-pharnyx
- cannulate trachea
- advance #7.0 ETT over scope

5. inhalational induction with cricoid pressure– keep patient spontaneously breathing, may be able to induce sitting upright but laying patient down to intubate may produce airway obstruction

- 2 anaesthetists
- vasoconstrictor + LA to nose
- surgeon scubbed for emergency tracheostomy
- sevoflurane/O2 induction
- sitting up
- proceed slowly
- if become apnoeic -> don't bag -> allow CO2 to rise and then to start spontaneously breathing again
- if obstructs insert nasopharyngeal airway
- once pupils midline and small -> laryngoscopy
- attempt intubation twice only
- if intubation fails -> tracheostomy while breathing spontaneously
- if there is sudden, complete airway obstruction -> immediate tracheostomy or single attempt with rigid bronchoscope

6. urgent femoral-femoral bypass if airway is unsecured and life-threatening hypoxia ensues

7. access to the airway via a median sternotomy or thoracotomy

Blunt PolyTrauma

- can clear Cx spine based on -ve CT scan = EASt guidelines
- may still have ligament injury but are stable injuries
- instrumenting airway:
    - most movement at C1/C2
    - LMA ⟹ post displacement
    - DI ⟹ ant displacement

Manual Inline Stabilisation

- =MILI
- limits C spine movement
- ↓grade view 1-2 for all views
- 25% will be 3-4 view
- slower & more diff to pass tube
- no evidence in VIVO of benefit of MILI
- Max fax trauma = highest failed intubation rate at 20%
- think surgical airway backup
- can combine fibre optic & VL to get view of ETT passing cords

Blunt Chest Trauma

Acute Life-Threatening Injuries

- Blast lung
- Aortic disruption
- Tension PTX
- Open PTX
- Massive haemothroax
- Flail Chest
- Cardiac Tamponade

Acute injuries - Secondary Survey

- Heart:
    - Myocardial contusion
    - Myocardial wall rupture
    - Arrhythmia
    - Acute papillary muscle rupture
    - Acute valve incompetence
    - Septal defects from trauma
    - Coronary artery damage with ischaemia
- Vessel injury:
    - Aortic rupture
    - Aortic dissection
- Lung:
    - pulmonary contusion
    - Simple PTX
    - Rupture of tracehobronchial tree
- Other:
    - Diaphragm Rupture
    - Oesophageal Rupture

Chronic injuries
- Shunts
- Fistulae
- Pericarditis
- Coronary thrombosis

Investigations
1. CXR – looking for
    - widen mediastinum (aortic dissection),
    - globular heart (tamponade),
    - white out (haemothorax from ruptured aorta),
    - Kerley B lines,
    - cardiomegaly,
    - upper lobe diversion,
    - fluid in fissure (acute mitral regurgitation from a papillary muscle rupture)

2. ECG –
    - signs of arrhythmia,
    - regional ischaemia (myocardial contusion),
    - change of axis,
    - ST changes with acute ischaemia from trauma to coronary arteries

3. Troponin – a sensitive marker of myocardial injury

4. Transthoracic Echo –
    - assess valve function, ejection fraction and presence of pericardial tamponade (justified in patient with abnormal ECG or positive troponins or have haemodynamic instability that is unexplained)
    - RWMA - for myocardial contusion

5. Transoesophageal Echo –
    - assessment of aortic arch integrity and better examination for pericardial tamponade,
    - better views of RV which is at risk in this injury

Treatment
- Intercostal chest drain:
    - indications for immediate thoracomtomy =
        - 1500ml bleeding immediately
        - >200ml/hr of bleeding/hr

Individual Chest Injuries

Pulmonary Contusion
- examination; seat belt injury, hypoxaemia, increasing O2 requirements
- investigations; CXR – normal -> patchy infiltrates
- management; CPAP -> ETT + IPPV, lung protective ventilation, cautious fluid therapy

Myocardial Contusion
- history; severe blunt chest trauma
- examination; sternal #, elevated JVP, hypotension
- investigations; arrhythmias, ST changes, elevated CK-MB, TNT, ECHO
- management; rule out tamponade and inotropes

Blunt Aortic Injury
- where mobile arch joins fixed descending aorta

- history; significant deceleration injury
- examination; upper limb hypertension
- investigations;
    - CXR –
        - widened mediastinum,
        - pleural capping,
        - left haemothorax,
        - deviation of trachea to right,
        - depression of left main bronchus,
        - loss of aortic knob,
        - deviation of N/G tube to right,
        - # of upper 3 ribs,
        - fracture of thoracic spine,
    - TOE
    - CTA
- management; control BP with anti-hypertensives, transfer to CTSU

Rupture of Diaphragm

- history; chest and abdominal pain
- examination; respiratory distress, diminished breath sounds,
- investigation;
    - 75% on left,
    - CXR –
        - elevated hemidiaphragm,
        - gas bubbles,
        - shift of mediastinum,
        - N/G tube in chest
- management; surgical repair via a lateral thoracotomy or thoracoabdominal incision, use a DLT with OLV

Oesophageal Rupture

- history; severe blow to upper abdomen, severe chest and abdominal pain
- examination; gastric contents in chest drain
- investigations; mediastinal air, a contrast study will confirm, endoscopy
- management;
    - NBM & broad spectrum Abx
    - urgent surgery to prevent mediastinitis (drainage and prevention of further contamination),
    - chest drain,
    - resuscitation,
    - may need oesophagectomy,
    - enteral feeding early via TPN or jejunostomy tube

Tracheobronchial Injury

- # larynx = rare
- history;
- examination; hoarseness, subcutaneous emphysema, palpable fracture crepitus
- investigation; CT, bronchoscopy
- management - if possible assess first:
    - CT
    - fiberoptically first ->
- induction options:
    - intubate (DLT) or tracheostomy
    - spont vent induction with volatile or propofol
- insertion of large bore chest drains, repair through thoracotomy

Emergency Thoracotomy

Objectives

- relieve cardiac tamponade
- perform open cardiac massage
- occlude aorta to increase blood flow to heart and brain
- control life threatening thoracic bleeding
- control bronchovenous air embolism

Requirements

- ETT
- shock or arrest with a suspected correctable intrathoracic lesion
- specific diagnosis (cardiac tamponade, penetrating cardiac lesion or aortic injury)
- evidence of ongoing thoracic haemorrhage

Accepted Indications

- penetrating injury + arrest + previous signs of life
- no indication in blunt trauma

Relative Indications

- penetrating injury + no signs of life and CPR < 15min

Contra-indications

- penetrating injury + no signs of life or CPR > 15 min
- blunt injury + no signs of life
- multiple blunt trauma
- severe head injury

Technique

1. Full aseptic technique
2. Left anterolateral thoracotomy from sternum (5^{th} intercostals space down to pleura)
3. Insert a self retaining rib retractor
4. Longitudinal pericardotomy incision (anterior to left phrenic nerve) -> evacuate blood, apply digital pressure, repair any significant injury
5. If still hypotensive -> pass a finger anterior to the pericardium and enter right pleural space and assess the chest cavity (if tension pneumothorax or haemothorax suspected -> extend incision into right hemithorax)
6. Can perform bimannual internal cardiac massage if required
7. Occlude descending aorta to increased myocardial and cerebral perfusion (elevate left lung, incise the mediastinal pleura, separate oesophagus from aorta, don't completely incircle aorta as may avulse the thoracic branches of aorta)
8. Transfer to OT for definitive treatment

Circulation

General

- important to differentiate between the patient who has ongoing bleeding and those who has bleed and stopped
- initial and sustained response to an IVF bolus is sensitive
- the actively bleeding patient is exquisitely sensitive to sedatives and analgesics
- 3 key issues:
    - Restrictive crystalloid resus
    - permissive hypotension
    - damage control surgery

Life threatening bleeding sites

CHEST
- ICT for peripheral injuries
- thoracotomy for central injuries + >1500mL or >200mL/hr

ABDOMEN
- unstable -> FAST -> OR
- stable -> CT/embolisation
- always think concealed retroperitoneal haemorrhage

PELVIS
- unstable pelvis on examination, XR and CT -> external compression, embolisation, screw fixation, internal packing

LONG BONES
- initially brisk loss but then tamponades

FLOOR
- from open injuries
- managed with external pressure, reduction and surgical ligation

Damage Control Surgery

= limiting initial surgery to that required to stop ongoing haemorrhage with the deferring of reconstructive surgery until completion of resuscitation.
- benefit = early and definitive haemorrhage control ⟹ better outcomes (maintenance of normothermia, coagulation function, fewer products used)
- Indication:
    - Hypotensive patient
    - Hypothermic
    - Coagulopathic
    - large injuries
    - Acidaemic

- typical patient = unstable patient with +ve FAST scan

1. taken to OT -> opened and 4 quadrants packed with gauze
2. each quadrant examined and haemostasis achieved
3. injured/solid organs fully or partially resected
4. injured bowel stapled off and removed (without reanastomosis)
5. injured vessels ligated
6. diffuse haemorrhage -> packed with gauze + fibrin sealants
7. abdomen covered with a sterile dressing but left open

8. transported to ICU or angio

- patient then taken back to OT 1-2 days later for more definitive care

Haemostatic Resuscitation

Goals:
- restoration of normal fluid volume and tissue perfusion
- preservation and support of normal coagulation

Components:

PERMISSIVE HYPOTENSION
- standard of practice in haemorrhaging patients without traumatic brain injury
- MAP of 60mmHg; SBP 80
- palpable radial pulse only

EARLY RED CELLS TRANSFUSION
- use type O "universal donor" RBC's
- has been found to be safe and effective

EARLY PLATELETS AND PLASMA
- in massive transfusion use 1:1 of plasma:RBC's
- early and aggressive use of FFP is associated with a significant reduction in mortality
- type AB "universal donor" plasma can be kept pre-thawed and immediately available without significant additional expense to Blood Bank

SPECIFIC PRO-COAGULANT THERAPY
- fibrin sealants bandages
- chitosan and zeolate based agents
- rFVIIa
- prothrombin complex concentrates

When to Stop
- normal vital signs
- normal mental status
- no BE
- normal pH
- normal lactate (patients who clear their lactate after initial resuscitation -> associated with better outcomes)
- normothermia

Massive Transfusion
- = replacement of a patients entire blood volume within 24 hours or blood loss >150mL/min

Factor VIIa
- = recombinant protein
- = tissue factor
- factor involved in:
    - initiation of the coagulation cascade
    - platelet aggregation
    - production of platelet-fibrin matrix
    - haemostasis

Pro's to Use

- can be life-saving
- good theoretical basis
- encouraging case reports from use in trauma
- can be administered quickly
- easy to store
- may avoid problems with ongoing transfusion – disease transmission, acute lung injury, TRALI, hypothermia, acid-base disturbance, volume overload
- doesn't carry risk of disease transmission
- acts quickly
- accepted by Jehovah's Witness patients

Con's Against Use

- no evidence for its use
- probable publication bias -> tendency to publish cases where it has produced successful results
- massive transfusion and trauma -> off licence use
- need platelets for rFVIIa to be effective
- expensive
- decreased availability
- requires T >35 C and pH >7.2 for it to be effective
- can produce thrombosis in blood vessels -> ischaemic damage
- need two doses 20min apart
- needs the consent of interested parties (Haematology)
- side effects haven't been fully documented when used in Trauma and Massive Transfusion
- no universal protocol that has been agreed upon

For the above reasons it is a useful drug in the management of Massive Transfusion in a Trauma patient but needs to be used with caution and consultation with other experts.

New Zealand Algorithm

Consider rFVIIa when patient has had:

- 10 RBC
- 8U FFP
- 2U Plts
- 2U Cryoprecipitate
- warfarin has been reversed
- heparin has been reversed
- anti-fibrinolytic agents (transexamic acid) have been considered

At this point if patient is still bleeding there are two options:

1. pH < 7.2 and T < 35 C -> DAMAGE CONTROL SURGERY AND ICU RESUSCITATION

OR

2. pH >7.2 and T >35 C -> give 90mcg/kg of rFVIIa with platelets, wait 20min and repeat

Trauma Induced Coagulopathy

- = lethal triad of :
  - acidosis <pH <7.1
  - Hypothermia <33deg
  - Coagulopathy - dilutional/consumptive

Mechanism

- unproven but thought
  - tissue hypo-perfusion ⟹ ↑regulation of vascular endothelium pathways ⟹ coagulation
  - tissue injury ⟹ massive activation of coagulation ⟹
    - consumption esp factor V & fibrinogen
    - activation protein C pathway
    - ↑fibrinolysis

Pathophysiology

- Inbalance between dynamic equilibrium of
  - pro-coagulant factors - platelets, endothelium
  - Anticoag factors - fibrinolysis
- see inflam response to tissue hypo-perfusion ⟹ inflame mediators ⟹ secondary organ damage
- see specifically:
  - Isolated factor V inhibition
  - Dysfibinogaemia
  - systemic anticoagulation
  - impaired platelet function
  - Hyperfibrinolysis
- is all exacerbated by ↓temp, acidosis & reuse with hypo coagulable fluid

Treatment

- rapid reversal of tissue hypoxia & restoration of blood flow ⟹ ↓SIRS & ↓coagulopathy
- stop haemorrhage
- early transfusion of blood & products:
  - 1 rbc : 1 FFP : 1 platelets
  - Early fibrinogen - in Europe use re-constituted concentrate
- early activation of MTP - cryo now higher in MTP protocol
- use point of care testing to guide products needed -
  - TEG/ROTEM
  - now functional fibrinogen assay available (removes platelet effect from MA)
    ↳ MA <15 = give cryo
- TXA