PRINCIPLES OF VASCULAR TRAUMA
Prof J van Marle

- Trauma is the main cause of death in people < 38 years
- < 10% of poly-trauma patients have vascular injuries
  - But:
    - Significant morbidity
    - Significant mortality
- Incidence and type of trauma differs between societies:
- 1\textsuperscript{st} World:
  - Blunt injuries MVA
  - Iatrogenic
- 3\textsuperscript{rd} World (RSA)
  - Fire arms
  - Stab injuries

1. Mechanism of vascular trauma

1. Blunt Trauma
   - Direct
   - Indirect

2. Penetrating Trauma
   - Stab
   - Missile:
     - Low velocity
     - High velocity
   - Shotgun
   - Bomb blasts

3. Iatrogenic Injury

1.1. Blunt Injury:
   - Direct Trauma is responsible for the majority of blunt injuries
     - Direct blow
     - Contusion by bony fragments
   - Indirect trauma: shearing and distraction injury caused by:
     - Hyperflexion
     - Hyper-extension
     - Hyper-rotation
     - Dislocation of joints
     - Displaced fractures
     - Accelleration-descelleration injuries:
       - MVA
       - Fall from a height
1.1. **Pathophysiology of Blunt Trauma**

The intima is the weakest layer and gives way first, followed by the media and eventually the adventitia when complete disruption occurs.

- **Intima**
  - Intimal tear → Partial obstruction

- **Media**
  - Intramural haematoma
  - Dissection

- **Adventitia**
  - Partial disruption → Pseudo-aneurysm
  - Complete disruption → Bleeding

1.2. **Pathophysiology of Penetrating Trauma:**

- **Complete transection**
  - Retraction
  - Constriction
  - ↓ Flow
  - Thrombus
  - Haemostasis
  - ↓ Pulses
  - Ischaemia

- **Partial transection including penetrating and perforating wounds**
  - Wound gapes open
  - Continuous bleeding
  - Active external bleeding → shock
  - Contained by surrounding tissues:
    - Pseudo-aneurysm
    - (Pulsating haematoma)

Damage can be localised: stab, low velocity gunshot
or
Shotgun → multiple sites of injury
extensive local damage
Bomb blasts → complex injuries: extensive local tissue trauma, high velocity fragments, thermal injury
1.3. **Iatrogenic Injuries**

- The most common type of penetrating vascular injuries found in the first world environment:
  - Invasive monitoring:
    - Central venous lines
    - Intra arterial lines
  - Diagnostic procedures:
    - Coronary angiography
    - Peripheral arteriography
  - Therapeutic procedures:
    - PTA
    - Laparoscopic procedures
    - Injections

2. **Sequelae of vascular injuries**

- Acute haemorrhage
  - Overt external bleeding
  - Contained eg muscle compartment
  - Concealed eg pleural cavity
- Hypovolaemia, shock
- Haematoma ± secondary infection
- Delayed bleeding, rebleeding
- Thrombosis acute, delayed
- Ischaemia acute, delayed
- Arterio-venous fistula
- Pseudo-aneurysm formation

**REMEMBER:**
- An injured artery may initially be patent, but thrombose later
- Propagation of thrombus → progressive obstruction of essential collaterals

**. Beware of delayed ischaemia**

**Therefore: assess regularly**

- Acute ischaemia: → Nerve damage occurs after 4-6 hours
  → Muscle damage after 6-12 hours
  → Damage being irreversible after > 12 hours

The Vascular Injury is Compounded by concomitant:

1. Orthopaedic injuries: fractures dislocations
2. Soft tissue injury: muscles, veins, nerves
3. Injury to the overlying skin
4. Contamination of the wound
3. **Clinical assessment**

3.1. **History:**
- Mechanisms of trauma
- Blood loss prior to admission
- Underlying vascular disease
- Medical co-morbidities

3.2. **Examination:**
- Initial assessment according to ATLS principles and manage life threatening conditions
- Complete vascular and systemic examination

4. **Clinical signs of vascular injury**

4.1. **Hard signs of vascular injury**
- Active pulsatile bleeding
- Shock with ongoing bleeding
- Absent distal pulses
- Symptoms and signs of acute ischaemia
- Expanding or pulsating haematoma
- Bruits/thrills over area of injury
- ABI < 0.9

**Indicative of vascular injury = surgery**

**Signs of acute ischaemia (hard signs!):**
- Pulse deficit (absent/diminished pulse)
- Pain
- Pallor
- Paresthesia
- Paralysis
- Poikilothermia
- Tender, swollen muscle compartments

**6 P’s**

4.2. **Soft signs of vascular injury**
- History of severe bleeding
- Unexplained hypotension
- Injury of anatomically related structure eg. nerve
- Small non-expanding haematoma
- Multiple fractures, extensive soft tissue injury
- Injury in anatomical area of major blood vessel

∴ ↑ index of suspicion

Further investigation to rule out vascular injury
4.3. Assessment of Distal Pulses
- Pulse may be present in significant arterial trauma
- Absent/diminished pulse:
  - Implies arterial occlusion until proven otherwise
  - Should not be diagnosed as vasospasm until arterial injury has been positively excluded!
- Arterial doppler pressure measurements and ankle brachial index (ABI) are an essential part of the clinical examination
  - ABI > 0.9 reliably excludes significant occlusive arterial injury

4.4. The Importance/Value of ABI in Vascular Trauma
- ABI < 0.90: 95% sensitivity, 97% specificity
- ABI > 0.90: 99% negative predictive value for an arterial injury

5. Diagnosis of arterial injury
- Thorough clinical examination (including ABI) accurate in excluding significant vascular injury
- Haemodynamic instability, active bleeding, expanding haematoma requires immediate surgery

6. Special investigations
- Should only be performed in patients who are haemodynamically stable (i.e. adequately resuscitated), and
- Where no clear indication for surgery exists

1. Plain X-rays:
   - Skeletal injuries, fractures, dislocations
   - Chest trauma
   - Penetrating injuries – mark entrance and exit wounds
   - Foreign bodies

2. Arteriography:
   - Indicated for
     - Zone 1+3 neck injuries
     - Thoracic and abdominal injuries
     - Multiple fractures
     - Extensive soft tissue trauma
     - Shotgun injuries
     - Knee dislocations and fractures around the knee
       - Distal femur, proximal tib-fib
   - Only in haemodynamically stable patients
   - Not routinely required in extremity trauma with “hard signs”
     - On-table angiogram can be performed if required
3. **Duplex Doppler:**
   - Extremity vascular trauma
   - Neck zone 2
   - Blunt abdominal trauma

4. **Spiral CT-Scan:**
   - Blunt cervical, abdominal and thoracic injuries

7. **Management of vascular trauma:**
   7.1. **Resuscitation and initial management:**
   Resuscitation of the unstable patient in urgent need of surgery may best be conducted in the OR.
   - Priorities: - Patent airway
     - Effective ventilation
     - Arrest bleeding: Direct pressure
       - Tourniquet
       - No blind clamping
     - Restore blood volume:
     **Hypotensive resuscitation : Systolic BP 70-90mmHg**
   - **Initial Management:**
     1. Immediate management of life threatening conditions eg. tension pneumothorax
     2. Reduction and stabilization of fractures and dislocations
        - To prevent further injury to soft tissues (artery, vein, nerve)
        - May improve blood circulation
     3. Cover open wounds with sterile dressing

7.2. **Principles of vascular repair after injury**
   1. Adequately resuscitated patient
   2. General anaesthesia
   3. Well equipped theatre, proper illumination
   5. Prophylactic antibiotics
   6. Adequate exposure: prepare adjacent anatomical areas
   7. Prepare an uninjured leg for possible vein harvesting if required for bypass
   8. Wide surgical exposure: no key hole surgery
   9. Vascular control proximal and distal to the injury
   10. Bleeding may be arrested with digital compression until clamp has been applied
   11. Debride artery until normal appearing intima is found
   12. Evaluate antegrade and retrograde flow. Use embolectomy catheters if required to remove clot from the distal circulation
   13. Irrigate distal circulation with Heparin – Saline solution
14. Technique of vascular repair:
   • Lateral Suture
   • Close defect with a vein patch
   • Resection with primary anastomosis
   • Resection with interposition graft
     o Autogenous vein
     o Prosthetic material
   • Use of temporary intraluminal shunt
15. Completion Angiography
16. Debridement:
   • Remove all devitalised and contaminated tissue, foreign material, bone fragments, etc
17. Repair associated injuries
18. Contaminated wounds are left open, but cover vascular repair
19. Repeated wound inspections → delayed suturing
20. Fasciotomy as per indication

8. **Post operative management**
   1. General principles regarding trauma patient:
      • Haemodynamic and respiratory support, renal function, blood transfusion, etc
   2. Vascular specific:
      • Check peripheral circulation regularly
        o Pulses, Doppler flow, ABI
      Be aware of
      • Compartment syndrome (where prophylactic fasciotomy was not performed)
      • Measures to prevent reperfusion injury and renal failure due to myoglobinuria

9. **Prognosis of arterial injury**
   Final outcome determined by:
   • Level of vascular injury
   • Quality of the collateral circulation
   • Pre-existing arterial occlusive disease
   • Concomitant injuries: fractures, dislocations, injuries to the veins and nerves, other life threatening injuries
   **NB - TIME DELAY BETWEEN INJURY AND REVASCULARIZATION**
10. **Venous injuries**
   - Often associated with arterial trauma
   - Principles of repair same as for arterial trauma
   - Usually lateral suture repair
   - Complex repair only attempted if:
     - Patient haemodynamically stable
     - It does not delay treatment of associated injuries
     - It does not destabilize the patient
   - All veins can be ligated in case of haemodynamic instability
     - Complications:
       - Venous hypertension
       - Leg oedema

11. **Endovascular management of vascular trauma**
   1. To obtain haemostasis:
      - Embolization of damaged vessels with haemostatic agents, coils, balloons
      - Used in pelvic fractures, injuries to the liver, spleen, kidney, etc.
   2. To obtain vascular control:
      - Temporary balloon occlusion of vessels in inaccessible regions
   3. For vascular repair:
      - Use of stentgrafts to repair injured vessels in anatomically challenging positions eg. thoracic aorta, thoracic outlet vessels, vertebral artery
MANAGEMENT OF VASCULAR TRAUMA

Suspected Vascular Injury (VI)

Emergency Management
- Resuscitation
- Stop bleeding
- Reduce/stabilize fractures, dislocations

Hard signs of VI

- Indication for immediate surgery
  - Haemodynamic instability
  - Active bleeding
    - Expanding haematoma
  - Severe ischaemia

- Location/extent clear
- Serious concomitant non-vascular injury

- Yes
  - Intra-operative arteriography

- No
  - Location/extent clear
  - Location/extent not clear

- Yes
  - Manage vasc and non-vasc injury according to priorities

- No

No Hard signs of VI

Non-extremity trauma
- Neck
- Chest
- Abdomen
- Pelvis

- Extremity trauma

ABI and dDoppler
- Abnormal
  - Arteriogram
  - Manage vasc and non-vasc injury according to priorities

- Normal and ABI > 0.9
  - Arteriogram
  - Manage appropriately

No significant arterial trauma