SURGICAL MANAGEMENT OF VASCULAR INJURIES

THOMAS G. GAZDECKI, DO, FACOS
BEAUMONT HOSPITAL-TRENTON
Objectives

- **Basic Principles** in the management of vascular injuries
- **Avoiding Pitfalls** in the preoperative period
- **Diagnostics vs Direct Exploration** vs Minimally Invasive interventions
- **Avoiding Pitfalls** during vascular repair
- **Regional Specifics**
- **Compartment Syndromes and Fasciotomies**
Basic Principles

Types of arterial injuries

- Intimal injuries (flaps, disruptions, dissections, or subintimal/intramural hematoma)
- Complete wall defects w/ pseudoaneurysm or hemorrhage
- Complete transections w/ hemorrhage or occlusion
- Arteriovenous Fistula
- Spasm
Basic Principles

Hard Signs of Vascular Injury

Absent Distal Pulses

Signs of Distal Ischemia (Pulseless, Pallor, Pain, Paresthesia, Paralysis, & Poikilothermia)

Audible Bruit or Palpable Thrill at injury site

Active Pulsatile hemorrhage

Large/Rapidly Expanding hematoma

Pulsatile Hematoma
Basic Principles

Soft Signs of Vascular Injury

- Proximity of injury to vascular structures
- Major single nerve deficit (e.g., Sciatic, femoral, median, ulna or radial)
- Non-expanding hematoma
- Hypotension or moderate blood loss at the scene
Principles

* Control Hemorrhage

* Assess Injury to Adjacent soft tissues and bone

* Determine Strategy of intervention based on overall status of patient and presence of other injuries
  
  Damage Control Resuscitation approach

* Treatment Goal
AVOIDING PITFALLS in The Pre-Operative Period

Avoid Missing the diagnosis

- History from patient or first responders
- Physical exam cues
  - Pulse? Perfusion? Effect of hypotension on evaluation
  - Hard Signs vs Soft signs
  - ABI’s
  - API’s
DIAGNOSTICS vs DIRECT EXPLORATION

Hard Signs
Location of injury
  Neck
  Chest
  Abdomen
  Pelvis
  Extremities
  Significance of groin penetrating injuries

Soft Signs
SUSPECTED ARTERIAL INJURY

HARD SIGNS
YES
OPERATIVE TREATMENT/INTERVENTION

NO

SOFT SIGNS
YES

API
>0.9
<0.9

NEG
POSITIVE

CT ANGIOGRAM

NO ARTERIAL INJURY

NO ARTERIAL INJURY CT ANGIOGRAM
AVOIDING PITFALLS during vascular repair

Operative Field Prep Issues

Avoid excessive blood loss during the Prep and Drape

Effect of incision on Scar Contracture (axilla, elbow, and knee)?

Cautious approach to the large pulsatile hematoma

Role of intraluminal shunts (open fractures w/ vasc. injury, distal perfusion while performing complex repairs, damage control, perfusion of amputated part of an extremity prior to reimplantation)

Effect of vessel repair method on outcome (and is heparin needed?)

Completion Angiography: when and why
REGIONAL SPECIFICS

NECK
CHEST
ABDOMEN
PELVIS
EXTREMITIES

DISCUSSION
Zone 1: Sternal Notch to Cricoid  
Important structures: Aortic Arch, Proximal Carotids, Subclavian vessels, Innominate vessels, trachea, lung apices, esophagus, brachial plexus, and thoracic duct

Zone 2: Cricoid to the angle of the Mandible  
Important structures: common, internal and external carotid arteries, internal and external jugular veins, larynx, hypopharynx, and esophagus.

Zone 3: Angle of the Mandible to the base of the Skull  
Important structures: Internal and external carotid arteries, vertebral artery, jugular veins, venous plexus, and facial nerve trunk
Strategies with penetrating neck injuries:

**Zone 1-3:** Pt’s with “hard signs” or hemodynamic instability require expeditious transfer to the OR (delayed only by securing an unstable airway, w/ surgical airway if attempts at oral-tracheal intubation are unsuccessful. If direct pressure is unable to minimize significant bleeding, focused attempts with a balloon tamponade may be of benefit. **Zone 1 & 3** injuries may benefit from endovascular management if they can be stabilized or treated emergently. **Vertebral artery** injuries can be challenging; as a rule, they can be managed either expectantly if bleeding is minimal, or with ligation. When a common or internal carotid injury is identified, it should be repaired primarily. Jugular vein injuries many time go undiscovered, but can be repaired or ligated without risk. **Zone 1** patients without indications for immediate neck exploration should undergo CTA of the chest and neck. Endovascular techniques for injuries identified are useful, but if not available standard open procedures with proximal and distal control are required for arterial and venous injuries. **Zone 2:** without symptoms or signs, manage with expectant observation/serial examinations. Patients with symptomatic Zone 2 injuries should be explored by either standard anterior sternocleidomastoid incision or cervical collar incision, depending on the nature of the injury. **Zone 2** patients with suspicion for injury but without symptoms on P.E. should undergo CTA of the neck to evaluate for both vascular and aerodigestive injuries. **Zone 2** hemodynamically stable CTA proven injury should undergo Open Repair. **Zone 3** hemodynamically stable pts with suspicion for injury should undergo CTA. **Zone 3** patients should undergo endovascular intervention where possible; vertebral artery ligation, embolization or packing.
ZONE 1
PENETRATING TRAUMA
PENETRATING NECK INJURY

ZONE 1: STERNAL NOTCH TO CRICOID
ZONE 2
NECK
LACERATION
NECK EXPLORATION ZONE 2

Repair Common & Internal Carotids primarily if possible, patch or replace if needed. Ligation last resort. Jugular veins are expendable. Vertebrals are ligated.
ZONE 3 PENETRATING NECK TRAUMA
PENETRATING CHEST INJURIES
METHODS OF HEMORRHAGE CONTROL IN PENETRATING CHEST TRAUMA

Packing
Suture pneumorrhaphy
Stapled pulmonary tractotomy
Clamp pulmonary tractotomy
Non-anatomic resection
Formal Lobectomy
Pneumonectomy
Aortic Clamping
Thoracic Aortic Cross Clamp

- Anterolateral thoracotomy 4\textsuperscript{th}-5\textsuperscript{th} ICS
- Retract lung anteriorly, feel concavity of ribs as they arch toward the spine
- Open parietal pleural!!
- Clamp first tubular structure (Aorta before Esophagus
STAPLED PULMONARY TRACTOTOMY
Abdominal Hemorrhage: Exposure and control
KOCHE MANEUVER

1. Identify duodenum
2. Incise posterior peritoneum immediately lateral to duodenum
3. Reflect the duodenum and pancreatic head from the retroperitoneum.
EXTENDED KOCHER MANEUVER

- Carry the classic Kocher incision caudally along white line of Toldt

- Access to entire infrahepatic IVC, right kidney/right hilum, right iliac vessels, etc.
CATTELL-BRAASCH MANEUVER

Advantages:
- Exposes entire inframesocolic retroperitoneum
- Infrarenal aorta
- IVC
- Bilateral Renal hila
- Bilateral Iliac vessels
- Superior Mesenteric vessels

Potential Pitfalls:
- Injury to the SMV at the root of the mesentery
MATTOX MANEUVER (Left Medial Visceral Rotation)
Retroperitoneal Hematoma

Approach to RPH

ZONE 1

ZONE 2

ZONE 3
Zone 1 of Retroperitoneum

Mandatory exploration!

Supramesocolic:
• Prox. Control: Suprareciliac aorta
• Mattox maneuver

Inframesocolic:
• Prox. Control: Infrarenal aorta/IVC
• Infrarenal aortic exposure/right-sided medial visceral rotation (Cattrell-Braasch Maneuver)
Zone 2 of Retroperitoneum

- Selective Exploration (if penetrating)
  - Inframesocolic exposure +/- Medial Visceral Rotation

- Leave alone if from blunt trauma
Zone 3 of the Retroperitoneum

- Selective exploration (if penetrating)
  - Inframesocolic exposure +/- cecal/left colon mobilization

- Leave alone if from blunt trauma
Pelvic Vascular Isolation

- “Walking the clamps”
- Global and selective clamping
- Interposition graft of injured artery vs ligation and extra-anatomic bypass
- Ligate vein injuries
Damage Control – Arteries

“Ligatable” arteries:
- Common and external carotid
- Subclavian, axillary
- Internal iliacs
- Celiac axis, IMA

ICA ligation..... 10-20% risk of CVA
EIA, CFA, SFA ligation ...... High risk of limb ischemia/subsequent amputation
SMA: gut necrosis

Damage Control – Venous

Almost all veins (including the IVC) can be ligated when needed.
MANAGEMENT OF VASCULAR INJURIES: SUMMARY

• Up to 25% of patients with abdominal trauma will have major vascular injury (95% penetrating)
  • IVC most commonly injured vessel
• Shock out of proportion to injury extent suggests major vascular injury
• Explore all retroperitoneal hematomas if from penetrating trauma
• Abdominal vascular trauma is technically challenging, carries a high mortality and exposure of major vessels is difficult because of their retroperitoneal location, overlying viscera, especially when bleeding is brisk.
• The Key to success: EXPOSE, ACHIEVE PROXIMAL CONTROL, EXPLORE & ASSESS INJURY, and RESTORE FLOW
What constitutes a compartment syndrome; how do we diagnose?

Who is at risk for a compartment syndrome?

- **Hypotension** in the field
- **Delay in treatment**, especially if no arterial inflow into the injured extremity for 4-6 hours
- **Disproportionate pain** in the injured extremity
- **In unstable patients** with ongoing hemorrhage in whom a comprehensive physical examination of the injured extremity is not possible, ‘high risk’ situations would include
  1. **Ongoing hypotension** and continuing resuscitation
  2. **Crush injury**
  3. **Significant swelling** of the extremity without much local injury.
- **Patients at ‘high risk’** based on operative management would include
  1. **Combined arterial and venous injuries** mandating simultaneous clamping, especially at the Popliteal level
  2. **Need for arterial or venous ligation or early thrombosis of repair.**
FOREARM FASCIOTOMY
DORSAL INCISION FOR FOREARM FASCIOTOMY
THIGH COMPARTMENT FASCIO TOMY: ONE INCISION PLACED LATERALLY
THE FORELEG COMPARTMENTS
DISCUSSION AND QUESTIONS