Exposure & Control of Abdominal Vascular Trauma

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Case #1

- 19 yo man
- s/p GSWs to Rt flank (L1 - L2) and R gluteal area
- Additional wound at right anterior midthigh
- Initially GCS 15, c/o mild epigastric tenderness
  - VS 118/81 83 33 96% 96 F
- FAST: fluid in Morrison’s pouch
Subsequent Course

- To CT scanner for abdominal CT
- Vomited and became hypotensive
- Fluid bolus and STAT to OR
- BP corrected en route
- Massive transfusion protocol initiated
Operative Findings

• Midline laparotomy
• Massive hemoperitoneum encountered
• Large expanding Lt. zone 2 hematoma
• Hole in duodenum 2
• Injury to upper pole of right kidney,
• Multiple holes in supra/infrarenal IVC
• Body of pancreas nearly transected
• Brisk retropancreatic bleeding
• Multiple enterotomies
Multi - Focal Exsanguination

- PEA → Lt anterolateral thoractomy, X-clamp aorta
- Unstable despite MTP
- Ligated IVC
- Transected pancreas for access
- Packed R kidney injury
- Retroperitoneum packed
- Pt acidotic, coagulopathic, hypothermic
- Aortic clamp remained
- Died in SICU after 2h from irreversible shock
Case #2

- 42 yo obese man
- Single GSW to right buttock
- Extruding bullet in RLQ/inguinal region
- Hemodynamically stable
In ED

- Weak L femoral pulse
- No femoral pulses on R
- Previous lower midline scar
- Progressively tachycardic / hypotensive
- L femoral cordis placed
- MTP initiated (26u PRBC, 7u FFP, 2u platelets)
- Taken emergently to OR for exploration
In OR

- 2L of hemoperitoneum
  - large R sided pelvic hematoma
  - near transection of R external iliac artery
  - injury to R common iliac vein
  - L internal iliac artery/vein injuries
  - Profound bleeding from Batson’s sacral plexus

- Multiple holes in small and large bowel
What Was Done

• **PEA**\(\rightarrow\) left anterolateral thoracotomy \(\rightarrow\) X clamp aorta

• **Procedures:**
  - R common iliac vein ligation
  - R external iliac artery shunt insertion
  - L internal iliac vein and artery ligation
  - Ligation of injured bowel with umbilical tape
  - Packing of pelvis / sacral bleeding
Postoperative Course

- Unstable throughout case
  - MTP and pressors pushed
  - Coagulopathic, hypothermic, acidotic
  - Packed abdomen, brought to SICU
- L subclavian cordis placed in SICU
- Died in SICU from irreversible shock
Questions?
How Do We Control Abdominal Vascular Injury?

KEEP CALM I'M A SURGEON
Abdominal Vascular Trauma

- Technically challenging
- High mortality
- Major abdominal vessels are retroperitoneal
- Aorta and IVC & major branches covered with viscera & hard to expose
- Much more common in penetrating trauma
- ~25% of patients with major abdominal injuries have significant vascular trauma
The Key Sequence

• Expose

• Achieve proximal control!

• Explore & assess injury

• Restore flow
Patient has sustained abdominal trauma for which operative exposure is warranted

- Prepare abdomen, as well as chest and upper thighs. Perform midline celiotomy.

Only hemorrhage is present
- Pack abdomen. Allow anesthesia to catch up.

Hemorrhage and contamination are present
- Control bleeding and contamination. Allow anesthesia to catch up if necessary.

Only contamination is present
- Control contamination.

Bleeding persists
- Reevaluate patient and continue efforts to control bleeding. Treat any coagulopathies.

Bleeding ceases
- Perform systematic evaluation of abdomen.

Bleeding persists
- Pack abdomen.

Bleeding ceases
- No additional exposure is required.

Additional exposure is required
- Perform Kocher maneuver. Perform left or right medial visceral rotation, as indicated.

Patient is physiologically unstable
- Perform damage-control procedure. Leave abdomen open.

Patient is physiologically stable
Exposure

- Notoriously difficult:
  - Retrohepatic IVC
  - Suprarenal aorta
  - Celiac axis
  - Proximal SMA
  - Junction of SMV, splenic and portal veins
  - Bifurcation of IVC
Damage Control - Arterial

- “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 limb ischemia

- SMA: gut necrosis
Damage Control - Venous

• Almost all veins (including the IVC) can be ligated when needed
Aortic Clamping in the Chest

- Anterolateral thoracotomy 4th/5th ICS
- Retract lung anteriorly, feel concavity of ribs as they arch toward spine
- Open parietal pleura!!
- Clamp first tubular structure
Supraceliac Aortic Control

- Mobilize left lobe of liver
- Bluntly open lesser omentum to expose crura
- Split overlying fibers of the right crus
- Digitally create space for clamp
# Retroperitoneal Hematoma

## Operative Approach to Retroperitoneal Hematoma

<table>
<thead>
<tr>
<th>Hematoma</th>
<th>Explore?</th>
<th>Proximal control</th>
<th>Key maneuver</th>
</tr>
</thead>
<tbody>
<tr>
<td>Penetrating</td>
<td>Blunt</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Midline supramesocolic</td>
<td>Yes</td>
<td>Supracaeliac aorta</td>
<td>Mattox maneuver</td>
</tr>
<tr>
<td>Midline inframesocolic</td>
<td>Yes</td>
<td>Infrarenal aorta or IVC</td>
<td>Infrarenal aortic exposure or right-sided visceral rotation</td>
</tr>
<tr>
<td>Lateral perinephric</td>
<td>Selective</td>
<td>Hilar clamping or midline looping</td>
<td>Mobilize kidney</td>
</tr>
<tr>
<td>Pelvic</td>
<td>Yes</td>
<td>Distal aorta/IVC</td>
<td>“Walking the clamps”</td>
</tr>
</tbody>
</table>
Zone I

• Mandatory exploration
  – Supramesocolic:
    • Prox. control: Suprarenal aorta
    • Mattox maneuver
  – Inframesocolic:
    • Prox. control: Infrarenal aorta / IVC
    • Infrarenal aortic exposure / right-sided medial visceral rotation
Zone II

- Selective exploration (if penetrating)
  - Inframesocolic exposure +/- medial visceral rotation

- Leave alone if from blunt trauma
Zone III

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

- Leave alone if from blunt trauma
Exposures based on retroperitoneal attachments

**Boundaries**

- Superior - Diaphragm
- Posterior - Muscles of deep back
- Lateral - Abdominal muscles
- Inferior - Pelvic floor muscles
Left Retroperitoneal Exposure

- Mattox maneuver (left sided medial visceral rotation)
- Achieve exposure of entire abdominal aorta, left renal vessels, celiac, SMA, and left iliac arteries
Pitfalls of Mattox Maneuver

• Splenic injury
• Avulsion of L descending lumbar vein (comes off L renal vein)
Right-sided Medial Visceral Rotation

Stage I: Kocher Maneuver

1. Identify duodenum
2. Incise posterior peritoneum immediate lateral
3. Reflect the duodenum and pancreatic head from retroperitoneum
Classic Kocher Continued

- Allows access to infrahepatic IVC, distal CBD, duodenum, pancreatic head, right renal hilum
Stage II: Extended Kocher Maneuver

- Carry the classic Kocher incision caudally along white line of Toldt
- Access to entire infrahepatic IVC, right kidney/R hilum, right iliac vessels
Stage III: Super-Extended Kocher (Cattell- Braasch Manuever)

- Extended Kocher+
  incise line of fusion
  of small bowel
  mesentary to
  posterior
  peritoneum
- Swing small bowel
  and right colon out
  of abdomen
Cattell-Braasch Continued

• Exposes entire inframesocolic retroperitoneum, infrarenal aorta, IVC, B/L renal hila, B/L iliac vessels, superior mesenteric vessels
Pitfalls of Cattell-Braasch Maneuver

• Injury to the SMV at the root of the mesentery
The Wounded “Surgical Soul”
(Case #1)
“Surgical Soul”

- **Superficial layer:** pancreaticoduodenal complex
- **Middle layer:** retropancreatic vessels, SMA/SMV, portal vein
- **Deep layer:** IVC, R renal pedicle
Surgical Soul Wound Management

- Perform widest possible Kocher (Cattell-Braasch)
- Portal triad injury - perform "Double Pringle" maneuver
  - Ligation of the portal vein is bail out solution
Retropancreatic Vessels

- Portal vein confluence and retropancreatic SMA difficult to expose in presence of massive bleeding from venous injury
  - Transect pancreas for access
Pelvic Vascular Isolation

• “Walking the clamps”
• Global and remote control to selective clamping
• Interposition graft of injured artery vs ligation and extra-anatomic bypass
• Ligate vein injuries
Vena Cava Injuries

- “Big Blue”
- Right sided medial visceral rotation
- Define edges of laceration
- Lateral repair if simple
- Complex injury- ligate!
IVC Injuries Cont

- Plenty of branches!!
- Injuries closer to heart more fatal
IVC Bifurcation

• IVC bifurcation obscured by the right common iliac artery
  – Divide R CIA to expose caval injuries at this level
  – MUST repair the artery or amputation will likely be necessary
<table>
<thead>
<tr>
<th>Site of abdominal vascular injury</th>
<th>Principle route of operative exposure</th>
<th>Preferred management options</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infrarenal aorta</td>
<td>Midline inframesocolic retroperitoneum</td>
<td>Lateral suture, patch repair, or interposition graft (rare) Ligation requires extraanatomic bypass reconstruction</td>
</tr>
<tr>
<td>Suprarenal aorta</td>
<td>Left-to-right medial visceral rotation (spleen, pancreas, and left colon)</td>
<td>Lateral suture or patch repair Interposition graft requires bypass to celiac, superior mesenteric, or renal arteries (rare) No ligation</td>
</tr>
<tr>
<td>Celiac axis</td>
<td>Left-to-right medial visceral rotation (spleen, pancreas, and left colon)</td>
<td>Lateral suture if feasible; ligation otherwise preferred; interposition graft if collaterals disrupted (rare)</td>
</tr>
<tr>
<td>Hepatic artery</td>
<td>Hepatoduodenal ligament</td>
<td>Lateral suture, interposition graft, or ligation (may require bypass graft)</td>
</tr>
<tr>
<td>Splenic artery</td>
<td>Through lesser sac</td>
<td>Ligation preferred</td>
</tr>
<tr>
<td>Superior mesenteric artery</td>
<td>Left-to-right medial visceral rotation (spleen, pancreas, and left colon); base of mesentery</td>
<td>Lateral suture, patch repair, or ligation and distal bypass</td>
</tr>
<tr>
<td>Inferior mesenteric artery</td>
<td>Midline inframesocolic retroperitoneum</td>
<td>Ligation preferred</td>
</tr>
<tr>
<td>Proximal renal arteries</td>
<td>Midline inframesocolic retroperitoneum, right-to-left medial visceral rotation (right colon and left duodenum), or left-to-right medial visceral rotation</td>
<td>Lateral suture, patch repair, ligation and bypass, or nephrectomy</td>
</tr>
<tr>
<td>Distal renal arteries</td>
<td>Right-to-left medial visceral rotation (right colon and duodenum) on right; left-to-right medial visceral rotation on left</td>
<td>Lateral suture, patch repair, interposition graft or nephrectomy</td>
</tr>
<tr>
<td>Common and external iliac arteries</td>
<td>Midline pelvic retroperitoneum; medical reflection of sigmoid colon on left</td>
<td>Lateral suture, patch repair, interposition graft, or ligation with bypass to external iliac artery (may be extraanatomic)</td>
</tr>
<tr>
<td>Internal iliac arteries</td>
<td>Midline pelvic retroperitoneum</td>
<td>Ligation preferred</td>
</tr>
</tbody>
</table>
### TABLE 7: Abdominal venous injuries: exposure and management options

<table>
<thead>
<tr>
<th>Site of abdominal vascular injury</th>
<th>Principal route of operative exposure</th>
<th>Preferred management options</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infrarenal inferior vena cava</td>
<td>Midline inframesocolic retroperitoneum or right-to-left medial visceral rotation (right colon)</td>
<td>Lateral suture, patch repair, or ligation</td>
</tr>
<tr>
<td>Renal veins</td>
<td>Right-to-left medial visceral rotation (right colon and duodenum) on right; midline inframesocolic retroperitoneum on left</td>
<td>Lateral suture or patch repair, ligation if collaterals intact on left; interposition vein graft on right or on left if no collaterals; nephrectomy</td>
</tr>
<tr>
<td>Juxtarenal inferior vena cava</td>
<td>Right-to-left medial visceral rotation (right colon and duodenum)</td>
<td>Lateral suture or patch repair</td>
</tr>
<tr>
<td>Retrohepatic inferior vena cava</td>
<td>Right-to-left medial visceral rotation (right colon, duodenum and right liver) with vascular exclusion of the liver (Pringle's maneuver and atriocaval shunt)</td>
<td>Lateral suture or patch repair</td>
</tr>
<tr>
<td>Portal vein</td>
<td>Hepaduodenal ligament; right-to-left medial visceral rotation (right colon and duodenum); lesser sac and transpancreatic</td>
<td>Lateral suture, patch repair (vein), splenic vein bypass to superior mesenteric vein, or ligation</td>
</tr>
<tr>
<td>Iliac veins</td>
<td>Midline pelvic retroperitoneum; medial reflection of sigmoid colon on left; divide iliac artery (rare)</td>
<td>Lateral suture, patch repair, or ligation</td>
</tr>
</tbody>
</table>
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
• Medial visceral rotations to expose retroperitoneal major midline vessels
• Supraceliac aortic clamping extremely important manuever
Questions?
Question #1

• 22M was stabbed multiple times in the left epigastrium. On arrival in the emergency department he is hypotensive with a distended abdomen with a positive (FAST) exam. On ex lap, he is found to have an expanding hematoma in the central retroperitoneum. Which of the following is the optimal surgical exposure for this injury?

a) Direct opening of the hematoma
b) Left-sided medial visceral rotation
c) Exposure through the gastrocolic omentum
d) Anterolateral left thoracotomy
e) Mobilization of the duodenum and right colon
A 52-year-old man struck by an automobile sustains abdominopelvic trauma and arrives at the emergency department in a state of shock. The patient is taken directly to the operating room for exploratory laparotomy. The spleen is found to be severely lacerated, necessitating splenectomy. The only other finding is a left retroperitoneal hematoma that progresses into the pelvic retroperitoneum during the operation. The anesthesiologist notices that the urine is blood tinged. Which of the following represents the most appropriate management?

a) Complete exploration and close. Obtain immediate post op CT scan to image left kidney

b) Perform renal exploration by exposing midline aorta and identifying and controlling L renal artery and vein

c) Perform renal exploration by mobilizing the kidney laterally through Gerota fascia and reflecting it up on its pedicle

d) Obtain an intraoperative arteriogram. If the findings are normal, complete the abdominal exploration and close
Question #3

• A hematoma in the retroperitoneum found during exploration of the abdomen following trauma should be explored if:
  a) A hematoma is found at the pelvic brim
  b) A small hematoma behind the duodenum is seen
  c) A large hematoma associated with a pelvic fracture is found
  d) A large hematoma over the kidney is found
References

- Hirshberg A, Mattox KL: Top Knife: The Art and Craft of Trauma Surgery. tfm publishing Ltd, Harley, Shropshire, United Kingdom, 2005