Vesalius SCALpel™ : Abdominal trauma (see also: trauma clinical folios)

Damage control principles

- hemorrhage and loss of body heat lead to acidosis, coagulopathy, core hypothermia (< 36C)
  - permissive hypotension: maintain mean arterial pressure (MAP) ~90 to prevent pressure-induced rebleeding from sealed vessels
  - transfusion: trauma pts < 55 without heart disease Hb 7-9 is adequate
- combination hypothermia, acidosis, coagulopathy: 90% mortality, 60% survive damage control
- identify when risk of death exceeds need to repair organ damage (except arterial bleeding)
- hypothermia: < 36 or rapid drop causes inability to control “medical bleeding/ooze”
  - warm fluids, room
  - T < 34 = 100% mortality
  - severe hypothermia: internal warming, bypass
  - bretylium for V-fib
- acidosis: progressive deterioration cardiac performance, increasing arrhythmia, pH < 7.2, increasing resistance to catechols
- coagulopathy factors:
  - hypothermia; fibrinolysis activated by tissue trauma and endothelial damage; dilution
  - ooze, stop, restart; PT > 19, PTT > 60,
- rapid control of bleeding, pack ooze (balance v compartment syndrome), temporizing measures for other injuries, leave open abdominal wall/vac, 48h ICU stabilization before return to OR

Dx algorithm

- immediate OR:
  - unstable, intraperitoneal fluid, penetrating transperitoneal
  - peritonitis: 80% of patients with torn viscus have severe abdominal pain
- free fluid without evidence of organ injury
  - relatively benign exam repeat CT w oral contrast 6-8h
  - if increased fluid or free air to OR

Absolute indications for laparotomy

- blunt abdominal trauma with persistent hypotension despite adequate resuscitation
- peritonitis
- penetrating stab injury with hypotension
  - (stable pt with anterior stab penetrating abdominal injury now 66% managed non-operatively, 12h observation [only 6 hour misses 50% of injuries])
- gunshot wound
- evisceration (70% intraabdominal injuries)

Physiology of abdominal trauma

endothelial cell assumes proinflammatory phenotype, cell surface chemotactic proteins activated, attract WBCs, inflammation, edema
separation of endothelial cells increases leak, intra and extracellular edema
compounded by blunt abdominal trauma
critical capillary closure pressure 25mm Hg, lower = organ damage
increased intraabdominal perssure leads to abdominal compartment syndrome (ACS)
can be initiated by massive resuscitation in non-abdominal trauma (extremity, burn) = secondary ACS
ischemia/reperfusion (I/R) injury:
    activates WBCs, free O_2 radical production, damage cell membranes, double hit, exacerbate extra and intracellular edema
        greatest damage during I/R
    return of anaerobic metabolic products from lower extremities and abdomen
        ameliorated by pre-decompression bicarb

Abdominal compartment syndrome (ACS)

slower development (than limb compartment) because of compliance of abdominal wall and diaphragm
increased abdominal pressure, increases intrathoracic pressure
    bladder pressure measurement: instill 50cc saline, transduce, > 30mm Hg elevated
    increased airway pressure (>45cm H_2O), decrease pO_2, increase pCO_2 (> 50), decreased compliance
    false elevation of CVP
decreased cardiac output
    direct cardiac compression
    decreased abdominal blood return, decreased preload
decreased renal blood flow, urine output, leads to acute tubular necrosis (ATN)
decr. cardiac output (CO), urine, hi CVP mimics CHF (diuresis exacerbates compartment syndrome)
increased intrathoracic pressure increases intracranial pressure
    in combo with hypotension decreases cerebral perfusion pressure (< 60 critical)
splanchnic hypoperfusion, gut mucosal acidosis, bowel and liver ischemia
ischemic muscle and gut activate systemic immune response (SIRS) -> MOF (lungs first)

Spleen

blunt
    FAST exam has replace peritoneal lavage, go to CT scan if positive or suspicious for injury
    CT grading more accurate in pediatric than adult
    grade
        I < 10% of surface, < 1cm deep

II non-expanding subcapsular hematoma 10-50% of surface, non-expanding intraparenchymal hematoma < 2cm, bleeding capsular tear or parenchymal laceration 1-3cm deep without trabecular vessel involvement

III expanding subcapsular or intraparenchymal hematoma, bleeding subcapsular hematoma > 50% of surface, intraparenchymal hematoma > 2cm, parenchymal laceration > 3cm deep or trabecular vessel involvement

IV ruptured intraparenchymal hematoma with active bleeding, laceration involving segmental or hilar vessels resulting in major (> 25% of volume) devascularization

V completely shattered or avulsed, hilar laceration with total devascularization

non-op management (grade I-III)

stable patient, grade I-III: ability to do serial exams (even on vent.), <2U blood loss related to spleen (v pelvic, femur fx), benign abdoman, no hypotension (BP>100), pulse < 100

low failure rate (80% of blunt trauma are candidates; 95% success pediatric, 80% adult)

chance of failure increases with grade, III 25% risk failure

60% of failures occur < 24h

40% of failures due to inappropriate selection

incidence of missed injuries ~2%

most deaths due to delayed treatment of intraabdominal injuries

failure: hemodynamic decompensation, new or increased abdominal pain (other visceral injury), dropping Hct

other predictors of failure: > 55yo, injury severity score (ISS) > 25, higher grade

contrast blush on angio indicates active bleeding, poor prognosis, to OR

24h ICU observation, 3-4d bed rest, minimal activity 1-2w, no contact sports 3 mo

no need for CT or US f/u

indications for splenectomy: hemodynamic instability, peritoneal signs, ongoing blood loss

unstable pts with even minor injury require operation

delay in unstable pts 37% mortality

splenorrhaphy (those who are candidates with isolated splenic injury don't go to the operating room anymore)

blood loss <500cc, minimal associated injuries, no hilar involvement, minimal-moderate splenic disruption, normal coag., no associated injuries

suture, cautery, surgical, hemostatic glue, partial splenectomy, mesh wrap

pseudoaneurysm: embolize only in stable patient

penetrating LUQ with intraabdominal bleeding requires surgrery

Liver

most require damage control, push together, not down into IVC

pack above and below

hepatic v injury 65% mortality: direct approach, no shunt (higher mortality)

degree of injury on CT does not correlate with need for operation v hemodynamic status

> 93% of even grade III-IV lacs can be observed if no other abdominal injuries

1/3 of combined liver/spleen injuries can be managed non-operatively

arterial blush in stable pt go to angio intervention
    increases chance of operative success if can't control
    unstable to OR, lobectomy rarely necessary
large liver resection not warranted at 1st operation
biloma
    may form weeks to months after injury
    associated with liver abbreviated injury score (L-AIS) > 4
    HIDA, MRCP detect leaks
    percutaneous drain
    ERCP/stent speeds closure of leak
    failure of non-operative mgmt: open debridement, omentoplasty
        hepaticojejunostomy for extrahepatic bile duct disruption
hemobilia
    iatrogenic 25-50%: biliary drainage, liver bx
    trauma: blunt (2%) after penetrating
        late occurrence after trauma
        vascular contrast in Gb
    abdominal pain, UGI bleed, jaundice; all 3 in 22%
    blood loss, occlusive clots in the biliary tree
    major bleed: melena 90%, hematemesis 60%, biliary colic 70%, jaundice 60%
    EGD, R/O other sources, 10% diagnostic
    no ERCP, percutaneous cholecystostomy or lap chole: catastrophic decompression
    Dx: angio, therapeutic embolization 80-100% success
    surgery if embolization fails: ligate vessel, excise aneurysm, hepatic a ligation, resection

Pancreas

civilian injury frequency distribution: 6% gunshot, 5% blunt, 2% stab
isolated pancreas injury rare:
    blunt: associated with duodenum, liver, spleen
    penetrating: stomach, vascular, liver, colon, spleen, kidney, duodenum
5 grades in pancreas organ injury scale: based on ductal disruption, location of injury
CT 68% accurate, if question do ERCP, stent proximal duct injury if possible
dynamic secretin stimulated MRCP may aid detecting ductal injury
contusion, laceration: omental plug, drain
head: resect in stable, sphincterotomy, operative ERCP, PO duct stent
    complex head injury requiring Whipple rare, highly lethal
        most common indication: massive uncontrollable retroperitoneal hemorrhage (portal v, SMA, SMV)
body, tail: distal pancreatectomy in stable patient
transection to OR: distal pancreatectomy with splenic preservation if stable
    splenectomy if unstable
    no pancreaticojejunostomy: time consuming, high leak rate
contusion and peripancreatic hemorrhage repeat CT 6-8h
    non-op controversial, if stable repeat CT

if increased fluid or increased inflammation to OR

GU

kidney
- < 5% incidence renal injury in blunt trauma, requires hi energy, often other associated injuries
- manditory imaging: shock with hematuria, do contrast CT or IVP pre-op or in OR
- non-operative management: grade I-III lacs, hemodynamically stable, 90% success
  - late consequence: Page kidney = capsule scarring, incr. renin, hypertension
- operative management: grade IV, V; pulsating hematoma, penetrating
  - control pedicle first, nephron-sparing surgery
  - non-perfused kidney can only revascularize within 2h
    - later than 2h leave kidney in situ, observe for hypertension
- back table repair if sole kidney and would need transplant after nephrectomy
- persistent bleeding, pseudoaneurysm embolize

ureteral injury
- rare, most iatrogenic (ligated, disrupted), distal 1/3
  - transection, patrial, cautery, devascularize, kink by suture, crush
  - points of injury: broad lig during hysterectomy (3/4 of injuries), sigmoid resection (2nd most common), IMA ligation, lateral pedicles of rectum, reperitonealization
- risk factors: large tumor, prior pelvic surgery, radiation, infection (diverticulitis), endometriosis
- stent doesn't prevent, but helps identify (late Dx increased morbidity)
- partial injury: closure with absorbable over stent
- cautery injury: debride to bleeding, spatulate, repair over stent (leave 6 weeks), drain
- late discovery: tube nephrostomy to temporize
- psoas hitch, Boari flap, ileal conduit (proximal injury), transureteroureterostomy, renal mobilization, autotransplant

bladder injury
- 80% of bladder injuries due to pelvic fracture, bone spicule
  - 10% of pelvic fractures have bladder injury
  - 70% extraperitoneal
- blunt, seat belt injuries more likely intrapertoneal rupture
  - contrast urethrogram (at least 300cc)
- Rx:
  - intraabdominal: open repair
    - double layer absorbable, suprapubic catheter
  - extraabdominal: Foley (2-3wks)

urethra/prostate
- associated with pelvic fx
- urethral injury usually below urogenital diaphragm
- inability to void, blood at the meatus
- high riding boggy prostate
- retrograde urethrogram (pericath)

place suprapubic catheter if in doubt
movement toward primary realignment
cystoscope through bladder
complications: stricture, impotence
penile fracture/testis rupture: repair tunica albuginea

Colon

predictors of complications
severe fecal contamination
> 4U transfusion 1st 24h
shock on admission
> 6h delay treatment
severe associated injuries
diversion v anastomisis has no influence on complications
non-destructive injuries (<50% circumference, no devascularization): debride, primary anastomosis
destructive: resection, primary anastomosis

Seat belt injury

hi risk small bowel injury
explore: free fluid, thickened bowel, pneumoperitoneum
if laparotomy indicated clinically, no role for DPL, US
15% of patients with small bowel injury have no signs
associated pancreatic and duodenal injury
seat belts much more effective (45%) decreasing mortality than airbags (15%)
most effective in front end, rear and rollover accidents
(airbags lo risk of ocular trauma 0.4%)

Retroperitoneal hematoma (regions I-III)

I central abdomen
penetrating: explore for vascular, duodenal, pancreatic injury
blunt: explore all with shock
CT grade
mild: no exploration
moderate to severe: depends on associated injuries
II lateral
blunt: hematoma usually from renal injury
exploration rarely necessary unless rapidly expanding
urine extravasation does not require exploration
stent and percutaneous drainage 80% resolution
penetrating: can observe if imaging is adequate, if not explore
greater chance of renal loss with exploration
III pelvic

penetrating: explore to R/O major vascular injury
blunt: usually from pelvic fracture
exploration releases tamponade, increases blood loss
expanding hematoma at ex lap explore v pelvic pack and embolization

Vascular

arterial
celiac: ligate if there is backfill
SMA: shunt
renal: nephrectomy in most, especially unstable
iliac: shunt if feasible; if ligate do fasciotomies
venous
iliac, infrarenal IVC, SMV, portal
ligation tolerated in most cases, bowel swelling
pelvic packing only method of control
retrohepatic IVC pack
skin: close to put pressure on packs
interventional Rx
previously only stable pts could be taken to angio suite
now interventional Rx in the OR allow damage control or definitive endovascular repair of many vascular injuries

Pregnancy and trauma

principle: treating the mother is the best treatment for the fetus
physio changes
50% increase in blood volume, 30% increase RBC mass
= hemodilution, normal Hct 34
2L/30-40% of volume before tachycardia or drop in BP, rapid deterioration > 2,500cc
CO increases 50% 1st trimester, uterine blood flo 20% of CO, dependent on MAP
20 weeks aortocaval compression decreases CO 30% supine
decreased BP due to progesterone induced decreased systemic vasc. resistance (SVR)
CVP drops from 9 to ~4 as uterus enlarges, HR increases ~15BPM
15-20% increased O_2 consumption
20% decrease FRC, rapid desaturation with decreased respiration
increased minute ventilation, decreased $PaCO_2$ 25-30, (normal level of 40 in pregnant trauma patient is concerning)
compensatory renal excretion bicarb, slight metabolic acidosis is normal
increased PaO_2 ~105
maintain maternal O_2 sat > 95 to maintain PaO_2 > 70
fetal compromise < 60
decreased gastric tone and motility and decreased LES tone, risk aspiration
lower ext pooling increases blood loss leg injury & increases risk thrombosis
pelvic pooling increases risk retroperitoneal bleeding, hematoma
leukocytosis 15-25K normal

increased procoagulant factors helps hemostasis
low fibrinogen, split products, low platelets suggests DIC
increased risk DVT/PE, prophylaxis after stable

Combined head and abdominal injuries

less than 1% require both craniotomy and laparotomy
head CT more likely to delay laparotomy