

## **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 pressure 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<sub>2</sub> 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<sub>2</sub>O), decrease pO<sub>2</sub>, increase pCO<sub>2</sub> (> 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 abdomen, 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 surgery

## 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 1<sup>st</sup> 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

mandatory 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, partial, cautery, devascularize, kink by suture, crush

points of injury: broad lig during hysterectomy (3/4 of injuries), sigmoid

resection (2<sup>nd</sup> 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 intraperitoneal 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 1<sup>st</sup> 24h  
shock on admission  
> 6h delay treatment  
severe associated injuries  
diversion v anastomosis 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% 1<sup>st</sup> 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<sub>2</sub> consumption  
20% decrease FRC, rapid desaturation with decreased respiration  
increased minute ventilation, decreased PaCO<sub>2</sub> 25-30, (normal level of 40 in pregnant  
trauma patient is concerning)  
compensatory renal excretion bicarb, slight metabolic acidosis is normal  
increased PaO<sub>2</sub> ~105  
maintain maternal O<sub>2</sub> sat > 95 to maintain PaO<sub>2</sub> > 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