

Penetrating Abdominal Trauma

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Overview

- Epidemiology
- Unstable patient
 - Resuscitative thoracotomy
- Case presentation 1
- Diagnostic studies
- Management options
 - Specific injuries
- Damage control abdomen
- Case presentation 2

Epidemiology

- Affects 35% of patients admitted to urban trauma centers
- 1-12% of suburban or rural centers
- Frequency relates to industrialization of developing nations, weapons available, and presence of military conflicts
- Mortality rates civilian GSWs 9.5-12.7% and 3.6% for stab wounds in US
- Majority are males, up to 90%

Mechanisms

- Gunshot wound
 - Handgun, rifle
 - Kinetic energy = $\frac{1}{2} mv^2$
 - Airgun
 - Low velocity
 - Shotgun
 - Multiple pellets
- Stab wound
- Impalement
 - Remove objects in OR

Shotgun Wound



Impalement



Initial Resuscitation - Preparation

- Protect yourself
- Equipment
 - Markers
 - Crash cart
 - Chest tube trays
 - Thoracotomy tray
- Monitors
- Intubation tray
- IVs, IV fluids, rapid infuser
- Warm blankets

Primary Survey

- A - Airway
 - Shock - intubate
- B - Breathing
- C - Circulation
 - Pulses?
 - Electrical activity?
- D - Disability
 - Assess movement of extremities
- E - Exposure/Environment
 - Find all wounds

Injury Assessment

- Identify wounds
 - Distinguishing entrance and exit unreliable
 - Location and appearance
 - Trajectory defines anatomic injury
- Cavitory triage
 - Radiographic imaging
 - Dependent on hemodynamic stability
- Operative repair more frequent in GSW vs stab wounds
 - 70-90% vs 25-45%
 - Small bowel, liver, stomach, colon, vascular structures

Resuscitative Thoracotomy

- CPR in progress or no vital signs
 - No pulses or measurable BP
- Evaluate for signs of life (SOL)
 - Spontaneous movements
 - Pupillary response, eye movement
 - Spontaneous respirations
 - Electrical complexes >40 beats/min on ECG
- Futile?
 - Overall survival ~4-5%
 - Highest survival rate in isolated cardiac injury
 - Risk to healthcare workers
 - 26% trauma pts HIV+ or Hepatitis+
 - Health care costs

Survival Based on Mechanism

Mechanism	Total No.	Survivors		Neurologically Intact Survivors	
		n	%	n	%
Overall	868	41	5	34	4
Blunt	385	8	2	4	1
Penetrating	483	33	7	30	6
GSW	330	12	4	12	4
SW	147	21	14	18	12

What About PEA?

Resuscitative thoracotomy indicated

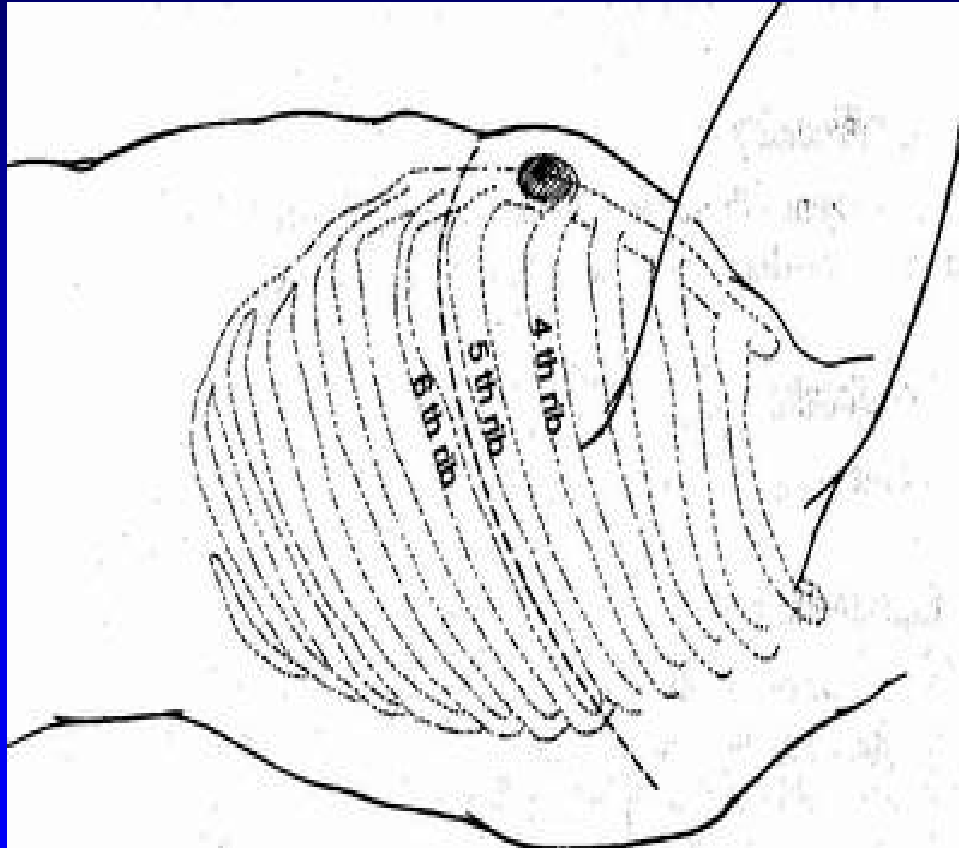
- PEA after penetrating trauma
 - Up to 70% good outcomes
 - HR good predictor of survival
 - <40 beats/min – no survivability
- PEA after blunt trauma
 - Typically poor outcome
- If CPR > 15 min, contraindicated

Breakdown of Treatment and Outcome for Pulseless Trauma Patients Based on Initial Electrical Activity of the Heart in the Field and in the Emergency Department (ED):

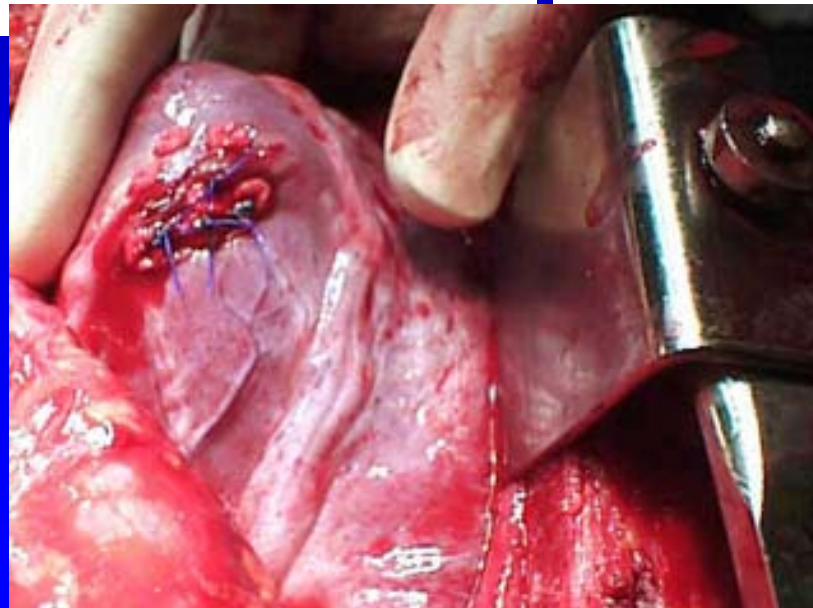
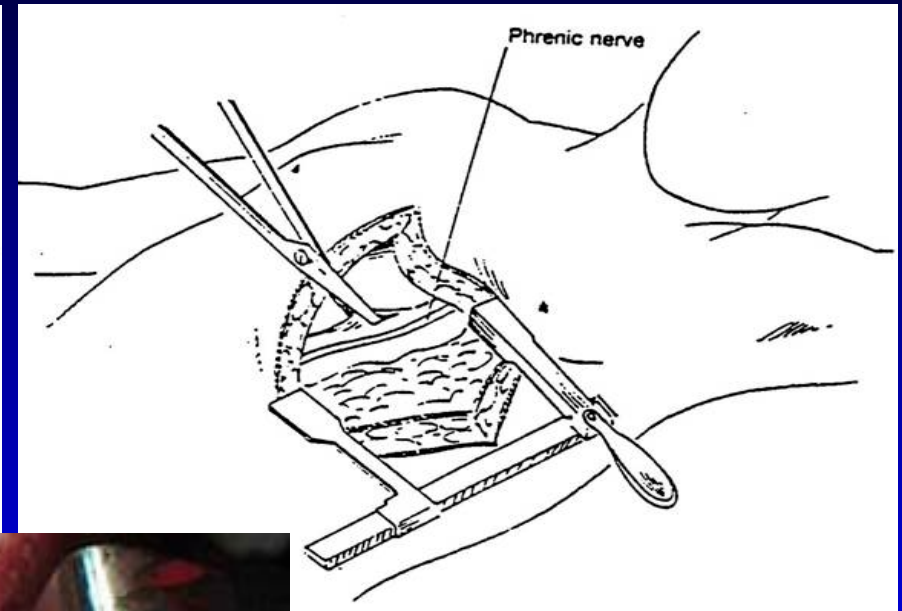
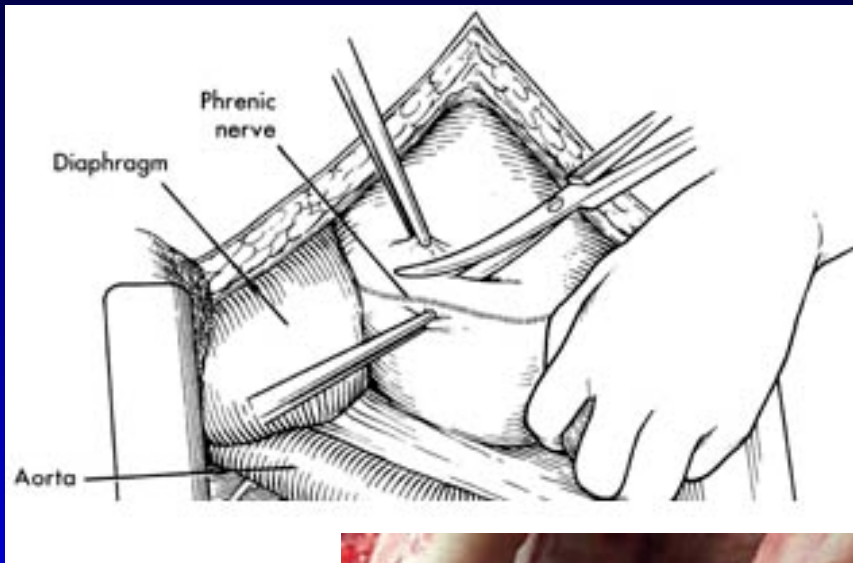
Treatment/Outcome	Prehospital Cardiac Rate, Beats/min		ED Cardiac Rate, Beats/min	
	<40 (n = 346)	≥40 (n = 256)	<40 (n = 455)	≥40 (n = 149)
ED thoracotomy	162	184	220	84
To OR for surgery	39	120	64	97
Outcome				
Lived	0	15	2	14
Died	346	241	453	135

Battistella, et al., Arch Surg 1999; 134: 742-746.

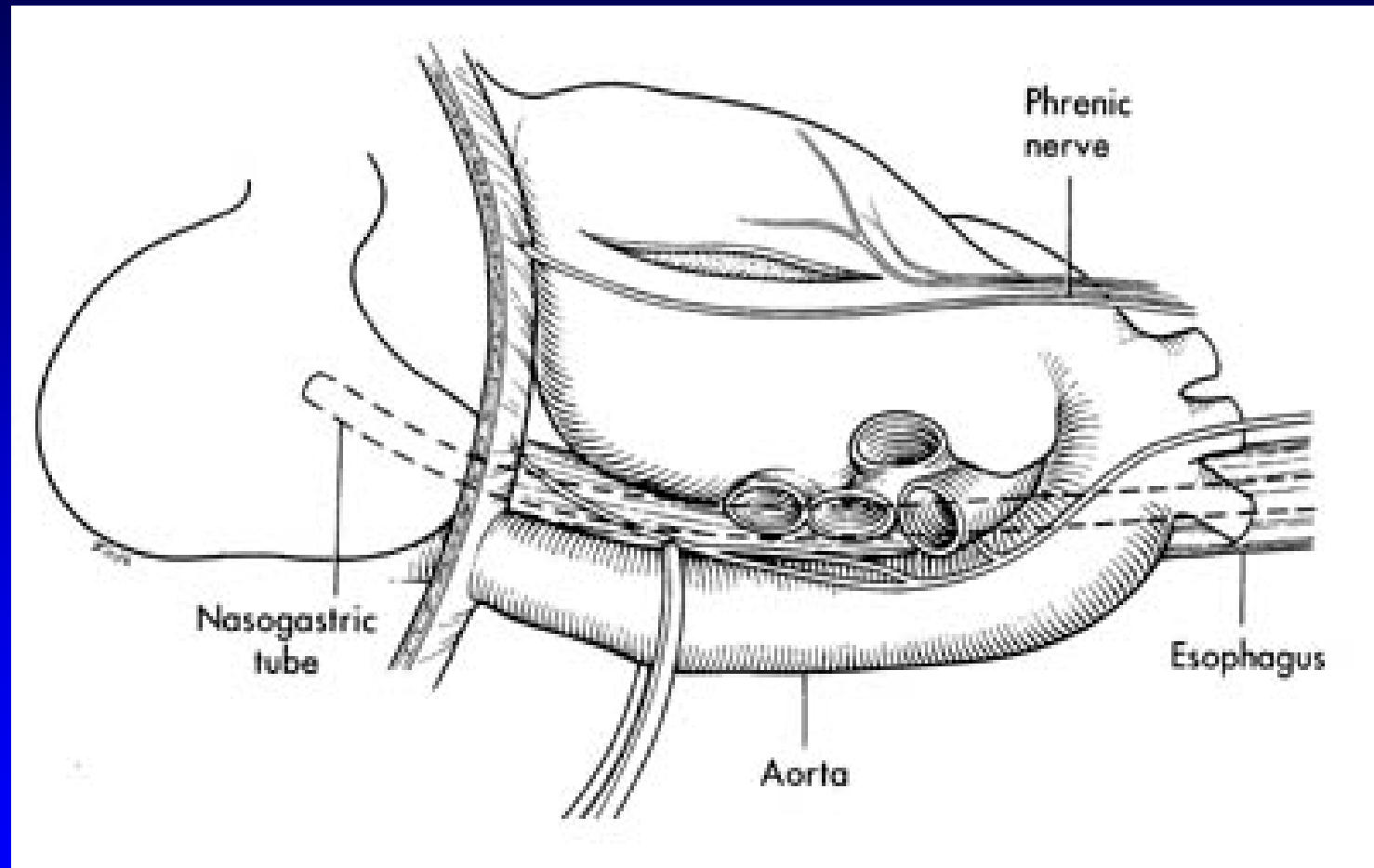
Procedure – Left Anterolateral Thoracotomy



Release Pericardial Tamponade



Occlude Descending Thoracic Aorta



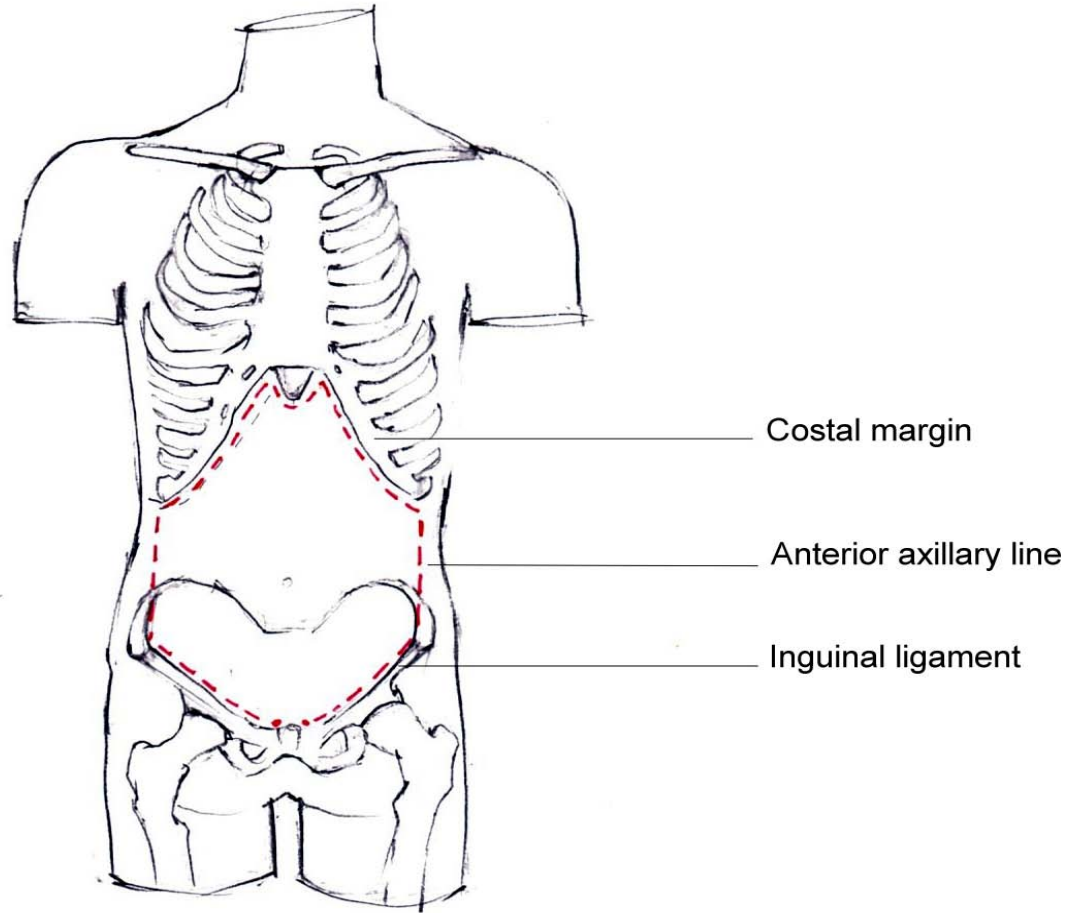
EDT for Abdominal Exsanguination

- Restrospective review
- 50 pts received pre-laparotomy EDT
- 94% GSW
- 84% field SOL, 78% ED SOL
- 8 pts (16%) survived neurologically intact
- 75% major abdominal vascular injury
- 25% severe liver injury
- All required massive blood transfusion

Secondary Survey

- External inspection
 - Anterior abdomen – costal margins to inguinal creases, between anterior axillary lines
 - Thoracoabdominal area – Nipple line and tip of scapula to inferior costal margins
 - Flank – scapular tip to iliac crest, between anterior and posterior axillary lines
 - Back – Scapular tip to iliac crest, between posterior and axillary lines
 - Examine body creases, perineum, rectum
 - GSW - odd number of wounds suggests retained bullet

Anterior Boundaries



Anterior abdomen

Laboratory Studies

- Type and crossmatch
- CBC
- BMP
- Coagulation studies
- ABG/VBG
- ETOH/toxicology screen

Diagnostic Studies

- Plain x-rays
 - Cavitary triage
- FAST (focused assessment sonography for trauma)
- DPL (diagnostic peritoneal lavage)
- CT scan

Case Presentation #1

SC is 23 y/o male s/p GSW to LLQ of abdomen and RLE. There was no pre-notification (dropped off by police). Patient arrived to trauma bay in mild shock, A&Ox3, anxious, skin moist, diaphoretic, MAE.

PMH/PSH: None, last tetanus unknown

All: NKDA

Meds: None

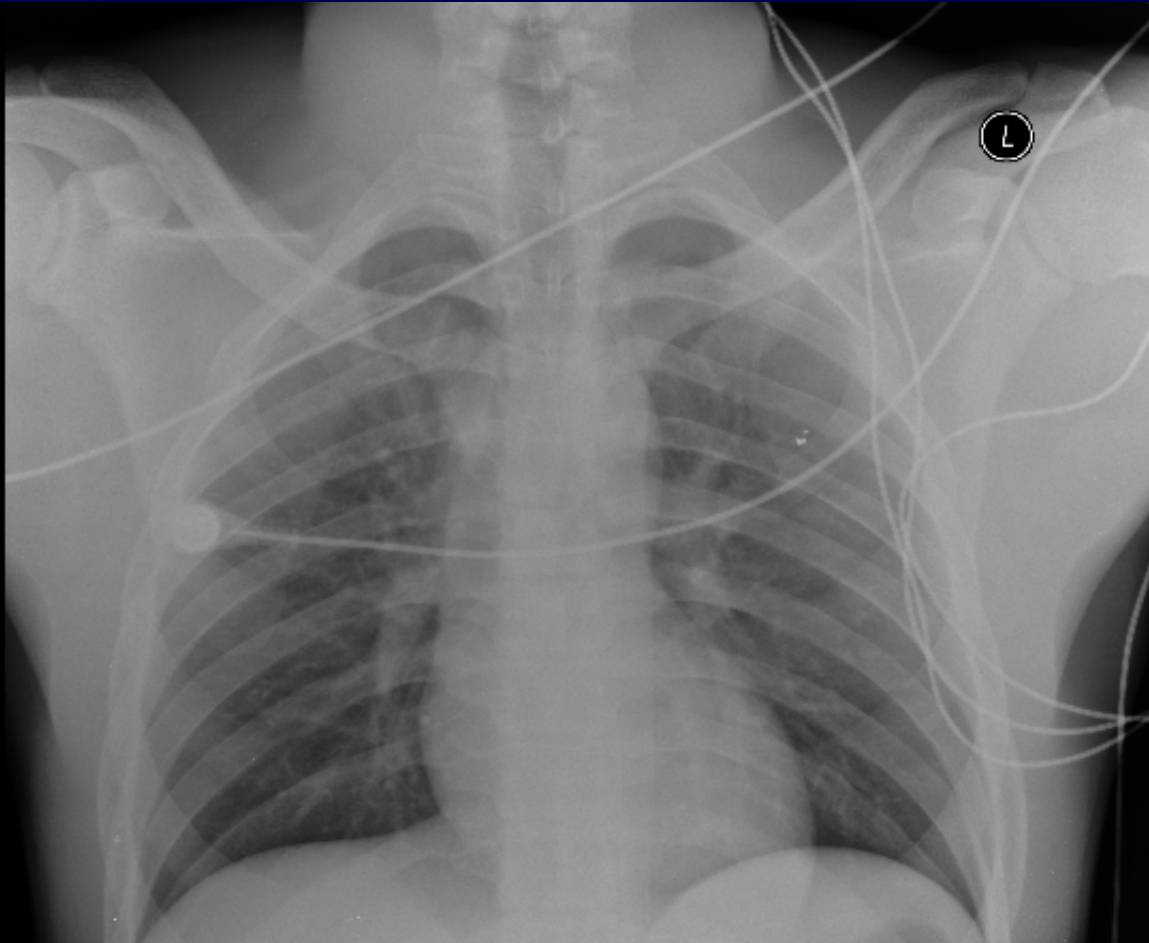
Initial VS: HR 105, BP 99/78, RR 26, Temp 98.0

Trauma Bay Resuscitation

- Primary Survey
 - Unremarkable
- Secondary Survey
 - Abdomen: GSW to LLQ, soft, diffusely tender, ND
 - Rectal: No gross blood
- + FAST
- Received: 1u pRBCs, Tetanus, Unasyn
- Initial labs
 - H/H: 13.8/41
 - LA: 4.3
 - ABG: 7.37/26/558/15.3/-7.5/99
- Taken to OR for exploratory laparotomy

Trauma Bay CXR

Se:1
Im:1

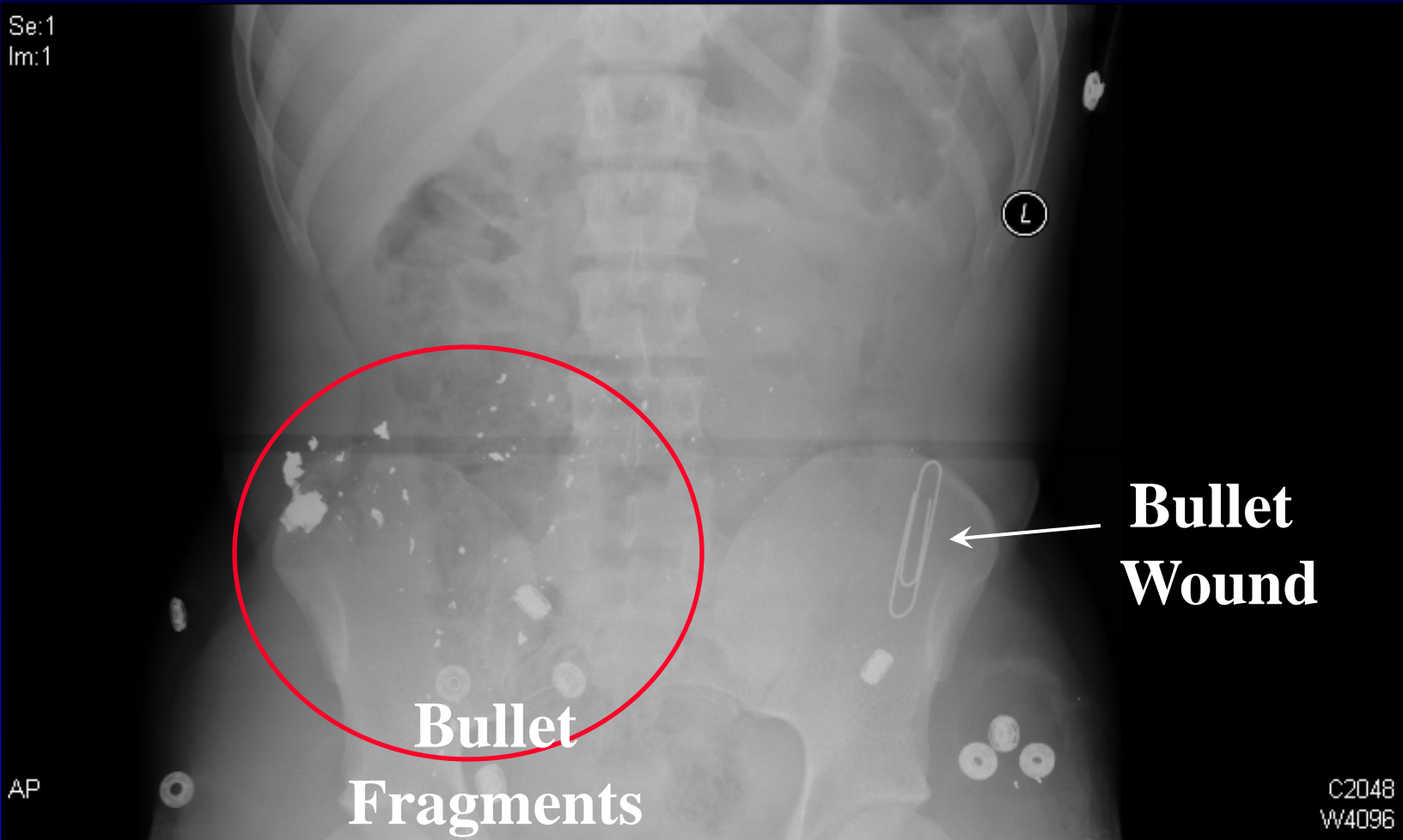


AP

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Trauma Bay AXR

Se:1
Im:1



**Bullet
Fragments**

**Bullet
Wound**

AP

C2048
W4096

FAST

- Advantages

- Speed
- Noninvasiveness
- Reproducibility

- Disadvantages

- Negative FAST does not rule out need for laparotomy
- User dependent

FAST



Diagnostic Peritoneal Lavage (DPL)

- Hemodynamically unstable patients with negative FAST
- Sensitive but NOT specific
- Positive if 10ml gross blood, $\geq 100,000$ RBCs/ml, ≥ 500 WBCs/ml, bacteria, bile, food particles
 - Lower for GSW ≥ 5000 RBCs (disagreement)
- Disadvantage
 - Invasive
 - Inability to evaluate retroperitoneum
 - High false positive rate

DPL



CT Scan

- Sensitive and specific for assessing injury and severity to solid organs
- Limitation is lack of sensitivity in diagnosing hollow visceral, and diaphragmatic injuries
- No indication for anterior penetrating trauma
- Useful for tangential, flank and back wounds
- Intraabdominal injuries and bullet trajectory can identified with >90% sensitivity and specificity*
- Triple contrast may increase accuracy

Procedures

- Local wound exploration
 - Anterior stab wounds
- Laparoscopy
- Laparotomy
- Proctosigmoidoscopy

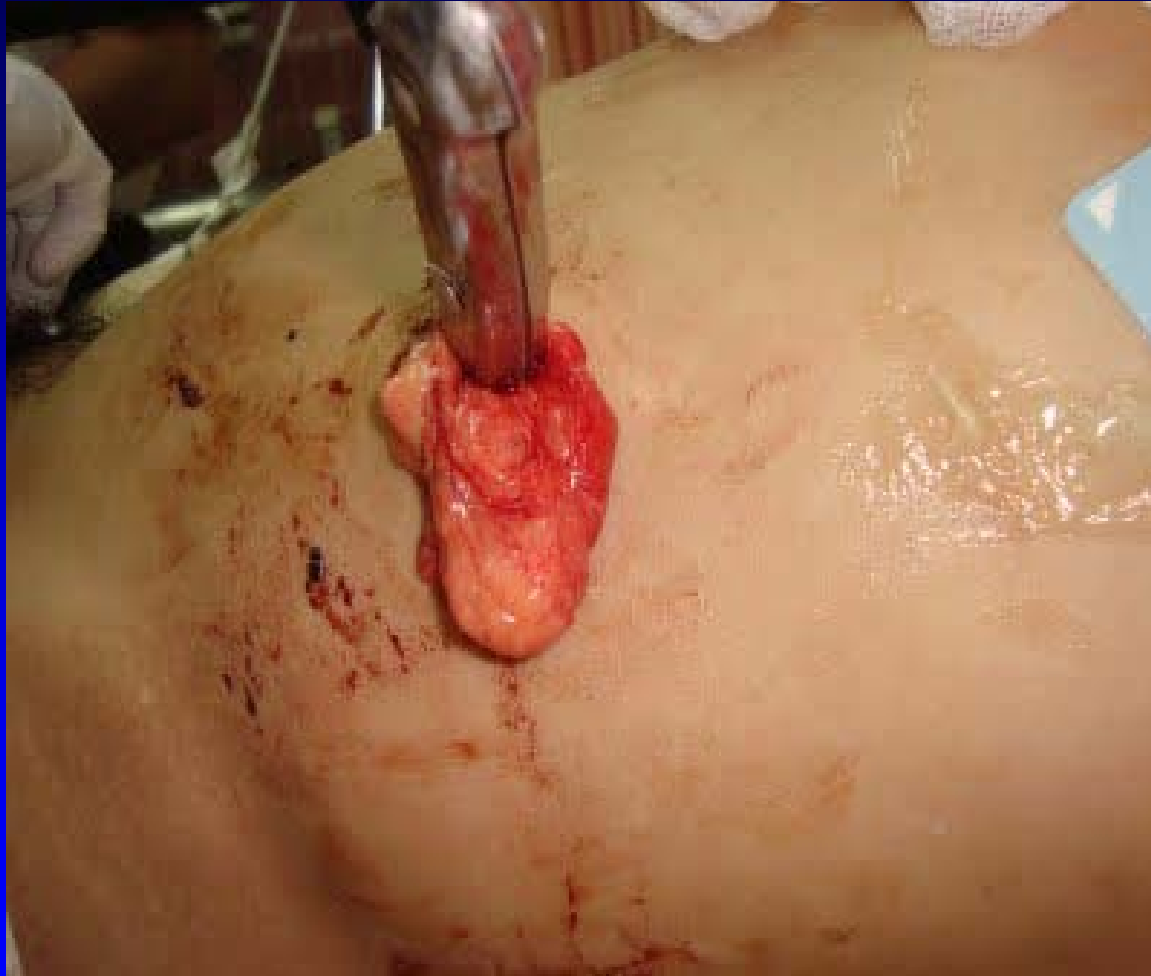
Local Wound Exploration

- Anterior stab wounds
- Aseptic technique, good lighting, local anesthesia
- Enlarge wound
- Penetration of anterior fascia is considered positive
- Positive study requires OR exploration

Local Wound Exploration



Omental Eviseration

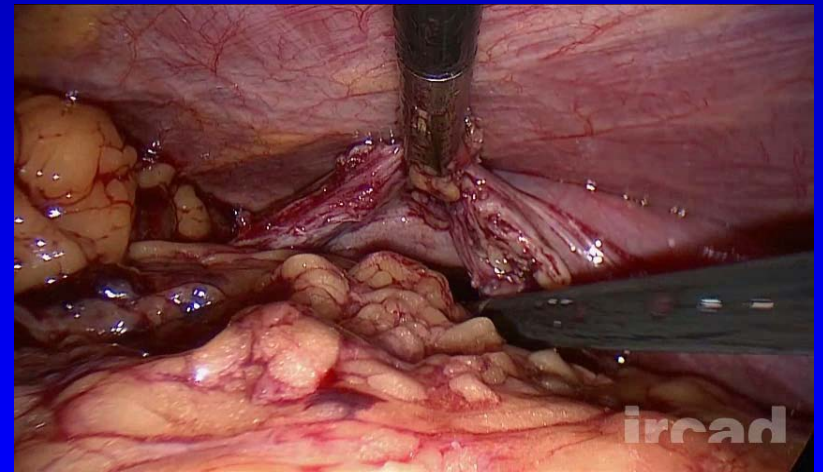


Laparoscopy

- Hemodynamically stable
- Reduce nontherapeutic laparotomies
 - Reduce LOS by 50% *
- Thoracoabdominal stab wounds
 - Diagnose diaphragm and/or intra-abdominal injuries
- Assists questionable peritoneal penetration

*Simon, et al., J Trauma 2002; 53: 297-302.

Laparoscopy



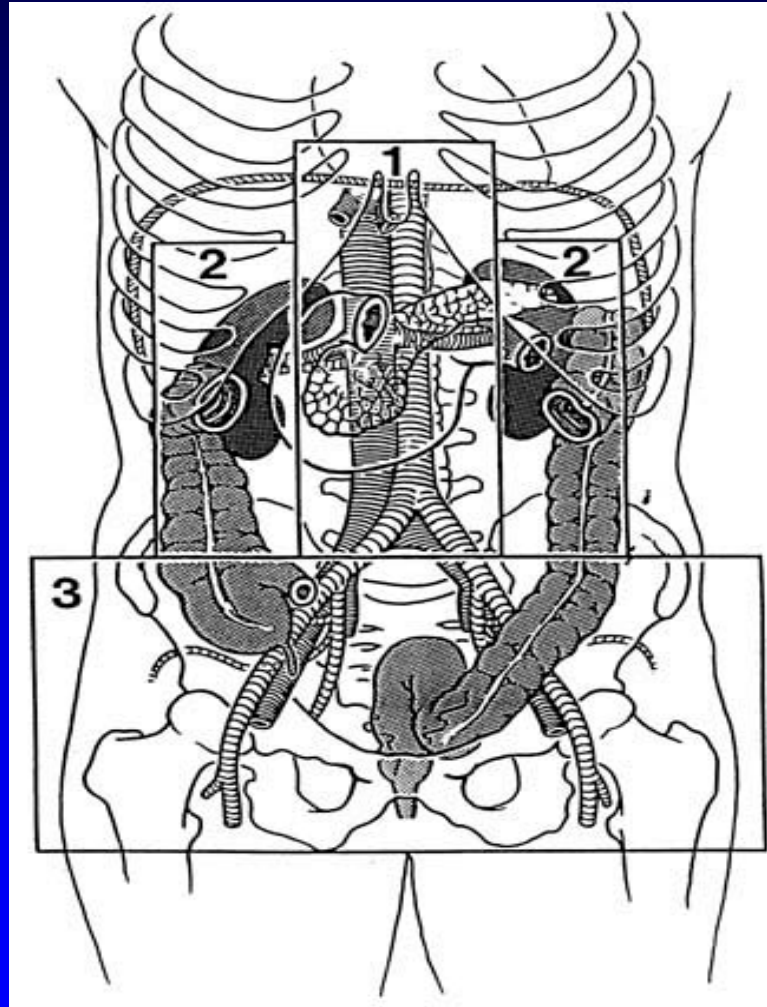
Laparotomy

- Prepare
 - Rapid infusion system
 - Cell saver
- Generous midline incision
- Pack all 4 quadrants
- Systematic exploration
 - Control bleeding
 - Control contamination
 - Resect/clamp/ligate/shunt
- Repair and/or closure
 - Dependent on stability

Retroperitoneal Zones

- Zone 1 – Inframesocolic region
 - Infrarenal abdominal aorta
 - Infrahepatic inferior vena cava
- Zone 2
 - Renal artery/vein
 - Kidney
- Zone 3
 - Common, external and internal iliac arteries and veins

Retroperitoneal Zones



Proctosigmoidoscopy

- Indicated for evaluation of suspected rectal injury in stable patient
- Scope introduced into anal canal and directed toward umbilicus
- Positive study is rectal blood, intramural hematoma, or full-thickness rents
- Positive requires prompt surgical exploration



Specific Injuries

- Solid organs
 - Liver/spleen
 - Kidneys/pancreas
- Hollow viscus
 - Small bowel/colon/stomach
 - Duodenum/rectum
- Major vascular
 - Aorta/IVC/iliac

Solid Organs

- Liver
 - Most commonly injured
 - Pack, pressure, Pringle, plug
 - Embolization
- Spleen
 - Remove
- Kidney
 - Perirenal hematoma unroofed
- Pancreas
 - Pack, debride and drain initially
 - Consider feeding jejunostomy
 - Distal resection

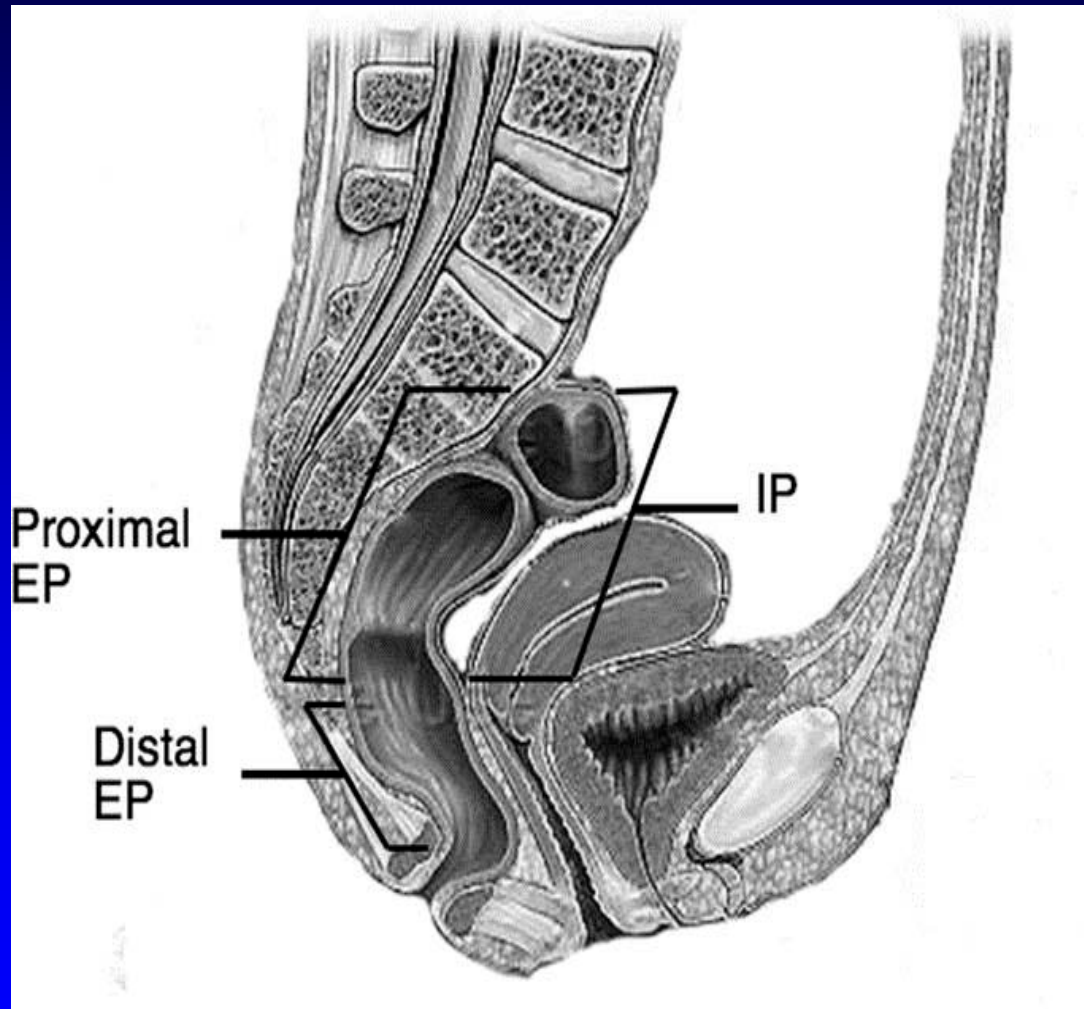
Hollow Viscus Injury

- Small bowel
 - Most commonly injured
 - Control contamination
 - Resect, repair if small; anastomosis if stable
 - Duodenum – transverse closure (71-85%), drainage, ?pyloric exclusion
- Colon/rectum
 - 25% of GSWs and 5% stab wounds
 - Primary repair, rxn/anastomosis, colostomy
 - Gross blood on rectal exam is pathognomonic for colorectal injury
- Stomach
 - Injury 10-15% of penetrating trauma
 - Debride and repair (2 layers)

Colon Injuries

- Primary repair should be performed for nondestructive colon injury
- Controversy for wounds requiring resection
 - Resection and anastomosis in patients w/o comorbidities and receiving 6 units of pRBCs
 - Diverting colostomy in patients w/ comorbidities, ≥ 6 units pRBCs, and moderate spillage
 - Leak rate 42 vs 3% high vs low risk patients

Rectal Injury



SC - Initial Surgical Interventions

- Exploratory laparotomy
- No significant bleeding, moderate amt contamination
- Small bowel rxn X 2
- R hemicolectomy
- Repair 3rd portion duodenum
- Methylene blue interrogation of Right ureter
- Damage control dressing
 - Coagulopathic
 - Temp 35° C
 - Mild acidosis (pH = 7.32, BE -5.0)

Damage Control

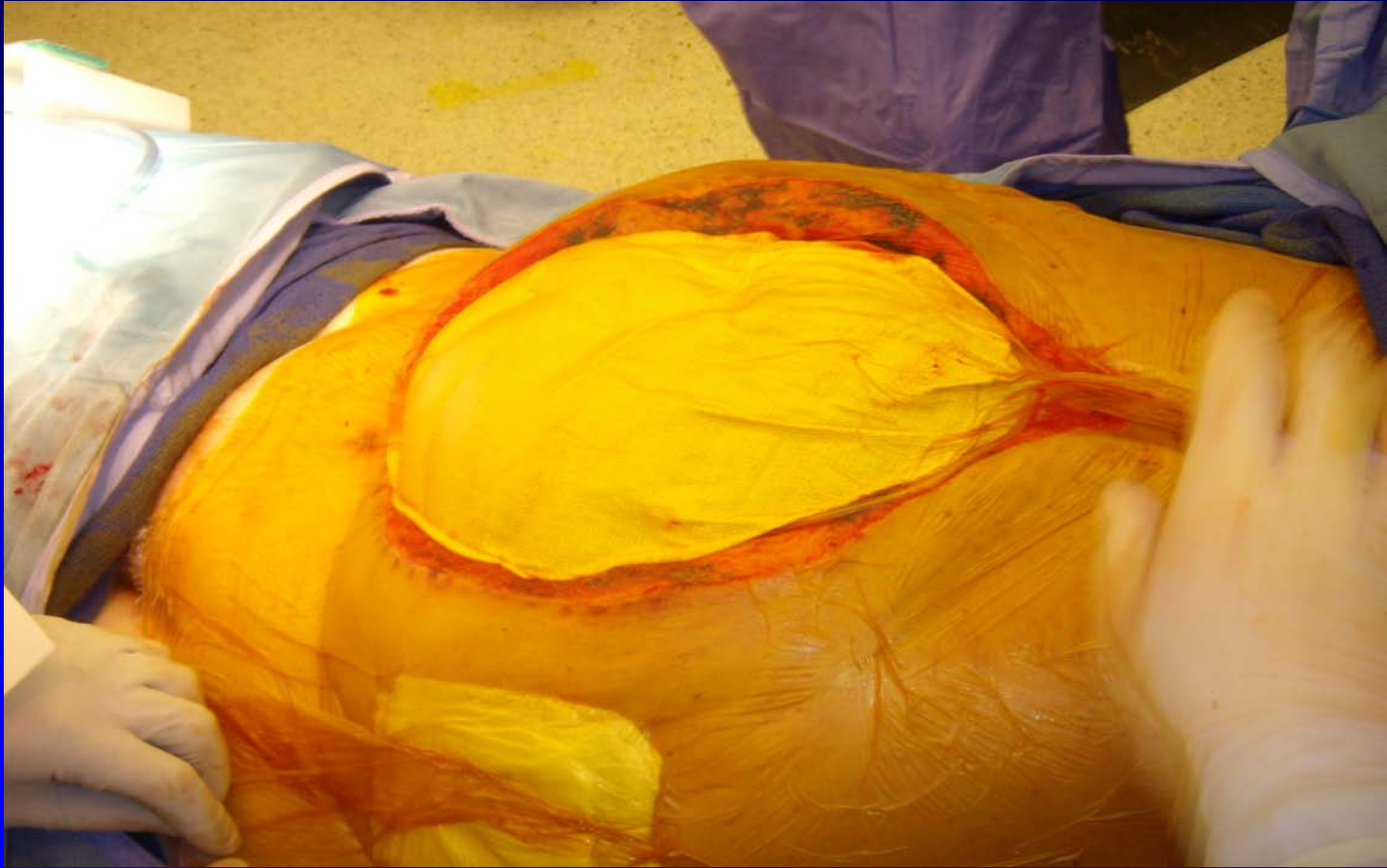
*Arrest hemorrhage, limit contamination,
temporary closure*

- Control of active hemorrhage
 - Packing
 - Clamp/ligate/shunt
 - Organ removal
- Contamination
 - Oversew/staple/drain

Damage Control Dressing



Damage Control Dressing



Objectives of Damage Control Closure

- Containment of viscera
- Control of abdominal secretion/leakage
- Maintaining of abdominal tamponade
- Optimize likelihood of eventual closure
- Speed

Schreiber et al, *Crit Care Clin*, 2004.

Indications for DC

Indications for the Damage Control Approach

1. Inability to achieve hemostasis due to coagulopathy
2. Inaccessible major venous injury
3. Time-consuming procedure in a patient with suboptimal response to resuscitation
4. Management of extra-abdominal life-threatening injury
5. Reassessment of intra-abdominal contents
6. Inability to reapproximate abdominal fascia due to visceral edema

Moore et al, *World J Surg*, 1998.

Phases of Damage Control Management

Damage Control, Phase I (DC-I)	Initial damage control procedure
Damage Control, Phase II (DC-II)	Resuscitative Phase
Damage Control, Phase III (DC-III)	Complete repairs of previously temporized injuries Management of the open abdomen
Damage Control, Phase IV (DC-IV)	Subsequent management of the ventral hernia

Martin ND, CPG, Trauma Center at Penn, 2008.

Damage Control Phase II

- Aggressive Correction of Abnormal Physiology
 - Re-warming
 - Correct coagulopathy
 - Restore circulating volume (euvoolemia)
 - Correct acidosis
 - Optimize pulmonary function (prevent ALI, ARDS)

Holcomb et al. *J Trauma* 2007.

Sagraves et al. *J Int Care Med* 2006.

SC - Surgical Interventions POD 1

- Resuscitation
 - 4000ml crystalloid fluids
 - 2u pRBCs
 - Am labs - H/H: 12.2/35 ABG: 7.45/32/188/22/-0.7/99.5
- Re-exploration
 - Small bowel anastomosis
 - Ileocolic anastomosis
 - Exploration of duodenal repair w/methylene blue
 - Fascial closure – removal of damage control

Damage Control Phase III

- Physiologic Capture
 - Warm
 - Normal pH
 - Normal coagulation
 - Hemodynamically stable
- Definitive Repair
 - Debridement and resection
 - Formal repair of vasculature and bowel
 - Abdominal wall closure
- Timing*
 - <72 hrs = 4.5% mortality, 4% abscess, 50% sepsis
 - >72 hrs = 46% mortality, 31% abscess, 77% sepsis

*Abikhaled et al, *American Surgeon* 1997.

Vascular Injuries

- Exposure
- Proximal and distal control
 - Use sponge sticks/foley/finger
- Most vessels can be ligated except
 - Aorta/proximal SMA/retrohepatic cava
- Shunts
 - Argyle shunts/IV tubing/chest tubes
- Repair
 - Primary/graft
 - Stent - controversial

Case Presentation #2

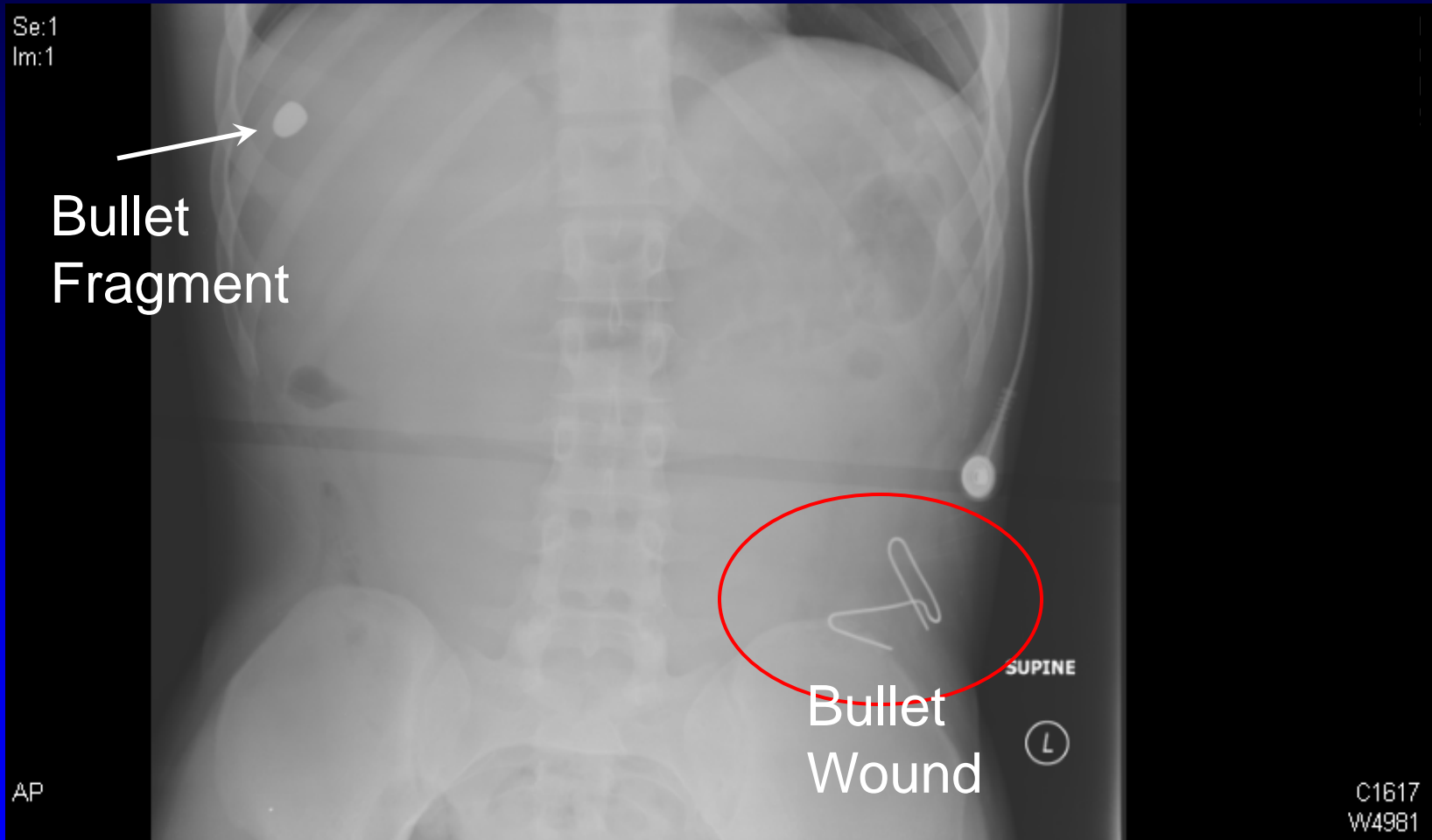
FG is 16 y/o male who sustained GSW to abdomen. He presented to ED without prenotification in extremis. Tachycardic, severe shock, diaphoretic, MAE.

HR 130-150's, BP 90/50's

Antibx given, taken emergently to OR

Massive transfusion protocol activated

Initial AXR



Initial OR

- Exploratory laparotomy
 - Massive hemoperitoneum
 - Significant zone I, II, & III hematoma
 - Patient became hypotensive
 - All four quadrants packed
- Emergent left thoracotomy
 - Cross-clamp descending aorta
 - Massive transfusion
- Performed Kocher maneuver
 - Large anterior infra-hepatic IVC injury at level of caudate lobe
 - Pringle maneuver performed

OR Continued

- Cardiothoracic surgery called
 - Placed variant form of veno-veno bypass
 - IVC (inferior to injury) to L main PA
 - Repair of IVC injury
 - Weaned from bypass, decannulated
- Continued significant bleeding in mid and pelvis
 - Iliac arteries/veins accessed – no bleeding
 - Mattox maneuver performed
 - Aorta to L renal vein – no injury
 - Concern for lumbar artery bleeding
 - Decision to move to IR
 - Damage control chest/abd

Interventional Radiology

- Patient hypotensive during travel
 - Continued massive transfusion, warming
- Aortic run-off performed
- Large aorto-IVC fistula discovered
- Active extravasation from aorta
- Aortic balloon inflated above injury
- Aortic covered stent placed by IR
 - Unsuccessful

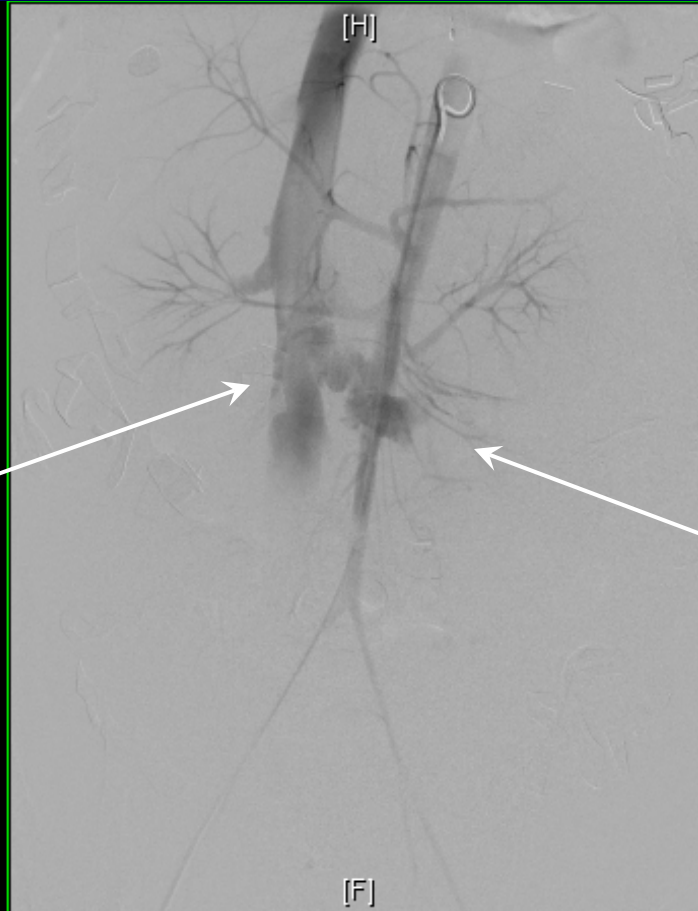
Initial Runoff

Se:1
Im:300 (F1/1)

[R]

Aorto-IVC
Fistula

SMA
IODINE



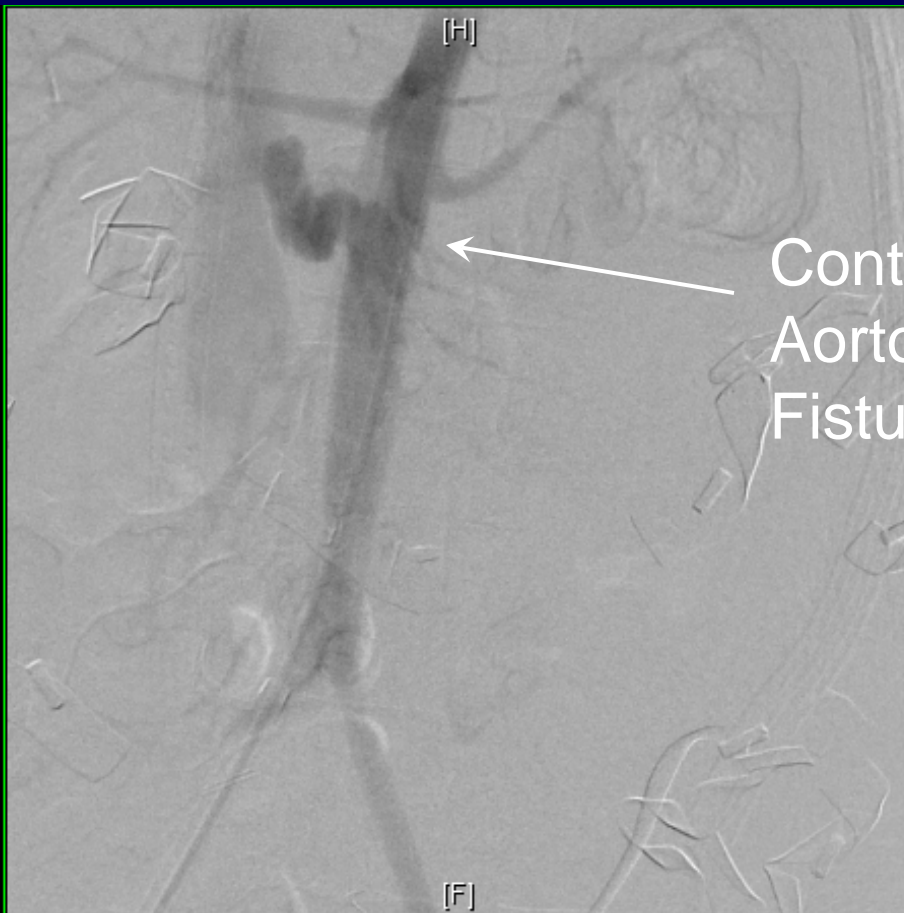
[L]

Aortic
Injury

C2048
W4095

Runoff Following Stent Placement

Se:11
Im:301 (F1/1)



Continued
Aorto-IVC
Fistula

SMA
IODINE

C2048
W4095

Return to OR

- From IR to OR with angio capability
- Vascular placed second stent, fistula still open
- Patient more stable, but on vasopressors and in rapid a-fib
- Reopening of laparotomy
 - Repair of medial IVC injury and posterior aortic injury (stent visible)
 - Bowel dusky
 - Damage control
- After fistula closure, a-fib resolved
- Patient cold and coagulopathic
- Planned return to OR in am

Management Controversies

- Stab wounds – Nonoperative management
 - Prospective study showed 47% patients could be managed non-operatively
- GSW – Nonoperative management
 - Solid organ injuries – CT scan
- Left thoracoabdominal injuries
 - Laparoscopy for patients without indications for laparotomy
 - GSW 59% had diaphragm injury
 - Asymptomatic patients – 24% occult diaphragm injury
- Antibiotics for penetrating injury
 - Regardless of contamination and degree of injury, 24 hrs adequate

Key Points

- Common in urban settings
- Consider EDT for pts who lose VS and HR > 40bpm
- Evaluate quickly and accurately, OR always best for unstable patients
- DPL, CT scan, laparoscopy useful if questionable injury
- Arrest hemorrhage, limit contamination, damage control
- Hollow viscus most common – repair or resection, colon/rectum – may have to divert
- Vascular – Proximal and distal control, ?stent