Agenda

• Our patient
  – Clinical presentation
  – Differential diagnoses
    • Abdominal Pain
    • Abdominal Pain in women
    • Anuria
  – Imaging
    • US
    • US of companion patient (Normal)
    • CT
  – Diagnosis
• Overview of Bladder Injury
  – Types: Contusion, Intraperitoneal, Extraperitoneal, Mixed
  – Anatomy Review
  – Imaging Examples
  – Diagnosis algorithm
  – Treatment
• Our patient
  – Treatment
  – Followup Imaging
Our Patient: History

- C.C., a 21 yo female college student presents w/ lower abdominal pain
- s/p fall from bicycle at low velocity in the morning
- Anuria
- PMH: none
- PSH: none
- Meds: none
- SH: social EtOH, no tobacco
• VS: HR 64; BP 160/106; RR 16
• Cr: 2.5 (baseline 0.8) – why? (we will discuss later)
• Mildly uncomfortable
• Abdomen softly distended, moderate periumbilical tenderness
• No rebound, no guarding
• HCG: negative
Our Patient: History of Lower Abdominal Pain

• C.C., a 21 yo female college student presents w/ lower abdominal pain
• s/p fall from bicycle at low velocity in the morning
• Anuria
• PMH: none
• PSH: none
• Meds: none
• SH: social EtOH, no tobacco
# Causes of Abdominal Pain

<table>
<thead>
<tr>
<th>Neurologic</th>
<th>Diffuse Abdominal Pain</th>
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<tbody>
<tr>
<td>Referred</td>
<td>Mesenteric Ischemia/infarction</td>
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<tr>
<td>Upper Abdominal Pain</td>
<td>Pregnancy</td>
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<tr>
<td>Biliary Disease</td>
<td>Ruptured Aneurysm</td>
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<td>Acute Pancreatitis</td>
<td>Peritonitis</td>
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<tr>
<td>Dyspepsia</td>
<td>Intestinal Obstruction</td>
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<td>Pneumonia</td>
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<tr>
<td>MI</td>
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<tr>
<td>Splenic Abscess/Infarction</td>
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<tr>
<td>Lower Abdominal Pain</td>
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<tr>
<td>Appendicitis</td>
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<tr>
<td>Diverticular Disease</td>
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<td>Kidney Stones</td>
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<tr>
<td>Bladder Distension/Injury</td>
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<tr>
<td>Pelvic Pain</td>
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</tbody>
</table>

- Rare Causes of Abdominal Pain
  - Celiac Artery Compression Syndrome
  - Painful Rib syndrome
  - Wandering Spleen syndrome
  - Abdominal migraine
  - Eosinophilic gastroenteritis
  - Epiploic appendagitis
  - Fitz-Hugh-Curtis syndrome
  - Familial Mediterranean fever
  - Hereditary Hemangioma
Differentials of Lower Abdominal Pain in Women

- PID
- Adnexal masses/cysts (w/ bleeding, torsion, or rupture)
- Ectopic pregnancy
- Endometritis
- Degeneration, infarction, or torsion of leiomyomas
Our Patient: History of Anuria

- 21 yo female college student w/ lower abdominal pain
- s/p fall from bicycle at low velocity in the morning
- **Anuria**
- PMH: none
- PSH: none
- Meds: none
- SH: social EtOH, no tobacco
Let’s consider some of the differential diagnoses associated with anuria…

Image credit: http://www.wrongdiagnosis.com/bookimages/4/fig24b.jpg
Causes of Anuria

**Pre-Renal**
- Absolute ↓ blood vol (e.g. hemorrhage, GI loss, trauma, surgery, burns)
- relative ↓ in blood vol (sepsis, anaphylaxis, vasodil drugs, nephrotic syndrome)
- disrupted renal autoreg due to ACE-I administration
- Renal artery or vein occlusion (thrombus, embolus, stenosis, AAA)

**Renal**
- small vessel vasculitis or acute glomerulonephritis due to CT disorders (SLE), scleroderma, malig HTN, preg, polyarteritis, post-streptococcal
- interstitial nephritis related to drugs (methicillin), infection, or cancer
- ATN related to ischemia, nephrotoxic antibiotics, heavy metals, solvents, contrast agents
- Congenital disorders (PCKD, medullary sponge kidneys)

**Post-Renal**
- Intra-abdominal Leak
- Obstruction
  - upper urinary tract obstruction (ureteral)
  - Lower urinary tract obstruction (bladder outlet obstruction; more common)
Our Patient: History of Alcohol Use

• 21 yo female college student w/ lower abdominal pain
• s/p fall from bicycle at low velocity in the morning
• Anuria
• PMH: none
• PSH: none
• Meds: none
• SH: social EtOH use, no tobacco
Our Patient: Further Details on Bicycle Accident

- After more careful questioning, the patient revealed that “in the morning” meant 4am in the morning after heavy drinking at a college party; inebriation had led to the college student’s inability to control her bike.
- During the accident, the student slid forward off her seat, resulting in her pelvis colliding with the bicycle’s cross-bar.
- This additional history will probably help narrow the differential...
Our patient next received an ultrasound (US) of the supra-pubic region to help narrow the differential. US images with significant findings are presented in the following 2 slides...
**Findings**

1. **Free fluid** - anechoic fluid collection suggests urine rather than blood because blood would show internal echoes due to clotting from delayed presentation after injury.

2. **Small Bowel loops floating in fluid**

3. **Shadowing Gas** in large bowel

Transverse US of the RLQ
Our Patient: Collapsed Bladder on US

Findings
- **Free fluid** (urine)
- **Bladder** (collapsed)
- **Uterus**

Sagittal US of the Uterus
Companion patient: Normal US

- **Fluid** (urine) within bladder
- **Uterus**

Sagittal US of the Uterus
Our Patient: Further Workup

- Following US imaging, a Foley catheter was placed
- Drained 2 L of cranberry colored urine (assumed to be bloody urine)

But our patient was anuric... where was the catheter draining from? Our patient received a CT of the region.
Our Patient: Free Fluid on CT
(Image 1 of Coronal Series)

CT Findings
- **Catheter** (entering pelvis)
- **Bladder** (collapsed)
- **Free fluid:**
  Avg Hounsfield Units: 3
  - Bone: 1000
  - Tissue: 40-80
  - Blood: 40
  - **Water** 0
  - Fat: -50 to -100
  - Air: -1000

Q: What’s this?
A: likely a bowel segment
Our Patient: Aberrant Foley Catheter on CT
(Image 2 of Coronal Series)

CT Findings
- **Foley catheter**
- **Bladder** (collapsed)
- **Free fluid** (urine)

Coronal CT of Pelvis
Our Patient: Aberrant Foley Catheter on CT
(Image 3 of Coronal Series)

CT Findings
- **Foley catheter**
- **Bladder** (collapsed)
- **Free Fluid** (urine)

Coronal CT of Pelvis
Our Patient: Intraperitoneal Foley Catheter on CT
(Image 4 of Coronal Series)

CT Findings
- **Foley catheter**
- **Bladder** (collapsed)
- **Free fluid** (urine)

Coronal CT of Pelvis
Our Patient: Bladder Rupture on CT
(Image 5 of Coronal Series)

CT Findings
- Foley catheter
- Bladder (collapsed)
- Free fluid (urine)

Coronal CT of Pelvis
Our Patient: Interim Summary & Diagnosis

- S/p fall from bicycle - blunt trauma to pelvis
- progressive low abdomen/suprapubic pain associated with anuria
- bladder ultrasound identified free fluid in the abdomen with a collapsed bladder
- Cr: 2.5 (baseline 0.8)
- foley placed drained 2L of cranberry colored urine
- CT scan without contrast identified foley catheter in the peritoneum and no other obvious solid organ injuries

Combination of clinical picture and imaging is suggestive of **bladder rupture**

**Question:** Why was her Cr high?
**Answer:** Peritoneal reabsorption due to bladder rupture!

**Note:** bladder rupture was not suspected at the outset because the mechanism of injury (short distance fall) would not normally suggest bladder rupture. This is why social history can be important – given large EtOH consumption, which will fill a bladder rapidly, the history is quite fitting!
Before we continue with our patient, let’s briefly review the classification, imaging, diagnosis, and treatment of bladder injury…
Bladder Injury: Causes

- High-energy blunt trauma that disrupt the bony pelvis
- A direct blow to a distended bladder
- Penetrating injuries (e.g. stab wounds)
- Various iatrogenic causes

Most frequent specific causes are:
- MVA (90%) w/ ejection or seat belt compression on full bladder
- Falls
- Industrial trauma/pelvic crush injuries
- Blows to lower abdomen
Bladder Injury: *Iatrogenic Causes*

The bladder is *the* most frequently injured organ during pelvic surgery.

<table>
<thead>
<tr>
<th>Injury type</th>
<th>Frequency</th>
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<tbody>
<tr>
<td>Vaginal delivery</td>
<td>0.1</td>
</tr>
<tr>
<td>Caesarean section</td>
<td>1.8</td>
</tr>
<tr>
<td>Caesarean section (in Zimbabwe)</td>
<td>17</td>
</tr>
<tr>
<td>Gynaecological surgery (all open)</td>
<td>1.5</td>
</tr>
<tr>
<td>Hysterectomy:</td>
<td></td>
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<tr>
<td>vaginal</td>
<td>9</td>
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<tr>
<td>for radical cancer</td>
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<tr>
<td>obstetric</td>
<td>61</td>
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<tr>
<td>Gynaecological surgery (all laparoscopic)</td>
<td>3</td>
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<tr>
<td>diagnostic</td>
<td>0.1</td>
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<tr>
<td>sterilization</td>
<td>0.2</td>
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<tr>
<td>hysterectomy (all)</td>
<td>10</td>
</tr>
<tr>
<td>Laparoscopically assisted vaginal hysterectomy</td>
<td>28</td>
</tr>
<tr>
<td>TUR of bladder tumour (intraperitoneal)</td>
<td>25</td>
</tr>
<tr>
<td>TURP (intra/extraperitoneal)</td>
<td>0.1</td>
</tr>
<tr>
<td>Laparoscopic bladder neck suspension</td>
<td>19</td>
</tr>
<tr>
<td>Tension-free vaginal tape for urinary incontinence</td>
<td>0.4</td>
</tr>
<tr>
<td>Laparoscopic herniorrha</td>
<td>1.6</td>
</tr>
</tbody>
</table>

Frequency is measured *per 1000 procedures*.

Gomez et al., 2004
Classification of Bladder Injury

**Contusion**
- True incidence unknown*
- Result from damage to mucosa or muscularis w/o full-thickness loss of wall continuity
- Extravasation not apparent on cystography but bladder outline may be distorted
*many either clinically silent and un-dx or manifested by transient hematuria with negative cystography, and receive no treatment

**Intraperitoneal Rupture**
- 38-40% of all ruptures
- Occurs when sudden rise in intravesical pressure 2nd to blow to pelvis or lower abd
- Increased pressure results in rupture of dome (weakest and most mobile bladder part)
- Contrast material and/or fluid seen in peritoneal space

**Extraperitoneal Rupture**
- 54-56% of all ruptures
- Almost exclusively w/ pelvic fractures: bladder usually sheared on ant lat wall near base by the pelvic ring disruption
- Occasionally, lacerated by sharp bony spicule
- Cystography: flame-shaped extravasation in perivesical soft tissues; may also extend to thigh via obturator foramen, to scrotum via inguinal canal, up ant abdominal wall, or retroperitoneally as high as the kidneys
- About 60% of the time, ‘contracoup’ bursting rupture opposite the area of fracture is seen, as well as an injury near the fracture site

**Mixed Intra- and Extra-peritoneal Rupture**
- 5-8% of injuries
- Mainly diagnosed during surgery
Intraperitoneal Bladder Injury: Anatomy

INTRAPERITONEAL RUPTURE
- blow to pelvis or lower abd → sudden rise in intravesical pressure
- pressure → rupture of dome (weakest and most mobile bladder part)
- Fluid/contrast tracks in a cephalad direction within the peritoneal cavity
Companion Patient 2: Intraperitoneal Rupture
(CT Cystogram, Axial Cut)

**INTRAPERITONEAL RUPTURE**
- The contrast has tracked in a cephalad direction within the peritoneal cavity to lie within the **perihepatic** and **perisplenic** spaces
- Contrast also surrounds loops of **small bowel**

Power et al, 2004
Extraperitoneal Bladder Injury: Anatomy

EXTRAPERITONEAL RUPTURE

- pelvic fracture → bladder usually sheared on anterior lateral wall near base by the pelvic ring disruption
- **Extravasation** in perivesical soft tissues; may also extend to thigh via obturator foramen, to scrotum via inguinal canal, up ant abdominal wall, or retroperitoneally as high as the kidneys
EXTRAPERITONEAL RUPTURE

- Extravasated contrast is seen in the space of Retzius dissecting superiorly

Power N et al, 2004
COMPLEX EXTRAPERITONEAL RUPTURE

- Contrast material is also seen in the adductor muscles bilaterally
- bordering the lateral portion of the vagina
- Fractures of the pubis symphysis and left inferior pubic ramus are also noted
We’ve seen imaging studies of injured bladders, but let’s now look at a menu of tests that can be used to evaluate the bladder, as well as a systematic way of approaching patients with suspected bladder injury…
Evaluating Patients with Abdominal Trauma

Abdominal Injury: Hemodynamically stable?

NO: Ultrasound (US) ± Peritoneal Tap reveals Hemoperitoneum?

YES: Abdominal Injury: Alert? Non-intoxicated?

Sources:
1. Isenhour et al., 2007
2. Morey et al., 2001
3. Gomez et al., 2004

- Gross Hematuria w/ Pelvic Fracture on CT or US?
  - Gross Hematuria w/o pelvic fracture
  - Microhematuria w/ pelvic fracture
  - Isolated microhematuria

  AND any of the following?
  - Suprapubic pain or tenderness
  - Inability to void, low urine output, clots in urine
  - Signs of major perineal trauma: swelling or hematoma, blood at urethral meatus
  - Unresponsiveness, intoxication, altered sensation
  - Free intraperitoneal fluid on CT scan or ultrasound
  - Preexisting bladder outlet obstruction, bladder surgery, or bladder abnormality
  - Abdominal distention, hypoactive bowel sounds
  - Increased serum BUN and/or creatinine

  YES: Intraproitoneal Surgical repair (catheter drainage alone only if minimal iatrogenic injury)

  Followup: Cystogram

  YES: Extraperitoneal Catheter drainage + Antibiotics

  Unless:
  - Failure of catheter to provide drainage (e.g. clot)
  - Concomitant vaginal/rectal injury
    - Bladder neck injury
  - If pt undergoing internal fixation of pelvic fracture (prevent infection of ortho hardware)
  - undergoing laparotomy for other injuries + stable enough for surgery

  NO: Gross Hematuria w/o pelvic fracture

  Microhematuria w/ pelvic fracture

  Isolated microhematuria

  YES: NOM or LAP

  YES: Extraperitoneal Catheter drainage + Antibiotics

  Unless:
  - Failure of catheter to provide drainage (e.g. clot)
  - Concomitant vaginal/rectal injury
    - Bladder neck injury
  - If pt undergoing internal fixation of pelvic fracture (prevent infection of ortho hardware)
  - undergoing laparotomy for other injuries + stable enough for surgery

  NO: Serial Exams ± CT

  YES: US – Evidence of Intra-Peritoneal Hemorrhage?

  NO: Abdom: Evidence of Intra-Peritoneal Hemorrhage?

  NO: Stabilize

  NO: Signs of extra-abdominal Hemorrhage? (e.g. pelvic frac, Long bone frac, laceration?)

  YES: Resuscitation then Abd CT: Evidence of Further injury?

  NO: Observe ± Admit

  YES: NOM or LAP

  NO: Observe ± Admit

  YES: NOM or LAP

  NO: Observe ± Admit

  YES: NOM or LAP

  NO: Observe ± Admit

  YES: NOM or LAP
Now that we have an overview of the approach to a patient with abdominal trauma and associated bladder injury, let’s explore in more detail some of the imaging modalities that are used in the process…
Our Patient: Ultrasound (US)

Use:
- integral component of trauma management used primarily to detect free intraperitoneal fluid/blood
- trauma US examination focuses on dependent intraperitoneal sites where blood is most likely to accumulate: the hepatorenal space (ie, Morrison's pouch), the splenorenal recess, and the inferior portion of the intraperitoneal cavity (incl pouch of Douglas)

Advantages
- **Portability**
- **Speed**: trauma assessment performed < 5min
- **Sensitivity** of 65 - 95 % percent in detecting as little as 100 ml of intraperitoneal fluid
- **Noninvasive**
- **Less expensive** than CT or peritoneal lavage

Disadvantages
- Injury to solid parenchyma, retroperitoneum, or diaphragm not well seen
- **Uncooperative patients**, obesity, bowel gas, and subcutaneous air interfere with image quality
- Lower sensitivity in pediatric patients
- Insensitive for detecting bowel injury

Transverse US of the RLQ
Our Patient: Computed Tomography (CT)

Advantages
• Better defines **organ injury** and potential for nonoperative management of splenic and liver injuries
• **Noninvasive**
• Detects not only the presence but the **source** and **amount** of hemoperitoneum
• Active bleeding often detectable
• **Retroperitoneum** and **vertebral** column can be assessed in conjunction with the peritoneum
• **Additional** imaging can be performed when needed (eg, head, cervical spine, chest, pelvis).

Disadvantages
• Suboptimal sensitivity for **pancreatic**, **diaphragmatic**, **bowel**, and mesentery injury
• **IV contrast is needed**; oral contrast is not needed as it rarely adds to diagnostic accuracy and may delay imaging
• Relatively **high cost**
• Can be unobtainable or harmful to obtain in unstable patients

**NOTE:**
• Should be performed in patients who are hemodynamically stable, but whose sensorium or reliability is altered by closed head injury, drug or alcohol intoxication, or significant distracting injury

Coronal CT of Pelvis
Companion Patient 5: Conventional Cystography

- It entails infusion of dilute contrast into the bladder under fluoroscopic guidance; views were obtained during filling, at full distension and after drainage.
- Before advent of CT, it was the only imaging modality available for the diagnosis of bladder injury.
- Although the technique is accurate in experienced hands, it is:
  - time consuming,
  - entails additional movement of the patient and
  - does not provide any information about surrounding structures.
- In addition, the images occasionally can be difficult to interpret, esp in the presence of fixation devices or bony fragments.
- advent of CT and its increasing use in trauma imaging means conventional cystography is now rarely performed, because bladder rupture can be diagnosed accurately at initial CT examination without further imaging or moving of the patient.

Film Findings:
- **Extraluminal contrast** outside confines of the normal bladder and spreading into peritoneal cavity.
- There is also contrast in the **left paracolic gutter** (yellow arrow), not within the bowel.
- **c/w INTRAPERITONEAL BLADDER INJURY**

Power et al., 2004
Companion Patient 4: CT Cystography

- CT cystography is quickly replacing conventional cystography in the evaluation of the injured bladder.
- It also entails infusion of dilute contrast into the bladder just prior to the CT scan.
- Views can either be taken of the bladder specifically, or bladder images from an indicated abdominal scan can be used (i.e., there is no need to perform additional scans through the bladder; this reduces radiation exposure).
- It has been shown to be highly accurate for bladder imaging, with bladder rupture diagnosed in 42 of 44 patients with a sensitivity of 95% and specificity of 100% in one study (Deck 2000).
- Doesn’t involve additional movement of the patient.
- Provides info about surrounding structures.
- Easier to interpret than conventional cystogram.

**COMPLEX EXTRAPERITONEAL RUPTURE**
- Contrast material is also seen in the adductor muscles bilaterally.
- Bordering the lateral portion of the vagina.
- Fractures of the pubis symphysis and left inferior pubic ramus are also noted.

Power et al., 2004
Deck et al., 2000
Now that we have received an overview of classification, diagnosis, imaging, and treatment of a patient with bladder injury, let’s return to our patient!
Our Patient: Treatment

• We left off at knowing that our patient had suffered from injury to the bladder
• We now know the importance of determining whether the rupture is intra- or extra-peritoneal because they are treated differently
• Based on her imaging, her injury is… **INTRA-peritoneal!**
• Our algorithm showed that intraperitoneal bladder ruptures are treated surgically, which is exactly how our patient was treated

Coronal CT of Pelvis
Our Patient: Followup

• To confirm patency of the bladder, a followup cystogram was obtained
• In this case, a conventional cystogram was used (i.e. infusion of diluted contrast into bladder followed by pelvic radiograph)
• What do you think?

**Perfect!**

The filled bladder shows smooth contours with no extravasation of fluid
References

Acknowledgedgements

- Rich Rana, MD
- Gillian Lieberman, MD