Catastrophic Errors and Solutions in the Acute Abdomen and Chest: an Algorithmic Approach

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ALGORITHMIC EVALUATION OF THORACIC AND ABDOMINAL EMERGENCIES

I. Abstract
II. Differential Diagnosis of Thoraco-abdominal Catastrophes
III. Strategic Pathways for Diagnostic Imaging
IV. Case Illustrations
V. Conclusions
Abstract

The evaluation of high risk, catastrophic conditions of the chest and abdomen presents significant challenges in the (1) evaluation of the clinical history, (2) assessment of the physical examination, and the (3) selection of appropriate laboratory and imaging procedures. Significant errors in management arise from multiple pitfalls: the history elicited is potentially incomplete or inaccurate, the physical examination may be misleading, and frequently utilized laboratory, electrocardiographic, and convention radiographic methods are typically neither sensitive nor specific enough to rule in or rule out critical disease processes. Of particular importance to emergency medicine, advances in imaging modalities and new analytic methods promise significant improvements in the precision in and promptness of diagnosis, thus permitting rapid differentiation of serious presentations from benign processes. The focus of this analysis will be to articulate more clearly the assessment of high risk differential diagnoses, and the importance of optimal temporal and parallel sequencing of laboratory and imaging studies in catastrophic thoraco-abdominal disease.
Abdominal and Chest pain are the most common reasons for ED visit: ~12% per NHAMCS 2003

50% of clinical management errors in the emergency department are related to the acute torso (UCSF, 3rd Mediterranean Conference)

Torso pathology (e.g., chest pain and other abdominal-pelvic disorders) comprises the most prevalent malpractice claims over 20 years (PIAA data)
Differential Diagnosis: Parallel Processing of Information

1. **Consider** the high risk differential diagnosis, on the basis of clinical history, physical examination, and laboratory studies.

2. **Concurrently** stabilize, initiate imaging sequence, and/or contact appropriate consultants.

3. **Confirm** benign etiologies *directly*, or indirectly *after* formal exclusion of the catastrophic differential diagnosis.
How are catastrophic conditions defined?

- **Catastrophic** conditions are those which have a significant risk of mortality, if the diagnosis is emergently missed.

- **Urgent** clinical conditions are those which have a significant risk of morbidity, if the diagnosis is delayed (e.g., appendicitis or diverticulitis).
Catastrophic clinical conditions

- Aortic dissection
- Aneurysm rupture
- Infarction
  - MI, PE, or mesenteric thrombosis
- Abdominal hemorrhage
  - ruptured ovarian cyst, ectopic, or solid organ laceration
- Bowel perforation
- Sepsis
Vital Sign Indications for Catastrophic Chest and Abdomen Differential Diagnosis

1. Tachycardia or bradycardia (heart rate <50)
2. Tachypnea or bradypnea (respiratory rate <7)
3. Significant pyrexia or hypothermia
4. Hypotension
5. Acute hypoxia
6. Pain severity
7. Weight loss
Clinical Catastrophic Criteria

- Acuity, severity, progression, persistence, refractory, atypical or unexplained:
  - Critical acute chest symptoms (i.e., chest pain, chest pressure, or respiratory distress)
  - Critical abdominal and pelvic clinical symptoms (i.e., pain, nausea, vomiting, diarrhea, distension, bleeding, or irritability)
  - Selective physical findings (absence of breath sounds, cardiac and pericardial murmurs; altered bowel sounds, masses or peritoneal signs).
  - Aberrant laboratory, electrocardiographic, or plain radiographic abnormalities.
Thoracic Imaging Modalities

- Chest Radiograph: PA/L, AP, Decubitus
- CT: Incremental, Spiral, Angiographic
- US: Gray Scale, Color Doppler, Amplitude Angiography
- Nuclear Medicine
  - Ventilation Perfusion Imaging
  - Myocardial Perfusion Imaging
- MR: MRI and MRA
- Cardiac Catheterization
  - Stenting for coronary thrombosis
# Thoracic Imaging: Critical Diagnoses

<table>
<thead>
<tr>
<th>STRUCTURE</th>
<th>CRITICAL DDx</th>
<th>IMAGING MODALITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pulmonary Artery</td>
<td>Pulmonary Embolism, Neoplastic Compression</td>
<td>CTA/CT</td>
</tr>
<tr>
<td>Aorta</td>
<td>Dissection, Transection, Aneurysm Rupture</td>
<td>CTA/CT</td>
</tr>
<tr>
<td>Pulmonary Parenchyma</td>
<td>Pneumonitis, Pulmonary edema</td>
<td>CXR, CTA/CT</td>
</tr>
<tr>
<td>Pericardium</td>
<td>Pericardial Effusion</td>
<td>CT (stable), US (unstable)</td>
</tr>
<tr>
<td>Coronary Arteries</td>
<td>Acute Coronary Syndromes</td>
<td>CT Angiography(?) NM Perfusion (stable)</td>
</tr>
</tbody>
</table>
1. What type of CT scanner is available at your hospital?

1. 1-slice
2. Multi-slice
3. Not known.
2. For which of the following diagnoses, have you utilized CT Angiography?

1. Aortic or Pulmonary Arterial disease, such as aortic aneurysm or PE
2. Coronary artery disease
Thoracic Imaging: Radiologic Sequence

Imaging evaluation of acute chest processes divides into three typical paths:

1. Chest Radiograph: general survey
2. CT/CTA (e.g., pulmonary embolism, aortic dissection, and acute coronary syndromes)
3. NM SPECT (e.g., lung and myocardial perfusion)
Thoracic Crises: Diagnostic Strategy

Critical Chest Signs/Sx

Clinical Information

Standard Diagnostic Testing

Advanced Imaging Options

Vital Signs

Cardiovascular and Pulmonary History

Auscultation Acoustic Doppler

1. Laboratory

2. ECG

3. CXR

1. CT/CTA

2. NM Imaging

3. Cardiac Catheterization
### Regional Differential Diagnosis in Acute Abdominal Pain

<table>
<thead>
<tr>
<th>Region</th>
<th>Right inferior thorax</th>
<th>Mediastinal</th>
<th>Left inferior thorax</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right upper quadrant</td>
<td>Right upper quadrant</td>
<td>Epigastric</td>
<td>Left upper quadrant</td>
</tr>
<tr>
<td>Right lower quadrant</td>
<td>Right lower quadrant</td>
<td>Inferior abdominal</td>
<td>Left lower quadrant</td>
</tr>
</tbody>
</table>
## Regional Differential Diagnosis in Acute Abdominal Pain

<table>
<thead>
<tr>
<th>Pneumonitis*</th>
<th>Esophagitis*</th>
<th>Pericarditis*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pleuritis*</td>
<td>ACS*</td>
<td>PE*</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hepatitis*</td>
<td>Gastritis*</td>
<td>Colitis*</td>
</tr>
<tr>
<td>Cholecystitis*</td>
<td>Pancreatitis*</td>
<td>Pyelonephritis*</td>
</tr>
<tr>
<td>Peritonitis*</td>
<td>AAA*</td>
<td>Nephrolithiasis*</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Appendicitis*</td>
<td>Cystitis*</td>
<td>Diverticulitis*</td>
</tr>
<tr>
<td>PID*</td>
<td>Ectopic*</td>
<td>Ovarian cyst*</td>
</tr>
</tbody>
</table>
Classical Algorithm for Acute Abdomen

- Acute Abdomen
  - History and PDx
  - Laboratory
  - Conventional Imaging
    - Consultation
    - Initial X-sectional Imaging
      - CT
      - US
    - Secondary Imaging
      - Nuclear Medicine
      - GI Contrast Studies
      - Angiography
3. Which of the following US modalities are available at your institution?

1. Emergency Physician performed US
2. Radiology Department US (24 hours)
3. Radiology Department US (weekday)
4. How much time is required to obtain an emergency US?

1. < 1 hour
2. 1 to 3 hours
3. > 3 hours
4. Not available
Parallel Algorithm for Acute Abdomen

- History and PDx
- Laboratory
- Conventional Imaging
  1. CXR
  2. Abdominal Series
- Imaging
  1. IV, Oral, Rectal
  2. CT Angiography
- US
  1. Color Doppler
  2. Power Doppler
- CT
  1. IV, Oral, Rectal
  2. CT Angiography
- Consultation

Acute Abdomen
# Clinical Pathways for Emergent Abdominal Imaging: Structural Criteria

<table>
<thead>
<tr>
<th>STRUCTURE</th>
<th>EXAMPLE</th>
<th>IMAGING MODALITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluid-filled</td>
<td>Vesicles, ducts</td>
<td>US</td>
</tr>
<tr>
<td>Gas-filled</td>
<td>GI tract</td>
<td>CT or GI series</td>
</tr>
<tr>
<td>Solid organs</td>
<td>Liver, Pancreas, Kidneys</td>
<td>CT</td>
</tr>
<tr>
<td>Vascular</td>
<td>Abdominal Aorta</td>
<td>US (unstable) CT (stable)</td>
</tr>
<tr>
<td>Reproductive</td>
<td>Pregnancy</td>
<td>US</td>
</tr>
</tbody>
</table>
## Acute Abdomen: Imaging Selection

<table>
<thead>
<tr>
<th>PDx / Lab</th>
<th>RUQ T</th>
<th>RLQ T</th>
<th>LUQ T</th>
<th>LLQ T</th>
<th>ADX T</th>
<th>CVA T</th>
<th>Trauma Vascul.</th>
<th>Diffuse T</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hematuria Pyuria</td>
<td>CT</td>
<td>CT</td>
<td>CT</td>
<td>CT</td>
<td>CT</td>
<td>CT</td>
<td>CT+I (O)</td>
<td>CT</td>
</tr>
<tr>
<td>Leukocytosis</td>
<td>US</td>
<td>US(-K)</td>
<td>CT+I/O</td>
<td>CT+R</td>
<td>US</td>
<td>CT ±I</td>
<td>CT+I (O)</td>
<td>CT±I (O) +2H</td>
</tr>
<tr>
<td>Lipase +</td>
<td>CT</td>
<td>CT</td>
<td>CT</td>
<td>CT</td>
<td>CT</td>
<td>CT</td>
<td>CT±I (O)</td>
<td>CT</td>
</tr>
</tbody>
</table>

Div. of Emergency Medicine, UCSF
Case #1, “Mr. S”

- 60 year old male
- c/o dull, burning substernal chest pain with radiation to back and left axilla
- Onset 2 hours prior to arrival while at rest
- PMH: depression
- SH: 40 pack year history cigarettes
- FH: Father MI at age 49
Mr. S

- Vitals: T 37 BP 192/100 P 68 RR 18
- General: Smiling, conversant, no distress
- Lungs: clear, no rales
- Heart: RRR
- Abdo: soft, NT
- Extr: no edema
Mr. S

- Monitor: sinus rhythm
- Oxygen and IV applied
- EKG obtained…
Mr. S

- CXR: normal
- NTG SL and ASA given: no relief
- GI cocktail given: positive relief
- Labs including troponin: negative
- Discharged home
- Dx: GERD
- Follow up advised with primary MD
Mr. S

- Unscheduled return to ED in 2 days
- c/o acute abdominal pain and dyspnea
- Markedly hypotensive (60/30), tachycardic and tachypneic with mottled extremities
- Rapid fluid, blood, and pressor support initiated; intubation required
- ECG obtained...
Mr. S

- Bedside US and Echo performed: normal abdominal aorta; no thoracic dissection, large pericardial effusion
- Urgent cardiac catheterization: tamponade and occluded branch of circumflex, bloody pericardial fluid drained
- Patient stabilized then succumbed 2 days later from PEA arrest
Mr. S

- Autopsy:
  - bloody pericardial effusion
  - acute plaque rupture of LAD, circ and right coronary occlusions
  - Acute lateral transmural myocardial infarct with ruptured left ventricular wall
Missed Diagnosis of Acute Ischemia

- Multi-center 10,689 patients (1993 data)
- 2.1% AMI sent home inadvertently.
  - 53% normal or non-diagnostic EKG
- 2.3% unstable angina sent home inadvertently.
  - 62% normal or non-diagnostic EKG
- Risk adjusted mortality ratio: 1.9 (0.7-4.8)

Pope, NEJM, 2000
Case #2, “Mrs. A”

- 62 year old female
- c/o abd cramping, loose stools, emesis
- poultry consumed night before
- PMH: hypertension
- Nurses’ notes: pain and tenderness in RLQ
Mrs. A

- Vitals: T37.2 BP 135/73 P 64
- Gen: no distress
- Abdomen: mild diffuse tenderness, no peritoneal signs
- Heme negative stool
Mrs. A

- Morphine and Compazine given
- WBC 11K
- ECG: no acute changes
- Dx: Colitis
- Rx: Vicodin/Compazine with prn follow up
Mrs. A

- Unscheduled return 2 days later
- Diffusely tender abdomen
- CT scan: …
Mrs. A

- OR: perforated appendix
- 6 day hospitalization with subsequent pain and wound problems
## Appendicitis

### Clinical Utility of Signs and Symptoms

<table>
<thead>
<tr>
<th>Item</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>LR+ (95% CI)</th>
<th>LR- (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RLQ pain</td>
<td>0.84</td>
<td>0.90</td>
<td>7.31-8.46</td>
<td>0.00-0.28</td>
</tr>
<tr>
<td>Rigidity</td>
<td>0.20</td>
<td>0.89</td>
<td>3.76 (2.96-4.78)</td>
<td>0.82 (0.79-0.85)</td>
</tr>
<tr>
<td>Migration</td>
<td>0.64</td>
<td>0.82</td>
<td>3.18 (2.41-4.21)</td>
<td>0.50 (0.42-0.59)</td>
</tr>
<tr>
<td>Pain before vomit</td>
<td>1.0</td>
<td>0.64</td>
<td>2.76 (1.94-3.94)</td>
<td>NA</td>
</tr>
<tr>
<td>Psoas sign</td>
<td>0.16</td>
<td>0.95</td>
<td>2.38 (1.21-4.67)</td>
<td>0.90 (0.83-0.98)</td>
</tr>
<tr>
<td>Fever</td>
<td>0.67</td>
<td>0.79</td>
<td>1.94 (1.63-2.32)</td>
<td>0.58 (0.51-0.67)</td>
</tr>
<tr>
<td>Rebound</td>
<td>0.63</td>
<td>0.69</td>
<td>1.1-6.3</td>
<td>0.00-0.86</td>
</tr>
<tr>
<td>Guarding</td>
<td>0.73</td>
<td>0.52</td>
<td>1.65-1.78</td>
<td>0.00-0.54</td>
</tr>
<tr>
<td>No similar pain</td>
<td>0.86</td>
<td>0.40</td>
<td>1.50 (1.36-1.66)</td>
<td>0.32 (0.25-0.42)</td>
</tr>
<tr>
<td>Rectal tenderness</td>
<td>0.41</td>
<td>0.77</td>
<td>0.83-5.34</td>
<td>0.36-1.15</td>
</tr>
<tr>
<td>Anorexia</td>
<td>0.68</td>
<td>0.36</td>
<td>1.27 (1.16-1.38)</td>
<td>0.64 (0.54-0.75)</td>
</tr>
<tr>
<td>Nausea</td>
<td>0.58</td>
<td>0.37</td>
<td>0.69-1.2</td>
<td>0.70-0.84</td>
</tr>
<tr>
<td>Vomiting</td>
<td>0.51</td>
<td>0.45</td>
<td>0.92 (0.82-1.04)</td>
<td>1.12 (0.95-1.33)</td>
</tr>
</tbody>
</table>

Wagner, JAMA, 1996
Case #3, “Mrs. D”

- 85 y/o female
- c/o acute back pain
- EMS noted BP of 50 systolic, IV fluids infused en route to ED
- PMH: HTN, CABG, “surgical” lesion in abdomen
Mrs. D

- Vital signs: T 37.2 BP 118/93 P 71 RR 27
- General: diaphoretic, obese female in mod distress
- Abdomen: soft, non-tender
- Back: bilateral flank tenderness
- Pulses: palpable in groins
Mrs. D

- IV fluids given for transient hypotension
- X-rays, labs/urine ordered
  - Hgb: 11g/dl
  - UA: positive for blood and leukocyte esterase
- CT scan (3 hours after arrival):…
Mrs. D

- CT scan: leaking dissecting AAA with retroperitoneal hematoma
- Vascular Surgery notified
- To OR for attempted repair, cardiac arrest on table
Abdominal Aortic Aneurysm

- Accuracy of Physical Exam: screened, asymptomatic patients (3000 pts.)
  - increased sensitivity with size
    - 29% 3-3.9 cm
    - 50% 4-4.9 cm
    - 76% 5cm or greater
  - overall performance (cutoff 4cm)
    - LR+ 15.6 (8.6-28.5)
    - LR- 0.51 (.38-.67)

Lederle, JAMA, 1999
Case #4, “Ms. P”

- 39 y/o female
- c/o LLQ pain radiating to right side for 1.5 days 10/10 intensity
- unprotected intercourse with new partner
- LMP 2 weeks prior
Ms. P

- Vitals signs: T 37.7 BP 111/67 P 66
- Gen: lying very still secondary to pain
- Abdomen: hypoactive bowel sounds, mild tenderness, no rebound or guarding
- Pelvic: no CMT, bilateral adnexal tenderness, no palpable masses
Ms. P

- IV/Labs/urine ordered/Morphine for pain
- Hct 35%
- Patient unable to provide urine specimen
- 4 hours later, urine obtained but inadvertently discarded
- MDs finally aware, add on Beta-HCG
Ms. P

- Beta-HCG: 958
- ED US performed: free fluid in abdomen
- Patient becomes orthostatic and dizzy
- stat Gynecology consult and formal US ordered...
Ms. P

- US: 6 x 4 cm left adnexal mass, abdomen full of blood
- Hct: 16%
- OR: ruptured ectopic, left salpingectomy, 4 units transfused
- Discharged in good condition
## Ectopic Pregnancy

### Utility of Physical Exam

<table>
<thead>
<tr>
<th>Item</th>
<th>LR+ (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Abdominal Exam</strong></td>
<td></td>
</tr>
<tr>
<td>Normal</td>
<td>0.51 (0.40-0.65)</td>
</tr>
<tr>
<td>Tenderness</td>
<td>1.9 (1.3-2.8)</td>
</tr>
<tr>
<td>Rebound</td>
<td>3.7 (2.0-6.7)</td>
</tr>
<tr>
<td>Rigidity</td>
<td>8.0 (1.9-38)</td>
</tr>
<tr>
<td><strong>Speculum Exam</strong></td>
<td></td>
</tr>
<tr>
<td>Normal</td>
<td>0.77 (0.60-1.0)</td>
</tr>
<tr>
<td>Vaginal bleeding</td>
<td>1.3 (1.1-1.6)</td>
</tr>
<tr>
<td>Tissue loss</td>
<td>0.33 (0.04-2.6)</td>
</tr>
<tr>
<td>Bleeding and tissue</td>
<td>0.57 (0.06-5.1)</td>
</tr>
<tr>
<td><strong>Digital Exam</strong></td>
<td></td>
</tr>
<tr>
<td>Normal</td>
<td>0.52 (0.42-0.65)</td>
</tr>
<tr>
<td>Adnexal mass</td>
<td>1.4 (0.48-4.3)</td>
</tr>
<tr>
<td>Pain</td>
<td>2.4 (1.4-4.0)</td>
</tr>
<tr>
<td>Pain and mass</td>
<td>2.3 (0.82-6.4)</td>
</tr>
<tr>
<td>Inconclusive because of pain</td>
<td>7.4 (3.6-15)</td>
</tr>
</tbody>
</table>

Mol, Ferti Steril, 1999
Case Summary: Chest and Abdominal Algorithm Review

- Mr. S (IMI): atypical chest pain in older patients: *imaging of myocardium and coronary anatomy essential*
- Mrs. A (appendicitis): unexplained abdominal pain and leukocytosis in older patients: *CT required.*
- Mrs. D (AAA): unexplained abdominal pain and diaphoresis in older patients: *CT required.*
- Ms. P (ectopic pregnancy): unexplained abdominal pain in women of child-bearing age: *urine or serum B-HCG (cath if necessary) and US required.*
Thoracic Crises: Diagnostic Strategy

- Critical Chest Findings
  - Clinical Information
    - Vital Signs
    - Cardiovascular and Pulmonary History
    - Auscultation
  - Standard Diagnostic Testing
    - 1. Laboratory
      - 1. CT/CTA
    - 2. ECG
    - 3. CXR
  - Advanced Imaging Options
    - 2. NM Imaging
    - 3. Interventional Imaging
Parallel Algorithm for Acute Abdomen

- **History and PDx**
- **Laboratory**
- **Conventional Imaging**
  1. CXR
  2. Abdominal Series
- **Imaging**
  - **US**
    1. Color Doppler
    2. Power Doppler
  - **CT**
    1. IV, Oral, Rectal
    2. CT Angiography
- **Consultation**
5. For a 16 year female with initial symptoms of gastroenteritis, and evolving RLQ pain, the best study to exclude appendicitis with the lowest radiation is:

1. US
2. CT
3. MRI