Imaging In The Adult Patient With Nontraumatic Abdominal Pain

“Abdominal pain – abdominal pain – and abdominal pain. Great. I haven’t even had a cup of coffee yet,” flashes through your head as you look at the charts waiting to be seen. An elderly woman with diffuse abdominal pain is waiting in room 1. When you go into the room, you note that she is in moderate distress and in atrial fibrillation on the monitor at a rate of 90 – 120. Her blood pressure is 100 / 60. You begin to wonder if that’s the best thing to do . . .

There is a young man in room 2 with a complaint of “Throwing up for two days with abdominal pain.” The patient has no past medical problems and claims the pain initially started in the midepigastrum with associated nausea. Today, after throwing up twice, the pain became acutely worse and radiates into his back and left shoulder. On exam, he is afibrile, his blood pressure is 110 / 70, he is tachycardic at 120, and his abdomen is diffusely tender with rebound. Radiology offers to expedite a CT and can get him on the table in one hour; however, you begin to wonder if that’s the best thing to do . . .

In room 3, there is an HIV patient complaining of fevers and severe right flank pain; the pain, which was coming and going in severe spasms for the past 24 hours, has become constant and unbearable this morning. On his last hospital visit one month earlier, his CD4 count was 100 and his creatinine was 1.9. You suspect renal colic, but nothing seems to be simple this morning . . .

Anyone who works in an emergency department (ED) knows that abdominal pain (or some variation of it) is one of the most frequent presenting complaints evaluated. Although it is difficult to truly quantify, it is estimated that abdominal pain accounts for 5 - 10% of all ED visits and that emergency physicians care for nearly eight million patients with abdominal pain each year. 1, 2 The sheer volume of potential diagnoses coupled with the lack of evidence to truly quantify, it is estimated that abdominal pain accounts for 5 - 10% of all ED visits and that emergency physicians care for nearly eight million patients with abdominal pain each year. 1, 2 The sheer volume of potential diagnoses coupled with the lack of evidence . . .

Upon completion of this article, you should be able to:

1. Delineate the problematic issues in the nontraumatic abdominal pain evaluation.
2. Utilize the information to form a logical decision making process in the evaluation of abdominal pain.
3. Be aware of the utility of plain radiographs in the work-up of abdominal pain.
4. Have a greater understanding of the imaging modalities used in the evaluation of nontraumatic abdominal pain.

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CME Objectives

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Evidence-based standards create a dilemma when determining a diagnostic study choice. The question of which radiological modality and when to utilize it is further complicated by the rapid advances in radiologic technology. The goal of this *Emergency Medicine Practice* article is to provide a functional framework for the diagnostic evaluation of the patient with nontraumatic abdominal pain.

**Critical Appraisal Of The Literature**

An electronic literature search of Ovid MEDLINE and PubMed was performed to obtain the references for this publication. The search words abdominal pain, radiology, and imaging were utilized. Disease specific qualifiers and imaging specific qualifiers were cross-referenced to enhance the scope of potential sources for inclusion. The reference section of each article was reviewed for additional reference material pertinent to the subject matter. The majority of studies on abdominal imaging are retrospective in design. Many of the prospective studies identified were observational rather than well designed with a gold standard control.

In 1994, the American College of Emergency Physicians (ACEP) published a clinical policy on the approach to patients presenting with nontraumatic abdominal pain; the clinical policy was updated in 2000 using an evidence-based approach. The task force that created the ACEP clinical policy titled, “Critical issues in the evaluation and management of nontraumatic abdominal pain,” followed a well-established and structured format. They utilized defined criteria to determine evidence-based standards (high degree of clinical certainty supported by strength of evidence), guidelines (moderate clinical certainty based on strength of evidence), and options (based on other evidence with panel consensus) for the emergency medicine community. This expert panel was able to formulate ten “options” and four “guidelines,” but could not establish any “standards” based on the strength of existing literature.

Another excellent practice guideline that the practicing emergency physician should be aware of is by the American College of Radiology (ACR) which formed a consensus committee that assigned evidence-based appropriateness criteria for the use of diagnostic modalities. The ACR Task Force on Appropriateness Criteria was created in 1993 and began developing appropriateness criteria utilizing the attributes for developing acceptable medical practice guidelines developed by the Agency for Healthcare Research and Quality (AHRQ). The AHRQ patterned their methodology after recommendations made by the Institute of Medicine. The ACR’s goal was to develop a system of nationally accepted, scientifically based guidelines to assist radiologists and referring physicians in making appropriate imaging decisions for given patient clinical conditions. Nine diagnostic and eight therapeutic panels were organized. Over 200 physician representatives with a broad representation of experts from within the field of radiology as well as fifteen non-radiology specialties were included on the panels. With guideline development protocols, it is generally accepted that data available from existing scientific studies are usually insufficient for meta-analysis; thus, broad-based consensus techniques are needed for reaching agreement in the formulation of the appropriateness criteria. Eighty percent agreement was considered consensus for the ACR panels. The Appropriateness Criteria™ created by the ACR is referenced throughout the body of this article. Like ACEP, the ACR stresses that the Appropriateness Criteria™ are only guidelines that should be applied within the context of clinical judgment.

**Epidemiology, Etiology, And Pathophysiology**

One of the major difficulties with the abdominal pain evaluation is the vast number of potential differential diagnoses that the provider must consider. A layman’s Google search results in hundreds of etiologies for abdominal pain. The Disease Database lists 529 separate types of abdominal pain. The ICD-9™ has over 800 possible diagnosis codes related to abdominal pain.

The anatomy and innervation of the abdominal structures also compound the difficulty in establishing a diagnosis. Compared to other regions of the body, the abdominal viscera are sparsely innervated so patients are frequently unable to precisely pinpoint the location of their pain. Additionally, most abdominal organs have bilaterally symmetric innervation because they embryonically originate as midline structures. Therefore, many diseased organs present with pain in similar locations. The degree of anatomic innervation varies from patient to patient creating different degrees of pain for patients presenting with the same illness. The range of possible diagnoses and the variability in presentation make it
impossible to utilize a “one size fits all” approach when determining the correct way to evaluate abdominal pain.

The majority of patients presenting to the ED with abdominal pain do not have a life-threatening illness; however, 20 – 25% of patients seen in the ED for abdominal pain will require hospital admission for further evaluation and treatment. Non-specified abdominal pain is one of the most common diagnoses for patients admitted to the ED. A 1972 study of 1000 patients presenting to a university hospital ED found that the surgical residents caring for these patients were unable to make a specific diagnosis in 41.3% of the cases. In 1993, Powers reviewed the records of 1000 patients presenting to a university hospital emergency department with the chief complaint of abdominal pain. He found that the incidence of non-specific abdominal pain or undifferentiated abdominal pain was 24.9%. He linked improvement in technology and EM faculty presence at the university hospital to the increase in assignment of a specific diagnosis. Other studies have shown similar results so whether Power’s temporal associations are correct or not, it is clear that at least 25% of the patients presenting to the emergency department with the chief complaint of abdominal pain are diagnosed with non-specific abdominal pain. Even though the diagnosis of “undifferentiated abdominal pain” is frequent, it has been reported that only 3% of patients discharged from the emergency department with this diagnosis require admission within the subsequent three weeks.

In a derivation study using 165 patients, Gerhart et al attempted to develop a clinical guideline for the work-up of unspecified abdominal pain in order to determine which patients require an urgent intervention. Four guideline models employing history, physical examination, laboratory evaluation, radiology studies, and 54 clinical predictor variables were applied prospectively. The authors concluded, “No clinical guideline was identified, exclusive of non enhanced helical computed tomography that possessed adequate sensitivity for exclusion of urgent intervention.”

**Differential Diagnosis**

Patients presenting to the ED with acute abdominal pain run the gauntlet from mild to severe, benign to life threatening, and simple to complex in terms of presentation, diagnosis, and treatment. There is no simple or expedient way to list every possible differential diagnosis for a patient presenting with the chief complaint of abdominal pain, see **Figure 1** and **Figure 2**. The two-headed arrows used in Figure 2 indicate the recommendation that EM physicians not limit their potential choice of diagnoses based solely on the location of the presenting signs and symptoms within a specific quadrant of the abdomen. Limiting the thought process of making a diagnosis to a specific location can lead to erroneous assumptions and diagnoses.

Appendicitis, cholecystitis, small bowel obstruction, renal colic, and diverticular disease are among the most common diagnoses of patients admitted to the hospital. There is no “classic presentation” or “common history” of disease for many of the patients presenting with acute abdominal pain. For example, appendicitis and abdominal aortic aneurysm have a variety of presenting signs, symptoms, and physical exam findings. Physical examination in patients with ruptured abdominal aortic aneurysm (AAA) can be unreliable; ie, bruits and a palpable abdominal mass may be absent in nearly 25% of the cases. The findings of flank pain and hematuria may lead the clinician to diagnose nephrolithiasis, infection, or etiology other than ruptured AAA.

The elderly or immunocompromised patient presenting to the emergency department can present a unique challenge. A retrospective review of 2406 patients over the age of 50 clearly demonstrated that elderly patients with abdominal pain present differently than younger patients. These patients are more likely to have a serious or potentially life-threatening etiology of their abdominal pain.

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**Figure 1. Diffuse Abdominal Pain: Differential Diagnosis Of Generalized Abdominal Pain**

- Abdominal aortic aneurysm
- Mesentric ischemia
- Perforated viscus
- Ruptured ectopic pregnancy
- Spontaneous bacterial peritonitis
- Inflammatory bowel disease
- Pancreatitis
- Diverticulitis
- Small bowel obstruction
- Metabolic disorders (eg, hypercalcemia, diabetic ketoacidosis)

* List not inclusive of every possible diagnosis
They are also more likely to have increased morbidity and mortality. They frequently have atypical presentations and these atypical presentations can lead to an initial misdiagnosis and an underestimation of the severity of the illness. There is evidence that a delay in diagnosis directly correlates to an increased mortality in elderly patients hospitalized with mesenteric ischemia.

Because the potential differential diagnosis is so large for all patients presenting with abdominal pain, the emergency physician needs to sustain an inclusive thought process until all relevant data (history, physical examination, pertinent laboratory analysis, and appropriate imaging studies) are complete. So-called “premature closure” or “locking in” on a diagnosis before all data are available is a cognitive error that can lead to a negative outcome.

### Prehospital Care

There is very little research on the prehospital care of patients with abdominal pain, even though one retrospective EMS review of 5298 transports revealed that abdominal pain was one of the most frequent patient complaints transported by EMS. Key questions that need to be studied include:

- Which patients with abdominal pain need to be transported by a paramedic based unit?
- Which patients with abdominal pain need to be

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**Figure 2. Localized Abdominal Pain: Differential Diagnosis Consideration For Patients Presenting With Localized Abdominal Pain**

<table>
<thead>
<tr>
<th>Right Upper Quadrant</th>
<th>Left Upper Quadrant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pulmonary embolism</td>
<td>Sigmoid volvulus</td>
</tr>
<tr>
<td>Cecal volvulus</td>
<td>Splenic enlargement</td>
</tr>
<tr>
<td>Cholecystitis</td>
<td>Pulmonary embolism</td>
</tr>
<tr>
<td>Choledocholithiasis</td>
<td>Peptic ulcer disease</td>
</tr>
<tr>
<td>Retrocecal appendicitis</td>
<td>Pancreatitis</td>
</tr>
<tr>
<td>Pancreatitis</td>
<td>Peptic ulcer disease</td>
</tr>
<tr>
<td>Hepatitis</td>
<td>Appendicitis</td>
</tr>
<tr>
<td>Peptic ulcer disease</td>
<td>Cholecystitis</td>
</tr>
<tr>
<td>Inflammatory bowel disease</td>
<td>Colitis</td>
</tr>
<tr>
<td>Nephrolithiasis</td>
<td>Early appendicitis</td>
</tr>
<tr>
<td>Pyelonephritis</td>
<td>Enteritis</td>
</tr>
<tr>
<td>Diverticulitis</td>
<td>Gastritis</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>Gastroenteritis</td>
</tr>
<tr>
<td>Gastritis</td>
<td>Inflammatory bowel disease</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Right Lower Quadrant</th>
<th>Left Lower Quadrant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aortic aneurysm</td>
<td>Aortic aneurysm</td>
</tr>
<tr>
<td>Ectopic pregnancy</td>
<td>Ectopic pregnancy</td>
</tr>
<tr>
<td>Penetrating or perforating ulcer</td>
<td>Appendicitis</td>
</tr>
<tr>
<td>Appendicitis</td>
<td>Bowl obstruction</td>
</tr>
<tr>
<td>Cholecystitis</td>
<td>Ovarian cyst / torsion</td>
</tr>
<tr>
<td>Diverticulitis</td>
<td>Psoas abscess</td>
</tr>
<tr>
<td>Psoas abscess</td>
<td>Pyelonephritis</td>
</tr>
<tr>
<td>Pyelonephritis</td>
<td>Prostatitis</td>
</tr>
<tr>
<td>Nephrolithiasis</td>
<td>Inflammatory bowel disease</td>
</tr>
<tr>
<td>Hernia</td>
<td>Hernia</td>
</tr>
<tr>
<td>Inflammatory bowel disease</td>
<td>Diverticulitis</td>
</tr>
<tr>
<td>Ovarian cyst / torsion</td>
<td>Psoas abscess</td>
</tr>
<tr>
<td>Testicular torsion</td>
<td>Pyelonephritis</td>
</tr>
<tr>
<td>GU infection</td>
<td>Nephrolithiasis</td>
</tr>
<tr>
<td></td>
<td>Hernia</td>
</tr>
<tr>
<td></td>
<td>Inflammatory bowel disease</td>
</tr>
</tbody>
</table>

* List not inclusive of every possible diagnosis
transported to a center with 24 / 7 CT capabilities
• Which patients with abdominal pain have an
underlying vascular emergency and need to be
transported to a center with access to a vascular
surgeon
• Which patients with abdominal pain can be treat-
ed with an analgesic in the field

There are no good outcome studies that provide
guidance on these and other questions. It is clear
that, if a patient is mis-triaged in the field, access to
life saving interventions may be impacted. For
example, if a patient with hypotension and severe
sudden onset abdominal pain radiating to the back is
transported to a hospital without rapid access to a
vascular surgeon, the chance of a good outcome
(repair of the abdominal aneurysm without ischemic
insult) is threatened.

Kennedy et al created a gender and age specific
medical priority dispatch system (MPDS) in an
attempt to determine which patients with abdominal
pain required or would benefit from ACLS transport.
Upon reviewing 343 rescue runs utilizing the gender
and age specific MPDS, they determined that dis-
patch protocols must incorporate information beyond
age and gender classification alone to avoid “over
triage” of patients to an ACLS transport. Lammers et
al created a six tiered dispatch system for patients
with the chief complaint of abdominal pain. The tiers
ranged from no ambulance dispatched, to an ambu-
lance dispatched for every call of abdominal pain, to
protocols with dispatch of an ambulance based on
gender, age, and symptom gradation. Utilizing this
system, the rate of over triage for ACLS transport
was 10 - 51%. The rate of under triage was 4 - 7%.
He concluded that no specific protocol had significant
advantage over the other. The interesting question
that arises from both of these studies is whether these
studies identified the correct range of age and / or
the correct definition of an emergency condition.
Many emergency providers might disagree with the
choice of the age range chosen (35 - 45 years old) and
the definition of an abdominal complaint emergency
(defined as risk of rapid deterioration, significant
morbidity, or death if not treated within one hour),
which necessitated ACLS transfer.

The issue of how to best treat patients with non-
traumatic abdominal pain during transport poses
more questions than answers. Table 1 on page 6
provides general guidelines for prehospital care
based on the best available evidence. Several
authors have suggested that giving analgesia to
patients with the chief complaint of nontraumatic
acute abdominal pain is beneficial and the risk
involved (masking peritoneal signs) is minimal. However, these studies are hospital based and the
use of analgesics is made after an evaluation by a
physician. Pointer and Harlan extrapolated hospital
based findings to the prehospital arena and deter-
mained that EMS personnel could give morphine
sulfate to patients with abdominal pain with no appar-
sent safety or misuse issues, though this awaits vali-
dation by a well designed prospective study.

ED Management

Most emergency departments employ a system of
patient triage. The Emergency Nurses Association
(ENA) supports a comprehensive triage system
based on the utilization of an emergency severity
index. Patients are usually classified as having emergent, urgent, or non-urgent medical needs.
The ENA and ACEP support the use of a triage sys-
tem that then further subdivides the patients into a
five-tiered format based on severity of clinical pres-
tentation, disease risk factors, and available
resources.

The emergency severity index utilizes key ques-
tions to determine triage level and, therefore, patient
placement in the emergency department queue.
These key questions and acuity levels are delineated
in Figure 3 on page 6. Patients with an ESI of 1
should go to a resuscitation room. Patients with an
ESI of 2 should be placed in the next available bed.

Resuscitation, rehydration, control of nausea /
vomiting, and adequate pain control are the main-
stay of the initial management of all patients present-
ing with nontraumatic abdominal pain. A frequent
debate on the management of these patients involves
the early use of analgesics and whether it will nega-
tively impact the evaluation and future reassess-
ments. LoVecchio et al published a study of 49
patients receiving pain medication for abdominal
pain and concluded that the abdominal examination
changes; however, the “change” did not effect the
management of patients with surgical disease.
Several authors from the fields of emergency medi-
cine and surgery have concluded that judicious use
of narcotic analgesia is safe and does not significa-
tly alter peritoneal signs.

One general caveat to remember is that patients
with acute coronary syndrome (especially inferior
wall myocardial infarctions) can present with upper abdominal pain. Therefore, it is generally recom-
mended to obtain an ECG in patients with upper abdominal pain who are at risk for vascular disease.

History
There are several historical features which can impact the decision making process in patients pre-
senting with abdominal pain. Age and gender of the patient are important identifiers to begin the differ-
ential diagnosis. Time of onset, duration of pain, type of pain, and associated signs and symptoms may reveal factors associated with acuity of illness. Acute onset of pain less than 48 hours in duration and of constant nature is more suggestive of a surgical disease process. Vomiting or diarrhea as the initial symptoms may be more indicative of a medical disease process. Previous abdominal surgeries (eg, obstruction, cancer, organ removal), medical illnesses which compromise the vascular system (eg, hyper-
tension, diabetes, connective tissue disease, atrial fibr-
illation), ingested substances which effect the abdominal organs (eg, cholesterol lowering agents, pain medication, alcohol, toxins), or agents which alter the immunologic state of the patient (eg, antibiotics, steroids) need to be identified.

Physical
As with any emergency patient presenting with a potentially life-altering or life-threatening illness, a physical examination for a patient presenting with acute nontraumatic abdominal pain should include general appearance and HEENT, cardiovascular, pul-
monary, abdominal, genitourinary, vascular, and neurologic examination as appropriate.'

Vital signs: Vital signs, especially in the elderly patient, can be misleading. Medications, such as beta-blockers, calcium channel blockers, benzodiazepines, opioids, or homeopathic remedies, can blunt cardiac response to illness or volume loss. Hypothyroidism, loss of vascular responsiveness, autonomic dysfunction, and other chronic disease states can alter the typically expected parameters of a patient responding to a significant illness, pain crisis, or infectious disease. There is significant variation in the accuracy of temperature measures. Infrared tym-
panic membrane thermometers are inaccurate com-
pared to oral temperature measurements and rectal temperature measurements. Oral temperature measurements do not have good linear correlation with rectal temperature measurements, especially

### Table 1. Guidelines For The Prehospital Management Of The Patient With Nontraumatic Abdominal Pain

<table>
<thead>
<tr>
<th>ACLS transport</th>
</tr>
</thead>
<tbody>
<tr>
<td>• There are no published protocols or pre-hospital triage criteria that can accurately determine the need for ACLS versus BLS transport: Age and gender specific dispatch criteria do not accurately predict the need for ACLS transport.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ABCs</th>
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<tbody>
<tr>
<td>• Clinical conditions of abdominal pain manifesting with airway compromise, respiratory compromise, or rapid mental status deterioration usually require airway protection in the form of manual positioning techniques and/or artificial airway protection devices.</td>
</tr>
<tr>
<td>• Supplemental oxygen is indicated in symptomatic, hypoxic patients.</td>
</tr>
<tr>
<td>• Intravenous lines should be started in patients displaying signs or symptoms of hemodynamic instability, dehydration, or electrolyte abnormalities or in patients who may need medications administration.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Analgesia</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Administer narcotic analgesia, under medical direction or clearly written protocols, in patients with severe pain.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Electrocardiographic monitoring</th>
</tr>
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<tbody>
<tr>
<td>• Consider an ECG in patients with co-morbid conditions (ie, coronary artery disease, diabetes, vascular disease).</td>
</tr>
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</table>

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when the patient is mouth breathing, has a high respiratory rate, requires supplemental oxygen, or has an unexplained tachycardia. Lack of a fever in the elderly patient does not reliably differentiate admitted non surgical disease (medical) from surgical disease. In two studies with a total of 348 patients, nearly 13% of elderly patients with a proven surgical etiology as the cause of their abdominal pain did not have a fever.

Abdominal Exam: The location of the abdominal pain and the presence / absence of rebound tenderness should be determined. These findings may help to prioritize the medical decision making process, but should not be the sole indicator to exclude other potential diagnoses. A meta-analysis of 10 studies and nearly 4000 patients reported that rebound tenderness only has a sensitivity of 63% and a specificity of 69% for acute appendicitis. A well done prospective analysis of 686 patients reported similar results for acute appendicitis; it showed that rebound tenderness had a sensitivity of 73% and a specificity of 56%. A separate review of 142 patients reported that rebound tenderness has a sensitivity of 81% and a specificity of only 50% for patients with peritonitis.

Auscultation was found to be neither sensitive nor specific in a prospective study of 1333 patients, but abnormal bowel sounds may be useful in the diagnosis of small bowel obstruction. Abnormal bowel sounds in an elderly patient can be an indicator of serious disease. Rectal examination is frequently performed and may be indicated based on the presenting signs and symptoms (eg, gastrointestinal hemorrhage), but the examiner needs to realize that it does not yield significant diagnostic information for patients with acute appendicitis, peritonitis, or other inflammatory process.

Laboratory Analysis
The usefulness of laboratory testing is impacted by the pretest probability of the disease being considered. Only the ancillary studies that are likely to impact patient management, care, and disposition should be ordered. Laboratory analysis can help guide the practitioner in the decision making process, but should not be the only diagnostic tool. Positive studies should have far more impact on the physician’s decision making process toward final disposition than negative studies.

Parker et al concluded that laboratory screening

had no predictive value for differentiating medical abdominal pain (non surgical) from surgical abdominal pain. The American Gastroenterological Association surmised that laboratory abnormalities were a late finding in mesenteric ischemia occurring only after transmural bowel infarction has occurred; therefore, it could not be used to diagnose mesenteric ischemia in its early stages. The clinical condition of the patient and the risk assessment for each disease process must always be taken into consideration.

Nagurney et al measured the utilization and diagnostic value of the tests ordered by emergency physicians in the evaluation of 124 patients with undifferentiated abdominal or flank pain, see Tables 2 and 3. This study concluded that urinalysis and abdominal-pelvis computed tomography (CT) were the most valuable tests in the evaluation of patients presenting with a chief complaint of nontraumatic abdominal pain. It also highlighted the importance of selecting the appropriate laboratory work up for each patient and the need for vigilant attention to ALL components of the presenting complaint.

| Table 2. Utilization Of The Tests Ordered By Emergency Physicians In The Evaluation Of Patients With Undifferentiated Abdominal Or Flank Pain

<table>
<thead>
<tr>
<th>Test Performed</th>
<th>Total (%)</th>
</tr>
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<tbody>
<tr>
<td>CBC</td>
<td>115 (93)</td>
</tr>
<tr>
<td>Chemistry 7</td>
<td>113(91)</td>
</tr>
<tr>
<td>Urinalysis</td>
<td>94(76)</td>
</tr>
<tr>
<td>Amylase / lipase</td>
<td>71(57)</td>
</tr>
<tr>
<td>Liver function tests</td>
<td>71(57)</td>
</tr>
<tr>
<td>HCG</td>
<td>53(43)</td>
</tr>
<tr>
<td>Abdominal / pelvic CT scan</td>
<td>48(39)</td>
</tr>
<tr>
<td>Abdominal / pelvic US</td>
<td>31(25)</td>
</tr>
<tr>
<td>Plain abdominal x-ray</td>
<td>22(18)</td>
</tr>
<tr>
<td>Blood or urine cultures</td>
<td>8(6)</td>
</tr>
<tr>
<td>Electrocardiogram</td>
<td>5(4)</td>
</tr>
<tr>
<td>Other tests</td>
<td>6(5)</td>
</tr>
</tbody>
</table>

| Table 3. Diagnostic Value Of The Tests As Ranked By Emergency Physicians In The Evaluation Of Patients With Undifferentiated Abdominal Or Flank Pain

<table>
<thead>
<tr>
<th>Test</th>
<th>C: If disposition changed; N = 51</th>
<th>D: If change in #1 diagnosis; N = 46</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abdominal CT scan</td>
<td>22 43%</td>
<td>18 39%</td>
</tr>
<tr>
<td>Urinalysis</td>
<td>8 16%</td>
<td>5 11%</td>
</tr>
<tr>
<td>CBC</td>
<td>5 10%</td>
<td>3 7%</td>
</tr>
<tr>
<td>Ultrasound</td>
<td>5 10%</td>
<td>7 15%</td>
</tr>
<tr>
<td>Liver function tests</td>
<td>4 8%</td>
<td>4 9%</td>
</tr>
<tr>
<td>Plain x-ray</td>
<td>4 8%</td>
<td>4 9%</td>
</tr>
<tr>
<td>Other</td>
<td>3 6%</td>
<td>5 11%</td>
</tr>
<tr>
<td>Total</td>
<td>51/124 = 41%</td>
<td>46/124 = 37%</td>
</tr>
</tbody>
</table>
Diagnostic Imaging Studies

Radiographs (x-ray)

There is no consensus in the literature on what constitutes an appropriate “abdominal series.” A one-view abdominal radiograph provides limited information. A two-view series (supine abdomen (Figure 4) and upright abdominal radiograph) may provide the most information while limiting the radiation exposure to the patient. A three-view series also includes an upright chest radiograph, helps assess for foreign body (e.g., stones, ingested objects) and free air, see Figures 5 and 6. A three-view series is the best choice if the physician utilizes the abdominal radiographs as indicated in the remainder of this paper.

As other diagnostic modalities have become more readily available over the past decade, the role of plain film abdominal radiography has come under question. Access to bedside ultrasound and helical CT has significantly impacted the approach to evaluating the acute abdomen. That said, there is still a defined role for conventional radiography; this role is accentuated when the ordering physician considers why the test is being ordered. If the etiology of the abdominal pain is thought to be due to appendicitis, pyelonephritis, pancreatitis, or diverticulitis, an abdominal series is unlikely to be diagnostic. The sensitivity of abdominal radiographs for these disease processes is zero. However, when abdominal radiographs are performed on patients believed to have bowel obstruction or foreign bodies, the sensitivities jump to 49% for obstruction and as high as 90% for some foreign bodies. Abdominal radiography can be a rapid first line imaging modality to rule in these disease processes. Should the plain films be undiagnostic and the clinical suspicion for obstruction or foreign body remain high, further diagnostic imaging modalities may need to be performed.

Eisenberg prospectively evaluated the abdominal series for 1780 patients presenting with abdominal pain. Only 10% of the radiographs showed evidence of a disease. Evaluation of the patients and their final diagnoses led to the conclusion that limiting the abdominal radiographs to only those patients with moderate to severe abdominal pain and a high clinical suspicion for bowel obstruction, perforation, stones (renal, gallbladder, or ureteral), or foreign body would have eliminated 956 radiologic studies (53.7%) without missing any significant pathologic.

Figure 4. Supine Abdomen Showing Small Bowel Obstruction - Plain Film

Figure 5. Small Bowel Obstruction - Upright Abdomen

Arrows indicate air fluid levels.
process. A similar prospective\textsuperscript{59} study surmised, “A considerable number of plain films taken for patients with acute abdominal pain could be avoided by focusing on clinical variables relevant to the diagnosis of bowel obstruction.” The authors created a clinical decision making algorithm demonstrating their findings, see Figure 7.

In addition to evaluating for obstruction, the upright abdominal radiograph plays an important role in diagnosing free air or pneumoperitoneum, see Figure 8. In one retrospective review of 166 patients with gastro-duodenal perforations\textsuperscript{61}, the abdominal radiograph had evidence of pathologic disease in 85.5\% of the cases. However, the lack of free-air or pneumoperitoneum did not exclude the diagnosis of intestinal perforation since the remaining 14.5\% of patients had gastric perforations diagnosed by additional diagnostic modalities (ultrasound, CT). The lack of an abnormality on conventional radiograph should never dissuade a physician from pursuing the diagnosis of intestinal perforation if the history and clinical presentation strongly suggest this disease process.

There is a growing body of literature showing that when conventional radiographs are compared to other diagnostic imaging modalities, ultrasound (US)\textsuperscript{62,63} and CT\textsuperscript{64-67} have increased diagnostic sensitivity. However, in some emergency departments, US and CT are not available 24 hours a day, while plain films are generally readily available and quickly obtained. US and CT may have significant delays in study interpretation, they have an increased cost, and in the case of CT, increase exposure to ionizing radiation.\textsuperscript{68} For these reasons, the utilization of plain radiographs should not be dismissed and remains a first line diagnostic modality in select cases.

---

**Figure 7. Decision To Perform Abdominal Radiographs**

- Acute abdominal pain
- Medical history
- Physical examination
- Perforation suspected or any two of the following symptoms present
  - Distended abdomen
  - Increased bowel sounds
  - History of constipation
  - Previous abdominal surgery
  - Age over 50
  - Vomitting (Class II)

- Plain radiograph
- No radiograph

---

**Figure 6. Free Air Under Right Diaphragm**

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**Figure 8. Pneumoperitoneum - Upright Abdomen**
Ultrasound / Sonography
Bedside sonography has emerged as a valued diagnostic tool for patients presenting with nontraumatic abdominal pain. Sonographic imaging occurs when sound waves pass through an acoustic window to the area of interest. The waves are either transmitted through the structure / process of interest (appearing black on the sonographic image) or are reflected back to the US probe (appearing white on the sonographic image). It is the degree of transmission and reflection variation for each structure / process of interest that is visualized. Blood, bile, and other fluids transmit the sound waves; since little sound reflects back through these structures, they appear as a black image. Structures like gallstones reflect the sound waves back toward the US probe so stones appear white on the US image. Because minimal sound waves pass through a dense object, such as a gallstone, a darker area of “shadow” may appear distal to the stone.

Unless the emergency physician practices at a trauma center, the majority of US studies are for patients presenting with nontraumatic abdominal pain. As with the acute abdominal series, the diagnostic sensitivity of ultrasound is maximized when it is selectively used. Bassler et al reported that goal-directed abdominal US, “Significantly impacts diagnostic, treatment, and disposition certainty.”

The disease entities most impacted by US examination are abdominal aortic aneurysms (AAA), hepatobiliary disease, pancreatitis, appendicitis, and renal colic.

Abdominal Aortic Aneurysm (AAA): The diagnosis of AAA (defined as a maximal aortic diameter of greater than 3 cm) and ruptured AAA has increased over the last several years. It is estimated that there are 11,000 cases of ruptured AAA each year in the United States. The majority of patients with ruptured AAA do not present with the classic triad of abdominal pain, shock, and pulsatile abdominal mass. Nearly 30% of patients who present to the ED with ruptured AAA are initially misdiagnosed. Early detection of a ruptured AAA with prompt surgical intervention can decrease mortality from 75 to 35%.

The diagnostic time sensitivity for AAA has promoted bedside US applications. Additionally, hemodynamic instability of a patient with a ruptured AAA may preclude transporting the patient to the radiology suite.

“Who should perform the emergent US” is an interesting question, though academic from the patient’s perspective. Some facilities have the capability to send a dedicated ultrasonographer to the ED for rapid patient assessment; many do not. Since the early 1990’s, multiple studies have demonstrated and validated emergency physician proficiency in the bedside US exam for AAA. The measurement of an abdominal aortic diameter of greater than 3 cm on the transverse plane of the US image is diagnostic, see Figure 9. If clinical suspicion is high, a CT evaluation of the aorta may provide a more accurate diagnosis, but US is strongly recommended as an initial imaging modality. See the March 2006 issue of Emergency Medicine Practice “Aortic Emergencies - Part II: Abdominal Aneurysms And Aortic Trauma,” for a comprehensive review of this topic.

Hepatobiliary Disease And Pancreatitis: Ultrasound is considered the imaging study of first choice by the ACR for the assessment of suspected gallbladder disease. It is also the imaging modality of choice for cases of uncomplicated pancreatitis. Visualization of gallstones (cholelithiasis), a sonographic Murphy’s sign, and gallbladder distension are specific for disease of the gallbladder, see Figures 10 and 11. The accuracy of ultrasound is better than scintigraphy with hepato- iminodiacetic acid (HIDA) scan at diagnosing gallstones and hepatobiliary distension.

Appendicitis: A normal appendix is no larger than 6 mm in diameter and should be compressible on US examination. A fluid filled appendix, measurement greater than 6 mm, noncompressibility, and tenderness on US compression of the structure are all con-
sidered positive signs for appendicitis. Non-visualization of the appendix and no tenderness with compression over the site is a strong indication of a negative US exam for appendicitis. However, due to the technical limitations of US imaging (obesity, overlying bowel gas, operator variability), a negative US in the setting of strong clinical suspicion should not rule out the diagnosis. US evaluation for acute appendicitis is a secondary choice for adult patients if CT is available and there are no contraindications to CT.

Renal Colic: Ultrasound evaluation of the kidneys and ureters can be performed to adequately assess a patient presenting with renal colic. Ultrasound evaluation combined with abdominal radiographs replaced the conventional intravenous pyelogram (IVP) in many institutions because it provides similar data, but does not require the administration of intravenous contrast; it's diagnostic sensitivity for hydronephrosis and nephrolithiasis is between 81% and 93%. Renal US is non-invasive and does not expose the patient to ionizing radiation. Although helical CT is replacing the role of ultrasound for the evaluation of renal colic at most institutions due to increased sensitivity for the detection of ureteral calculi, US remains a useful imaging modality for pregnant patients with renal colic or when CT capabilities are limited. Imaging for the pregnant patient is discussed in further detail later in this article.

Trauma: Occult trauma frequently presents as abdominal pain in the elderly. The focused abdominal sonogram for trauma (FAST) examination is utilized to detect hemoperitoneum. Three quadrants are assessed: The hepatorenal fossa (Morison’s pouch), splenorenal fossa (left paracolic gutter), and pelvis (pouch of Douglas). Blood will appear as a black stripe surrounding the liver, spleen or bladder. The FAST examination is now part of ATLS instruction and is considered to be a fundamental part of the preliminary evaluation for patients presenting with traumatic abdominal pain, see Table 4. FAST reaches its highest sensitivity (100%) for hemoperitoneum in abdominal trauma associated with hypotension (Rozycki et al.).

<table>
<thead>
<tr>
<th>Table 4. FAST Detection Of Hemoperitoneum</th>
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<tbody>
<tr>
<td>Study</td>
</tr>
<tr>
<td>Ma et al 91</td>
</tr>
<tr>
<td>Rozycki et al 92</td>
</tr>
<tr>
<td>Smith et al 93</td>
</tr>
<tr>
<td>Shackford et al 94</td>
</tr>
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</table>
In addition to hemoperitoneum, there are a few case reports of the FAST examination being utilized to diagnose diaphragmatic rupture in patients with blunt abdominal trauma. In one report, the diagnosis of diaphragmatic rupture was made in three patients because the diaphragm was poorly visualized and did not move with respiration. Although not part of the official FAST examination, more and more operators are looking at diaphragmatic movement and also assessing for hemothorax by looking above the diaphragm. See the November 2006 issue of *Emergency Medicine Practice* on “Thoracic Imaging” for more detailed information on this subject.

**Scintigraphy With Hepato-Iminodiacetic Acid (HIDA) Scan**

Hepatobiliary scintigraphy is a nuclear medicine study of the gallbladder structures which provides functional images of the cystic and common bile duct structures. An intravenous radiolabeled iminodiacetic acid is injected. The first generation studies utilized hepto-iminodiacetic acid. Many physicians incorrectly refer to all scintigraphy studies as a HIDA scan. There are numerous newer agents (IDA derivatives labeled with $^{99m}$Tc); thus, the correct terminology should be gallbladder scintigraphy unless referring to a scintigraphy performed with hepato-IDA.

With the scan, the radiolabeled agent is taken up by the hepatocytes and rapidly excreted into the biliary system. A well visualized gallbladder within one-hour of injection is considered a normal study. A diagnosis of cholecystitis is made if the gallbladder is not visualized within 60 minutes. A false positive reading (delay in visualization of the gall bladder) can be caused by a recent meal, fasting (vomiting), or an elevated bilirubin level. Kalimi et al retrospectively reviewed 132 patients who had received an US alone, a HIDA scan alone, or a combination of US and HIDA scan. They found a sensitivity of 48%, 86%, and 90% respectively for the diagnosis of cholecystitis. Specificity could not be calculated because all the patients studied had cholecystitis.

Although these results seem to suggest that HIDA scan is a better test compared to US for the diagnosis of cholecystitis, parameters, such as a minimum of a four-hour fast prior to the imaging study, limit the usefulness of these results in an acute setting. In addition, scintigraphy can only be considered when nuclear medicine capabilities are available. Until more research is conducted, scintigraphy has limited utility in the emergency department evaluation of patients presenting with acute abdominal pain.

**Computed Tomography (CT)**

There is no doubt that the widespread use of computed tomography has changed the way emergency physicians practice medicine. In the five-year interval of 2000 - 2005, the number of ED abdominal CT scans increased by 72% at one university tertiary care center. There were also similar or greater increases in the utilization of head, cervical spine, and chest CT at the same institution. It can be argued that the inexperience of resident house staff may result in the over utilization of CT; however, increases of this magnitude are more likely due to the conviction that this imaging modality adds valuable information to the overall patient assessment. The advancement of conventional CT to helical (spiral) CT and now to multi-detector CT (MDCT) has changed the way CT scans are performed and has increased the amount of detailed practical knowledge that a physician can glean from each scan.

Conventional dynamic CT scanning involves a start – stop – start – stop process. The patient takes a deep breath and holds it. A scan slice is performed. The patient then exhales and the table moves the patient a set distance. The process is repeated over and over until the scan is complete. This stop - start - stop - start process creates respiratory variation in each CT slice, which decreases the sensitivity and specificity of the CT for some abdominal disease processes. The diagnoses that can be made by the scan (pulmonary embolism for example) are limited due to respiratory variation, length of scan duration, and technical inability to accurately time IV contrast bolus for time dependent studies. There is also no ability to create two or three dimensional reconstructions. Some smaller hospitals still utilize conventional dynamic CT scanning which emphasizes the importance of understanding the resources available at one’s hospital.

Helical CT allows the entire scan to be performed in one breath hold. The patient takes a breath and the CT table moves continuously in one motion. The entire scan is completed in seconds rather than minutes as with conventional dynamic CT. Reconstruction (creation of two-dimensionsal multiplanar images and three-dimensional shaded surface reconstructions) gives the physician a much more detailed picture of the abdomen. The advent of
the MDCT has further advanced the information each study provides, expanded the number of images that can be created, and increased the potential number of disease states that can be evaluated, especially in the area of vascular diseases.⁹⁹

**Contrast:** There is literature for¹⁰⁰-¹⁰² and against¹⁰³ IV and/or oral contrast for abdominal CT imaging. There are several studies that state that no contrast of any kind is needed for the majority of acute nontraumatic abdominal CT scans.¹⁰⁴-¹⁰⁷ The debate is clouded by questions such as:

- Is it the machine (dynamic vs. helical vs. MDCT)?
- Is it the contrast?
- Is it the interpreter?

Lee et al¹⁰⁸ compared CT of the abdomen and pelvis with and without contrast. Scans were read by different radiologists at different times. There was 79% agreement between the non contrasted CT and the contrasted CT. Analysis suggested that the difference was due more to intra-observer variation rather than bowel opacification.

Clearly, the literature states that contrast is not indicated for suspected renal colic unless an abscess is also suspected. Most published studies advocate the use of IV contrast alone for vascular disease, hepatobiliary disease, and pancreatic disease unless ruptured aneurysm or abscess is suspected. Given the dichotomy in the published literature, it is beyond the scope of this paper to give a definitive answer and the reader must follow protocols at their institution. That said, a clinical pathway of computed tomography and contrast use has been created that is based upon the best available evidence and the ACR recommendations, see Figure 13.

**Intravenous Contrast:** The administration of intravenous contrast media is essential to many radiographic examinations. Iodinated contrast agents include ionic high-osmolar (greater than 1400 mOsm/kg), nonionic and ionic low-osmolar (600 - 850 mOsm/kg), and more recently, nonionic iso-osmolar (290 mOsm/kg) contrast.¹⁰⁹,¹¹⁰ Adverse contrast reactions can be classified as general (systemic) and organ-specific, such as contrast-induced nephropathy.¹¹¹ Due to the decreased risk of both general and organ-specific reactions with nonionic low-osmolar compared with ionic high-osmolar media, nonionic agents are the most popular types of iodinated contrast currently in use.¹⁰⁹,¹¹⁰

**Oral And Rectal Contrast:** The two main types of oral contrast for CT imaging are barium sulfate and water-soluble contrast. Water-soluble contrast is preferred in patients with suspected gastrointestinal tract perforation and it is the usual agent of choice for emergency studies for patients with abdominal pain. Approximately 800 cc to 1000 cc of oral contrast is typically administered. Bowel transit time is variable and, in general, CT scan delays of 60 to 120 minutes from the initiation of oral contrast are utilized. If the scan is delayed by several hours, it is possible for all of the oral contrast to pass into the colon and, depending upon the clinical indication, the administration of additional oral contrast may be helpful to opacify the stomach and small bowel.

Rectal contrast agent is typically a 3% solution of water-soluble contrast in saline that is administered by gravity via a rectal tube while the patient is on the...
In general, up to 1000 cc is administered as tolerated by the patient. A scout view can be obtained to determine if additional contrast is needed to opacify the right colon. The patient is scanned immediately, and the contrast can then be drained from the colon via the rectal tube.

**AAA:** CT (especially helical CT and MDCT) is an excellent way to evaluate the aorta in hemodynamically stable patients presenting with acute abdominal pain, see Figure 14. The aorta is easily visualized, can be accurately measured, and the CT images usually identify vascular leaking (rupture).

**Mesenteric Ischemia:** Mesenteric ischemia usually results from compromise of the arterial vascular system (thrombus, emboli, occlusion), but can be due to occlusion of the venous system, systemic hypoperfusion (cardiogenic shock, sepsis, intravascular depletion), vasculitis, or dissection. Although CT findings in patients with bowel ischemia can be nonspecific, it is the best imaging modality to diagnose mesenteric ischemia. Clark reviewed the CT findings in 22 patients with surgically diagnosed mesenteric ischemia. Bowel wall thickening, bowel edema, air within the bowel wall, mesenteric gas and / or mesenteric fluid were present on the majority of the CT scans performed on his patients. Although none of these radiographic findings are specific for mesenteric ischemia, the presence of one or more of these findings on abdominal CT should strongly suggest bowel ischemia in patients with abdominal pain and risk factors for mesenteric ischemia.

**Hepatobiliary Disease:** CT scanning is useful as an adjunct to US for patients with hepatobiliary disease. CT scan of the right upper quadrant will delineate complications of gallbladder disease, such as an emphysematous or gangrenous gallbladder, see Figure 15. Gas in the wall or lumen of the gallbladder, lack of wall enhancement, and pericholecystic fluid are the most specific CT findings diagnostic for gangrenous gallbladder. A gangrenous gallbladder also has more distension and wall thickening on CT when compared to cases of acute cholecystitis.

**Pancreatitis:** Pancreatitis usually presents with nausea, vomiting, and upper or diffuse abdominal pain. As indicated earlier, US is the imaging modality of first choice for uncomplicated pancreatitis. In cases where the patient has a fever, elevated serum markers, elevated white count, hypotension, severe pain, or evidence of early sepsis, CT is a better choice as it provides more information. CT will show extension of the disease to adjacent soft tissue, hemorrhage within the pancreas, and pancreatic necrosis. It can also identify and localize fluid collections and pseudocysts. The CT evaluation allows the provider to stage the severity of illness and create a continuing care plan based on those findings.

---

**Figure 14. AAA - CT**

**Figure 15. Gangrenous Cholecystitis**
**Renal Colic:** Unenhanced helical CT is recognized as the imaging study of choice for detecting renal stone, ureteral stones, and hydronephrosis associated with renal colic, see Figures 16, 17, and 18.\(^{86,90,134-138}\) It has been shown to be equal to or better than IVP in the detection of stones and hydronephrosis,\(^ {139,142}\) it doesn’t expose the patient to intravenous contrast, and it provides the opportunity to evaluate other potential etiologies of acute flank pain.\(^ {143}\)

**Bowel Obstruction / Perforation / Inflammation:** Although other studies can be used to identify bowel obstruction (Figure 19) and bowel perforation (Figure 20 on page 18), the CT scan is useful because it can identify the site of origin which may modify surgical treatment.\(^ {144}\) CT imaging also gives detailed information about surrounding structures which may be impacted by the disease. Diverticulitis can have a vague presentation that mimics obstruction, perforation, or other intra-abdominal process. Historically, barium enema was used to diagnose diverticular disease; however, CT has now replaced barium enema at most institutions, see Figure 20.\(^ {145-148}\) The degree of detail and the ability to rule out other disease etiologies, such as intra-abdominal abscess formation, (Figure 21 on page 18), give the physician much more information in the decision making process.
Oral and IV contrast are recommended for all these studies.149,151

Appendicitis: Multiple imaging modalities can be used to diagnose appendicitis, but the favored modality of choice is the helical CT scan85 as it has a high degree of diagnostic accuracy. An enlarged fluid filled appendix is diagnostic, see Figure 22 on page 18. Evidence of fat stranding (periappendiceal inflammation) and appendicoliths are suggestive of the disease.100,107 There is considerable controversy on the need for contrast in evaluating the appendix. Is oral contrast needed? Is IV contrast needed? These questions have not been answered definitively.

Part of the controversy is caused by the extremely rapid advances in CT technology (eg, MDCT) and the need for continuing education in the use of that technology. Prior to the advent of helical CT or MDCT, the recommendation was to use both oral and IV contrast for the diagnosis of appendicitis. Evolution in technology has changed - and continues to change - those recommendations.103,107 It is difficult to read the published literature to obtain a definitive answer because many studies are not comparative.

Clinical Pathway: Prehospital Care Of Acute Nontraumatic Abdominal Pain

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Clinical Pathway: ED Evaluation Of Acute Nontraumatic Abdominal Pain

Patient hemodynamically unstable

Resuscitate per ACLS and ED protocol & continue evaluation (Class II)

Physical examination has:
1) Pain less than 24 hours
2) Pain followed by vomiting
3) Guarding / rebound tenderness
4) Advanced age
5) Prior surgical procedure (Class III)

Consider early surgical consultation

YES

Select ancillary laboratory studies based on pre-test differential diagnosis

Laboratory studies confirm diagnosis (Class III)

YES → Treat

NO

Select Diagnostic Imaging Study

Clinical Pathway: Imaging Study Of Choice In Acute Nontraumatic Abdominal Pain

Clinical suspicion for:
- Bowel obstruction
- Foreign body
- Viscus Perforation (Class II)

YES → Radiograph

Clinical suspicion for:
- Gallbladder disease
- Pancreatic disease
- Hx of renal / ureteral calculi
- Appendicitis in pregnancy
- AAA – (quick assessment)
- Ruptured AAA – (hemodynamically unstable) (Class I)

YES → US

NO

Clinical suspicion for:
- AAA
- Ruptured AAA – (hemodynamically stable)
- Appendicitis
- Renal colic
- Diverticular disease
- Intra-abdominal Abscess
- Bowel obstruction – (to delineate origin) (Class II)

NO

YES → CT

The evidence for recommendations is graded using the following scale. For complete definitions, see back page. Class I: Definitely recommended. Definitive, excellent evidence provides support. Class II: Acceptable and useful. Good evidence provides support. Class III: May be acceptable, possibly useful. Fair-to-good evidence provides support. Indeterminate: Continuing area of research.

This clinical pathway is intended to supplement, rather than substitute for, professional judgment and may be changed depending upon a patient’s individual needs. Failure to comply with this pathway does not represent a breach of the standard of care.

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Anderson et al performed a meta-analysis of 23 studies and 3474 patients to determine whether oral contrast was indicated for patients undergoing CT evaluation for appendicitis. Five groups (rectal contrast, oral contrast, rectal and oral contrast, IV and oral contrast, and no contrast) were compiled to generate an aggregate sensitivity and specificity. Anderson’s group concluded, “Noncontrast CT techniques to diagnose appendicitis showed equivalent or better diagnostic performance compared to CT scanning with oral contrast. A prospective, comparative trial of CT with and without oral contrast for appendicitis should be performed to assess the adequacy of the modality.” Facilities with newer generation CT technology should be able to utilize the findings from the Anderson study; however, the wide variation in the types of CT technology in use throughout the country preclude the adoption of this process at every institution.

**Special Considerations**

**Adverse Reactions To Iodinated Contrast And Prevention Strategies**

General adverse reactions can be classified into two types: Acute (within one hour of injection) and delayed (one hour to one week after injection). Mild acute reactions (nausea, vomiting, limited urticaria, warmth, and pain on injection) are of short duration and generally do not require specific treatment. Moderate (symptomatic urticaria, vasovagal, bronchospasm, tachycardia, and mild laryngeal edema) and severe acute reactions (severe vasovagal, moderate and severe laryngeal edema, loss of consciousness, seizures, cardiac arrest, and circulatory collapse) require immediate treatment. The risk of an acute adverse reaction is lower with low-osmolality than with high-osmolality ionic contrast.

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**Figure 20. Perforated Diverticulitis With Evidence Of Pneumoperitoneum**

Small arrows indicate sigmoid diverticulitis. Large arrow shows extraluminal air.

**Figure 21. Right Abdomen Abscess**

Arrow indicates the air fluid level of a large intra-abdominal abscess.

**Figure 22. Appendicitis - CT**

Arrow indicates inflamed appendix with fat stranding.
contrast media, with mild reactions occurring in 3% of patients receiving low-osmolality compared with 15% of patients receiving high-osmolality contrast. Severe reactions are also lower with low-osmolality contrast (0.04 to 0.004%) versus high-osmolality contrast (0.22 to 0.04%).

Delayed reactions can occur as late as 1 - 7 days after the administration of contrast and generally present with cutaneous symptoms, such as rash, pruritis, and urticaria. Other symptoms can include nausea, vomiting, fever, and headache. These reactions are frequently mild and resolve or improve within seven days after radiography, although symptoms can occasionally persist.

Pre-Treatment Of Patients With A History Of Adverse Reaction: A common indication for pre-treatment involves patients with a history of prior allergy-like reactions to contrast media who require an examination with a contrast agent. Although premedication regimens have been shown to decrease the frequency of contrast reactions, no regimen has eliminated repeat reactions completely. According to the ACR Manual on Contrast Media, two frequently used regimens include the use of non-ionic, low-osmolality contrast with pre-medication as follows:

1. Corticosteroid/antihistamine
   Prednisone 50 mg by mouth at 13 hours, 7 hours, and 1 hour before contrast injection plus
   Diphenhydramine 50 mg IV, IM, or by mouth 1 hour before contrast injection

2. Corticosteroid alone
   Methylprednisolone 32 mg by mouth 12 hours and 2 hours before contrast injection; an antihistamine can also be added.

If the patient is unable to take oral medication, 200 mg of intravenous hydrocortisone may be substituted for oral prednisone. In a prospective study of the efficacy of corticosteroids in diminishing toxicity in patients receiving nonionic contrast, Lasser et al found that a 32 mg oral dose of methylprednisolone 6 - 24 hours before and again two hours before contrast medium injection resulted in a reduction of overall reactions to contrast material. This was a randomized, blinded study involving three institutions that was conducted over a three-year period with 1155 subjects successfully completing the protocol. The study group received methylprednisolone and the control group received placebo tablets containing the same materials used as vehicles in the active drug and administered at the same time periods. The demographic characteristics of the two groups were similar and all attending personnel were blinded regarding the premedication. Corticosteroid pretreatment was found to provide protection for overall reactions (1.7% versus 4.9%, \( p = .005 \)) and grade I (mild) reactions (0.2% versus 1.9%, \( p = .004 \)). The ACR recommends that, regardless of the route of steroid administration, steroids be administered at least six hours prior to the injection of contrast medium. In emergency situations, intravenous corticosteroids every four hours plus an H1 antihistamine one hour before the procedure has been used.

Measures To Reduce The Risk Of Contrast-Induced Nephropathy: The major risk factors for contrast-induced nephropathy include pre-existing renal dysfunction, long-standing diabetes mellitus, dehydration, and the use of other nephrotoxic medications. According to the ACR Manual on Contrast Media, recommended indications for serum creatinine measurement prior to the intravascular administration of iodinated contrast media include the following:

- History of kidney disease as an adult
- Family history of kidney failure
- Diabetes treated with insulin or other prescribed medications
- Paraproteinemia syndromes or diseases such as myeloma
- Collagen vascular disease
- Certain medications, such as metformin, non-steroidal anti-inflammatory drugs, and regular use of nephrotoxic antibiotics

Current risk-reduction strategies for contrast-induced nephropathy include volume expansion. However, there is no clear evidence regarding the optimal rate and duration of infusion. A regimen that has been used to reduce the risk of nephropathy consists of 1 - 1.5 mL / kg per hour of intravenous isotonic crystalloid initiated 12 hours before contrast injection and continued for 6 - 24 hours afterward. In an emergency situation, when it is deemed that the potential benefit from an urgent / emergent examination outweighs the risks of waiting, full pre-examination volume
expansion may not be possible, and it is recommended that appropriate post-procedure intravenous fluids be given.158

Another risk-reduction strategy consists of the administration of N-Acetylcysteine at a dose of 600 mg orally twice daily on the day before and the day of the procedure. In a prospective, randomized trial, Tepel et al159 demonstrated that the prophylactic administration of acetylcysteine and intravenous saline helps prevent the reduction in renal function with a nonionic low-osmolality contrast agent in patients with chronic renal insufficiency when compared with placebo and saline. An acute contrast-agent-induced reduction in renal function was defined as an increase in the serum creatinine concentration of at least 0.5 mg per deciliter 48 hours after the administration of the contrast agent.159 Due to the timeframe involved with the prophylactic administration of acetylcysteine, this strategy is less useful in the emergency department setting. While acetylcysteine has shown some benefit in patients receiving low doses of contrast typical for most CT examinations (greater than 140 mL), more conflicting results have been seen in clinical trials with higher doses of contrast.149 It is recommended that acetylcysteine not be a substitute for adequate hydration.153

**Intravascular Iodinated Contrast And Metformin:** Metformin is an oral hypoglycemic used to treat noninsulin dependent diabetes mellitus. It is excreted by the kidneys and a potential adverse effect of this medication is the development of lactic acidosis in the susceptible patient. Any factors that decrease metformin excretion, such as renal insufficiency, may increase this risk. Therefore, if there is a decrease in renal function due to iodinated contrast administration, decreased excretion of metformin could theoretically result in lactate accumulation. Although there have been multiple case reports of the development of lactic acidosis in patients taking metformin, controversy exists over the link between metformin use and lactic acidosis. In the Cochrane database review of 2003, Salpeter et al160 concluded that there was no evidence from prospective comparative trials or from observational cohort studies that metformin is associated with an increased risk of lactic acidosis compared to other anti-hyperglycemic treatments if prescribed per the study conditions and taking contraindications into account. The metformin package insert approved by the U.S. Food and Drug Administration recommends that metformin be discontinued at the time of the examination using intravascular iodinated contrast, be withheld for 48 hours after the procedure, and be reinstated only after renal function has been re-evaluated and found to be normal.161

**Abdominal Pain And The Pregnant Patient**
The pregnant patient presenting with nontraumatic abdominal pain adds dozens of potential diagnoses to the equation. It is also common for typical illnesses (like appendicitis) to present in atypical fashion due to the anatomic changes brought about by an enlarging uterus. Pregnant women develop all the same illnesses of the abdomen that non-pregnant patients develop, but in addition to that broad differential diagnosis, the emergency physician must consider all the pregnancy related causes of abdominal pain. Pregnant patients with abdominal pain do not have the same physiologic response to illness as non-pregnant patients. The decision to use imaging modalities in the pregnant patient and the selection of which modality to use can create consternation for emergency medicine physicians.

In general, imaging studies with the risk of radiation exposure should be ordered selectively in pregnant patients with abdominal pain. If the study does not have a high pre-test probability, it usually should not be performed; in other words, if you don't really need it, don't order it. Abdominal radiographs add little to the diagnostic decision-making process for the majority of nontraumatic abdominal complaints. For cases of suspected renal, gallbladder or uretal stone, ultrasound is the imaging modality of choice for pregnant patients. Intra-abdominal fluid, evaluation of the hepatobiliary disease, measurement of the aorta, evaluation of appendicitis, and fetal well being can all be assessed with US. The sensitivity and specificity of CT may be better than US for many of these diseases, but that needs to be weighed against the risk of radiation exposure to the fetus. If a CT scan of the abdomen must be ordered, it should be done without IV contrast (if possible) and with the mother’s full consent. Iodinated contrast agents have been shown to cross the placenta162 and the effects on the human embryo or fetus are unknown. Therefore, it is recommended by the ACR that there is documentation that there is no other means (such as ultrasoundography) to acquire the information, that the information needed affects the care of the patient and fetus during the pregnancy, and that it is not prudent
to wait to obtain this information until after the patient is no longer pregnant. It is also recommended that informed consent be provided to the patient and documented.  

Obtaining Consent For Contrast Injection
Although there are risks associated with iodinated contrast, these agents are generally considered to be quite safe, and there is controversy regarding the need to obtain informed consent. There are no absolute guidelines for obtaining consent for contrast injection. A survey of the chiefs of radiology at acute-care hospitals in the United States with 100 beds or more was performed in 1983 with a response rate of 40%. The survey showed that 66% of the respondents obtained no type of informed consent before injecting contrast agents. The legal climate has changed considerably in the United States since 1983, and it is possible that the results of this survey would be different if it was conducted today.

It has been recommended that a basic written consent directed at an eighth grade level of education describing the common risks and risk factors be obtained. Alternatively, the patient can be given an information sheet detailing risk factors (such as diabetes, renal dysfunction, prior contrast reaction or allergies) and risks, including the very small risk of death or cerebrovascular accident. The patient can then be informed that if he or she has any questions, a radiologist is available for further discussion.

Appropriateness Criteria™ For Patients With Abdominal Pain
The American College of Radiology created guidelines to assist radiologists and referring physicians in making appropriate imaging decisions for given patient clinical conditions. The formulation of these guidelines was described in the critical appraisal of the literature section at the beginning of this manuscript. There are over 160 criteria in existence or in the process of being developed; Figures 23 – 25 on pages 22 - 24 contain select Appropriateness Criteria™ for complaints relating to nontraumatic abdominal pain. Not every imaging modality listed by the ACR is included in the figures because some imaging modalities may not be readily available for use by the emergency medicine physician. The Appropriateness Criteria™ in entirety may be reviewed by utilizing the references at the end of this issue or through online use of the ACR web page (www.acr.org), keyword: “Appropriateness criteria.”

Cutting Edge And Controversies
CT Angiography
Helical CT technology has undergone rapid developments. MDCT has resulted in shortened scanning times and improved image resolution. This improvement in technology is allowing for much greater diagnostic capabilities for abdominal disease states – and more specifically for vascular disease of the abdomen. Multi-detector row CT angiography (CTA) allows clinicians to view “nearly perfect” three dimensional images of the abdominal vasculature utilizing a non-invasive radiological imaging study. Animal models have shown that CTA is an excellent modality for detecting vascular thrombus responsible for mesenteric ischemia. CTA is being utilized in the diagnosis of ruptured AAA, aortic dissection, intra-abdominal organ hemorrhage, graft fistulas, and mesenteric ischemia. As there is usually a significant time reduction for diagnosing acute abdominal vascular emergencies with CTA as compared to traditional catheter angiography, CTA is rapidly becoming the emergency vascular imaging modality of choice in patients with emergency abdominal conditions.

Emergent MRI
Magnetic resonance imaging (MRI) is becoming more available throughout the country with some EDs having 24 / 7 access. MRI has traditionally been used to evaluate the brain, spine, and musculoskeletal system. Newer and faster MRI techniques have eliminated many of the motion-related issues of MRI making MRI assessment of the abdomen a reality. MRI is better than CT for soft tissue structure discrimination and does not expose the patient to ionizing radiation. While MRI may provide increased information for hepatobiliary disease, pancreatitis, fluid collections, affected vascular area of blockage in AAA or mesenteric ischemia, and appendicitis, the significantly increased cost of MRI compared to CT must be considered. The usefulness of MRI in emergency patients presenting with acute abdominal pain may be low at this time; however, the lack of ionizing radiation in MRI imaging studies makes it an interesting consideration for pregnant patients with nontraumatic abdominal pain.

Documentation
ED documentation is discussed for a variety of reasons, including medical-legal objectives, compliance issues, federal performance standards, and reimburse-
ment. There is some evidence showing that standardized documentation leads to better outcomes for patients presenting with acute abdominal pain. Some investigators have demonstrated that the use of a computer-aided documentation and scoring systems improve sensitivity in diagnosing small-bowel obstructions, renal colic and appendicitis compared to clinical decision making alone. De Dombal looked at published studies of 100,000 patients worldwide and concluded: 1) The diagnosis of acute abdominal pain by inexperienced emergency surgeons (physicians) remains a difficult problem; 2) Doctors who have been assisted by a computer have, in many instances, improved their diagnostic and decision-making performance; and 3) This improvement has not been due to superior “artificial intelligence” of the computer, but due to the computer acting as an education focus and stimulus to good clinical practice. In a separate prospective study of 12,506 patients, de Dombal’s results reconfirmed the results that the use of computer-aided decision support improves the diagnostic and decision making process when evaluating patients with acute abdominal pain.

Emergency Department Billing – US Services For Abdominal Pain

Emergency physicians can (and do) bill for emergency ultrasound services. Unfortunately, it is not as

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**Figure 23. American College of Radiology ACR Appropriateness Criteria™**

<table>
<thead>
<tr>
<th>Radiological Exam Procedure</th>
<th>Appropriate Criteria Scale 1=Least appropriate 9= Most appropriate</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Right Upper Quadrant Pain. Fever, elevated WBC, positive Murphy sign.</strong></td>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
</tr>
<tr>
<td>US, abdomen</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>X-ray, upper GI series</td>
<td></td>
<td></td>
</tr>
<tr>
<td>X-ray, abdomen</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>X-ray, colon, barium enema</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>CT, abdomen</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td><strong>Fever, elevated WBC, positive Murphy sign, normal gallbladder ultrasound.</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CT, abdomen</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>X-ray, abdomen</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>X-ray, upper GI series</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>US, abdomen, repeat within 24 hours</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>X-ray, colon, barium enema</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td><strong>Right Upper Quadrant Pain. No fever, normal WBC.</strong></td>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
</tr>
<tr>
<td>US, abdomen</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>CT, abdomen</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>NUC, cholecsintigraphy</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>X-ray, upper GI series</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>X-ray, abdomen</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>X-ray, colon, barium enema</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td><strong>No fever, normal WBC, ultrasound shows only gallstones.</strong></td>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
</tr>
<tr>
<td>NUC, cholecsintigraphy</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>X-ray, upper GI series</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>CT, abdomen</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>X-ray, abdomen</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>X-ray, colon, barium enema</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td><strong>Acute Pancreatitis. Etiology unknown, first episode of pancreatitis.</strong></td>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
</tr>
<tr>
<td>US, abdomen</td>
<td>X</td>
<td>With or without contrast.</td>
</tr>
<tr>
<td>CT, abdomen</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td><strong>Acute Pancreatitis. Severe abdominal pain, elevated amylase lipase, fever, Elevated white blood cell count.</strong></td>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
</tr>
<tr>
<td>CT, abdomen</td>
<td>X</td>
<td>With or without contrast.</td>
</tr>
<tr>
<td>US, abdomen</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>
easy as checking a box on your treatment record and then sending it off to the billing company with the expectation that they will do the rest. The detailed process will vary from state to state and from hospital to hospital but, in general, if your group wishes to start billing for emergency US, there are a few basic principals that need to be followed.

Your group will need to review any restrictions placed on US billing that the State Office of the Inspector General and/or the State Board of Medicine has placed on emergency physician billing. The majority of states allow emergency providers to bill for US services (in addition to radiology and ECG interpretation); however, depending upon the

<table>
<thead>
<tr>
<th>Radiological Exam Procedure</th>
<th>Appropriate Criteria Scale 1=Least appropriate 9= Most appropriate</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Suspected Small Bowel Obstruction. Suspected complete or high-grade partial SBO.</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CT, abdomen and pelvis without oral contrast with IV contrast</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>X-ray, supine and upright abdomen</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CT, abdomen and pelvis with oral water soluble contrast, with IV contrast</td>
<td>X</td>
<td>Positive contrast in the bowel can obscure the etiology of the obstruction and enhancement of the mucosal bowel lumen</td>
</tr>
<tr>
<td>CT, abdomen and pelvis with oral dilute barium contrast, with IV contrast</td>
<td>X</td>
<td>Positive contrast in the bowel can obscure the etiology of the obstruction and enhancement of the mucosal bowel lumen</td>
</tr>
<tr>
<td>X-ray, small bowel follow-through with oral ingestion</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>US, abdomen</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td><strong>Suspected Small Bowel Obstruction. Suspected intermittent or low-grade SBO.</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CT, abdomen and pelvis with oral water soluble contrast, with IV contrast</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>CT, abdomen and pelvis with oral dilute barium contrast, with IV contrast</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>X-ray, supine and upright abdomen</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>CT, abdomen and pelvis without oral contrast, with IV contrast</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>US, abdomen</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td><strong>Pulsatile Abdominal Mass</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>US, aorta</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>CT, abdomen, with IV contrast</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>CT, abdomen, without IV contrast</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>X-ray, abdomen</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td><strong>Palpable Abdominal Mass</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CT, abdomen</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>US, abdomen</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>X-ray, abdomen, supine</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>X-ray, abdomen, supine and upright</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td><strong>Left Lower Quadrant Pain. Older patient with typical clinical presentation for diverticulitis</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CT, abdomen, with oral and IV contrast</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>CT, abdomen, with oral, IV, and colonic contrast</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>CT, abdomen, without contrast</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>CT, abdomen, with colonic contrast</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>X-ray, abdomen</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>X-ray, water-soluble contrast enema</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>US, abdomen, transabdominal graded compression</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>US, abdomen, transrectal or transvaginal</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>
strength of particular lobbying groups, there may be restrictions within your state of practice.

Your hospital by-laws may contain provisions that will impede or limit the emergency group from performing billing which could compete with other members of the hospital medical staff. Ultrasound billing is somewhat unique in the fact that there are codes for emergency US screening, in addition to codes for complete US examinations.

Credentialing for emergency US privileges will also vary from facility to facility. The operator must demonstrate proficiency in didactics, clinical procedure and the ability to have a consistent quality assurance process in place. ACEP has published an excellent policy statement on emergency medicine ultrasound imaging criteria which can be found at www.ACEP.org.\textsuperscript{178}

The CPT\textsuperscript{179} contains codes for emergency screening ultrasound services. These include the FAST exam, right upper quadrant exam, renal colic evaluation, intrauterine pregnancy, and aortic assessment for AAA among others. The indication for the US examination must be documented to show that the procedure was needed as part of the medical assessment of the patient’s disease process. The scope of the exam (limited, complete) must be included as well. The positive and negative findings of the US must be detailed. The final diagnosis for the US

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**Table 25. American College of Radiology ACR Appropriateness Criteria**

<table>
<thead>
<tr>
<th>Radiological Exam Procedure</th>
<th>Appropriate Criteria Scale</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Acute Onset Flank Pain. Suspicion of stone disease.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CT, kidney, helical, without contrast</td>
<td></td>
<td></td>
</tr>
<tr>
<td>X-ray, kidney, intravenous urography, IVP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>US, renal, with Doppler &amp; KUB</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preferred exam in pregnant &amp; allergic patients.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>X-ray, abdomen, KUB</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Most useful in patients with known stone disease.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right Lower Quadrant Pain. Fever, leukocytosis, classic presentation clinically for appendicitis in adults</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CT, abdomen, with IV contrast</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CT, abdomen, without contrast</td>
<td></td>
<td></td>
</tr>
<tr>
<td>US, abdomen RLO, graded compression</td>
<td></td>
<td></td>
</tr>
<tr>
<td>X-ray, abdomen, AP and upright</td>
<td></td>
<td></td>
</tr>
<tr>
<td>X-ray, chest</td>
<td></td>
<td></td>
</tr>
<tr>
<td>US, pelvis and endovaginal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>X-ray, barium enema, air contrast</td>
<td></td>
<td></td>
</tr>
<tr>
<td>X-ray, barium enema, single contrast</td>
<td></td>
<td></td>
</tr>
<tr>
<td>X-ray, small bowel, enteroclysis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acute Right Lower Quadrant Pain. Fever, leukocytosis, possible appendicitis, atypical presentation, adults and adolescents.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CT, abdomen, with IV contrast</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CT, abdomen, without contrast</td>
<td></td>
<td></td>
</tr>
<tr>
<td>US, abdomen RLO, graded compression</td>
<td></td>
<td></td>
</tr>
<tr>
<td>US, pelvis and endovaginal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>X-ray barium enema, air contrast</td>
<td></td>
<td></td>
</tr>
<tr>
<td>X-ray, barium enema, single contrast</td>
<td></td>
<td></td>
</tr>
<tr>
<td>X-ray, small bowel series, with barium</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crohn’s Disease. Adult; initial presentation (abdominal pain, fever, or diarrhea); Crohn’s disease suspected.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CT, abdomen and pelvis with neutral oral contrast, IV contrast (CT enterography)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CT, abdomen and pelvis, oral contrast</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CT, abdomen and pelvis, with positive contrast, IV contrast</td>
<td></td>
<td></td>
</tr>
<tr>
<td>X-ray, abdomen, supine and upright</td>
<td></td>
<td></td>
</tr>
<tr>
<td>X-ray, colon, barium enema, with air contrast</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
must be documented and the operator must sign the procedure. A hard copy of the examination may be needed for quality assurance reasons, but is generally not required for billing; however, the CPT code language for most ultrasounds includes image archiving, so most billing companies advocate keeping a copy (electronic or print) of the actual image.

**Disposition**

The majority of patients presenting to the ED with nontraumatic abdominal pain are found to have treatable / benign causes for their abdominal pain. Approximately 20% of patients will require hospital admission for further evaluation and / or surgical intervention.3

**Consultation**

There are no clear rules on who and when to consult; the number of potential diagnoses and varied presentations for the spectrum of disease for patients with acute abdominal pain are too vast. However, Brewer et al12 did identify five factors that, on retrospective review, helped identify the patients with an acute surgical abdominal and surgical disease confirmed in the operating suite. These factors were 1) Pain for less than 24 hours; 2) Pain followed by vomiting; 3) Guarding and rebound tenderness on physical examination; 4) Advanced age; and 5) A prior surgical procedure. It would seem prudent to consider surgical consultation for patients with these signs and symptoms.

**Follow Up**

Patients that are discharged with a known disease entity need follow up as dictated by the specific disease process. Patients that are discharged with undifferentiated abdominal pain should have specific discharge instructions with parameters for when to return to the ED in addition to timely (24 - 48 hour) follow up for re-evaluation.5

**Case Conclusions**

The elderly woman in room 1 with diffuse abdominal pain and atrial fibrillation is concerning. She has an unremarkable abdominal examination but the severity of her complaint, the blood pressure reading on the lower end of normal (100 / 60), the potential vascular compromising illness (atrial fibrillation), and her age increase the likelihood that a surgical etiology is the cause of her abdominal pain. Although abdominal radiograph could be considered, the imaging study most likely to yield the correct diagnosis is an abdominal CT with intravenous contrast (or emergency CTA if available) to assess her aorta and vascular patency to rule out AAA and mesenteric ischemia.

The young man in room 2 who has been throwing up for two days has unimpressive vital signs (except for his tachycardia) and no historical risk factors for severe illness. He has only thrown up twice today. However, he does report that the pain got acutely worse and his abdominal examination tells you “something” is going on in the abdomen. In a busy ED, it is tempting to let the nurses do the standard abdominal work-up of blood analysis and agree to the offer from radiology to expedite his abdominal CT. Yet laboratory analysis is unlikely to reveal anything of significance and CT is not the imaging study of first choice in this patient. The diagnosis of perforation is high on the differential for our young man. A three-view abdominal radiograph will (usually) quickly confirm the diagnosis of perforation. This rapid diagnosis allows for early surgical consultation, better coordinating of further imaging studies, and / or a trip to the operating room.

The gentleman in room 3 presents more of a diagnostic challenge. His immunocompromized status leaves him open to numerous infectious possibilities ranging from a simple urinary tract infection to pyelonephritis to an intra-abdominal abscess. Retroviral medications can have a toxic effect on abdominal organs. And, he could have any of the surgical or nonsurgical causes of abdominal pain. His pain

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**Key Points**

- A two-view abdominal radiograph series (supine and upright abdomen) is useful in evaluating obstruction, foreign bodies, and intestinal perforation.
- The ultrasonographic FAST examination is recommended for the initial imaging study in the evaluation of hemoperitoneum.
- Bedside US is useful in the evaluation of AAA and gallbladder disease and may be used to diagnose acute appendicitis when CT is unavailable or contra-indicated.
- US evaluation, especially when combined with abdominal radiograph, remains a valuable tool in the assessment of renal colic.
- Non-contrast helical CT is the imaging study of choice for renal colic.
- IV contrast is indicated for vascular disease and assessment of the hepatobiliary system.
- Oral and IV contrast is usually recommended for diverticular disease.
- Allergic reaction to contrast media should be treated by stopping the stimulus and treating the patient with corticosteroids, antihistamines, and H1 blockers. More aggressive steps are required if the patient presents with anaphylaxis. (See our October 2005 article on allergies).
is localized to the right flank area, he has a fever, and his creatinine was 1.9 last month making a study with intravenous contrast less desirable. The trick is to determine which imaging study will give you “the biggest bang for your buck.” In this scenario, urinalysis, creatinine measurement, laboratory analysis, and IV hydration can be started at the same time you order a renal ultrasound. Ultrasound is a good imaging modality for hydronephrosis, evaluation of the kidney, and assessment of infection (or masses) contiguous to the kidney. There is a high likelihood that US will be diagnostic. If the ultrasound is non-diagnostic, a CT (either without or with contrast) can be considered. Certainly, a noncontrast CT can be utilized as the first imaging modality; however, if it is undiagnostic in this patient at risk for intra-abdominal abscess, many radiologists will be reluctant to repeat the CT with contrast due to the ionizing radiation exposure. For a patient with less risk for intra-abdominal infection and a higher suspicion for renal colic, CT without contrast would be the imaging study of choice.

References

Evidence-based medicine requires a critical appraisal of the literature based upon study methodology and number of subjects. Not all references are equally robust. The findings of a large, prospective, randomized, and blinded trial should carry more weight than a case report.

To help the reader judge the strength of each reference, pertinent information about the study, such as the type of study and the number of patients in

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Pitfalls To Avoid

1. “His belly wasn’t very impressive.”
The physical examination can be misleading in many causes of abdominal pain, especially in the elderly or immunocompromised.

2. “The CBC was normal.”
All laboratory tests should be considered in the context of the potential disease process. A negative CBC in and of itself does not rule out an inflammatory or infectious process.

3. “I thought the nurse ordered the pregnancy test.”
A pregnancy test should be ordered and reviewed on women of childbearing age.

4. “X-rays of the abdomen are a thing of the past. I just go straight to CT.”
CT may provide more information depending on what disease process is most likely. However, in patients presenting with signs of perforation, foreign body ingestion, or SBO, it may be prudent to order abdominal radiographs first to potentially make the diagnosis and assist with choice of later imaging modality (nonenhanced vs. contrast enhanced CT).

5. “I wanted to get an ultrasound to evaluate a pregnant patient with flank pain and hematuria, but the urologist wanted a KUB.”
According to the ACR Appropriateness Criteria™, renal ultrasound is the preferred examination in pregnant patients with flank pain.

6. “The radiologist didn’t see the appendix on US, so I told the patient he could go home.”
A non-visualized appendix may be due to patient body habitus or overlying bowel gas and can be operator dependent. The negative predictive value of ultrasound for appendicitis (generally reported in the 70 - 75% range) is much lower than its positive value (above 90%). This is when the appendix is visualized. Failure to visualize the appendix on ultrasound does not rule out appendicitis, and necessitates further evaluation (usually with CT scan). No tenderness over the appendix with ultrasound probe compression is needed in addition to a non-visualized appendix to be considered a negative US. Clinical decisions should not be based on US alone.

7. “The patient was allergic to contrast so I couldn’t order a CT.”
Contrast allergy is usually due to the intravascular administration of an iodinated agent. Intravenous contrast is not required for many CT studies. Additionally, with the advent of newer generation CT technology, some radiologists are not using intravascular (or oral contrast) for abdominal CT imaging. Knowledge of available resources and communication with the radiologist interpreting the study is key to obtaining the appropriate study for your patient.

8. “The surgeon said that the patient needed oral contrast for the abdominal CT because the bowel obstruction was so bad.”
Oral contrast is not recommended as a first line choice for patients with high-grade or complete bowel obstructions. It may be useful for patients with partial SBO.

9. “The patient only had belly pain. The work-up was negative so I let him go home. He came back three days later with a perforated appendix. He should have known to follow up with his physician.”
Every patient discharged with undifferentiated abdominal pain should be given clear instructions for follow up. This includes specific instructions on when to return to the ED if the patient’s clinical condition worsens.
the study, will be included in bold type following the reference, where available. In addition, the most informative references cited in this paper, as determined by the authors, will be noted by an asterisk (*) next to the number of the reference.

1. McCaig LG, Stussman BJ. National Hospital Ambulatory Medical Care Survey: 1996 Emergency Department Summary. Advance Data from Vital and Health Statistics 1997; 293. (Vital statistics reports)


50. AGA technical review on intestinal ischemia. *Gastroenterology* 2000;18:954-68. (Consensus document, evidence based)


119. Alpern BM, Glazer GM, Francis IR. Ischemic or infarcted bowel: CT findings Radiology 1988;166:149-52. (Retrospective review, 23 records)


635. (Pictorial essay)


**CME Questions**  

17. Abdominal pain accounts for what percentage of emergency department visits each year?  
   a. 1 - 5%  
   b. 5 - 10%  
   c. 10 - 15%  
   d. 15 - 20%  

18. Of the patients presenting to the emergency department with nontraumatic abdominal pain, the percentage of patients that are diagnosed with undifferentiated or non-specific abdominal pain is approximately:  
   a. 5%  
   b. 10%  
   c. 20%  
   d. 25%  

19. ACR appropriate criteria are based upon:  
   a. Copious prospective, randomized, controlled, multi-centered trails  
   b. Consensus documents of academic experts  
   c. Consensus documents utilizing a grading system of the strength of evidence from published studies  
   d. Review of major textbooks  

20. The most accurate means of assessing temperature measurements is (are):  
   a. Infrared tympanic membrane probes  
   b. Orally  
   c. Rectally  
   d. Either oral or rectal as there is good linear correlation between the two  

21. Physical examination in patients with nontraumatic abdominal pain:  
   a. Should not be used to exclude potential differential diagnoses based on location of pain  
   b. Can be reliably used to eliminate diagnoses  
   c. Is very accurate for identifying specific disease entities  
   d. Has no role in the decision making process  

22. According to the ACR’s Appropriateness Criteria Scale, the study of choice in a young, afebrile man presenting with his first episode of uncomplicated pancreatitis of unknown etiology should be:  
   a. Ultrasound  
   b. CT  
   c. Upper GI series  
   d. HIDA scan  

23. Abdominal radiographs are:  
   a. Useless in the evaluation of patients presenting with nontraumatic abdominal pain  
   b. Sensitive for pancreatitis  
   c. Useful for patients with a high clinical suspicion of bowel obstruction or foreign body  
   d. Considered a standard of care for patients with acute nontraumatic abdominal pain  

24. The acoustic qualities of hemoperitoneum on US cause it to appear:  
   a. Black  
   b. White  
   c. White with underlying black “shadowing”  
   d. Gray and white speckled  

25. The imaging modality of choice for patients with suspected gallbladder disease is:  
   a. Plain film  
   b. US  
   c. Unenhanced CT  
   d. CT with contrast  

26. Which of the following is correct about abdominal US?  
   a. Non-visualization of the appendix rules out acute appendicitis  
   b. US is the imaging modality of choice to diagnose acute appendicitis  
   c. A normal appendix is usually less than 6 mm  
   d. Pain over the appendix with US compression is 100% accurate at diagnosing acute appendicitis  

27. Which imaging modality is not suggested for the evaluation of renal colic?  
   a. KUB with IVP  
   b. US  
   c. Non-enhanced helical CT  
   d. Contrast enhanced helical CT  

28. Suspected ruptured AAA in the hemodynamically stable patient is best evaluated with:  
   a. Abdominal radiographs  
   b. US  
   c. Non-enhanced helical CT  
   d. Contrast enhanced helical CT  

29. One of the main problems with the interpretation of non-contrast helical CT is:  
   a. Delay in scanning  
   b. Insufficient timing between contrast administration and performance of CT  
   c. Respiratory variation between images  
   d. Intra-observer interpretation variability  

30. The risk of IV contrast reaction during a CT scan is:  
   a. Lower with high-osmolality ionic contrast media  
   b. Eliminated with corticosteroid / antihistamine pre-treatment  
   c. Lower with low-osmolality ionic contrast media  
   d. Is equal for both types of contrast media
31. Narcotic analgesia in patients with nontraumatic abdominal pain:
   a. Is contra-indicated
   b. May be given if non-steroidal anti-inflammatory drugs are tried first
   c. Masks peritoneal signs of abdominal pain
   d. May be administered with minimal risk of masking peritoneal signs

32. In general, the imaging modality of choice for pregnant patients presenting with nontraumatic abdominal pain is:
   a. Abdominal radiograph with shielding of the uterus
   b. Ultrasound
   c. CT without IV contrast
   d. CT with IV contrast and the mother’s consent

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