ABDOMINAL PAIN AND ABDOMINAL MASS

Blake D. Babcock, MD, Mohammad F. Shaikh, MD, Alexander E. Poor, MD, and Wilbur B. Bourne, MD*

Acute abdominal pain and abdominal masses are two clinical entities that are intimately interconnected. In many cases, abdominal pain and abdominal mass clinically present together. Therefore, the diagnostic process for evaluating abdominal pain and abdominal masses is largely the same and has been preserved since ancient times. The varied differential diagnosis of such pathology was discussed in the Ebers Papyrus (ca. 1500 BC). Egyptian medical scholars kept detailed notes chronicling the conditions encountered and describing the methods of abdominal examination that were based on studies of basic anatomy and embalming practices. Centuries later, in his Book of Prognostics, the Greek-physician Hippocrates (ca. 400 BC) discussed the prognostic significance of various types of abdominal findings:

The state of the hypochondrium is best when it is free from pain, soft, and of equal size on the right side and the left. But if inflamed, or painful, or distended; or when the right and left sides are of disproportionate sizes; all of these appearances are to be dreaded. A swelling in the hypochondrium, that is hard and painful, is very bad…. Such swellings at the commencement of disease prognosticate speedy death. Such swellings as are soft, free from pain, and yield to the finger, occasion more protracted crises, and are less dangerous than others.2

Along with the basic methods of clinical evaluation known since antiquity, the modern surgeon has an armamentarium of sophisticated diagnostic studies that aid in the detection, diagnosis, and appropriate treatment of these frequently overlapping clinical entities. The primary goals in the management of patients with abdominal pain and/or an abdominal mass are (1) to establish a differential diagnosis through obtaining a clinical history, (2) to refine that differential diagnosis with a physical examination and appropriate studies, and (3) to determine the role of operative intervention in the treatment or refinement of the working diagnosis.

Diagnosis

As has been said of many professions besides surgery, “You must know the territory.” A sound understanding of the normal anatomy is essential for the evaluation of the abdomen as particular abnormalities tend to be associated with particular regions or quadrants of the abdomen.

In general, the term abdominal in relation to pain and masses refers to processes that lie anterior to the paraspinal muscles in a region bordered by the costal margins, the iliac crests, and the pubic symphysis. One method of description divides the abdomen into nine areas: epigastric, umbilical, suprapubic, right hypochondriac, left hypochondriac, right lumbar, left lumbar, right inguinal, and left inguinal.3 Our preferred method divides the abdominal cavity into four quadrants—right upper, right lower, left upper, and left lower—and makes specific reference to the epigastrium and the hypogastrum as necessary. This method of description also includes masses discovered within the retroperitoneal and the abdominal wall. For practical purposes, the abdominal wall begins from the diaphragm superiorly and continues inferiorly to the pelvic cavity through the pelvic inlet. The anterior, posterior, and lateral boundaries of the abdominal wall should be familiar to surgeons. For accurate assessment of the origin and character of the abdominal complaints, it is essential to possess a thorough understanding of the normal anatomy, the anatomic variations that may be observed, and the distortions that may be caused by the various potential disease processes, both intraperitoneal [see Table 1] and extraperitoneal [see Table 2]. Further anatomic detail is available in other sources [see Figure 1].4,5

CLINICAL HISTORY

A careful and methodical clinical history should be obtained in the patient with abdominal complaints. Key features of the history include the dimensions of abdominal symptoms (i.e., mode of onset, duration, frequency, character, location, chronology, radiation, and intensity) and the presence or absence of any aggravating or alleviating factors and associated symptoms. Often such a history is more valuable than any single laboratory or x-ray finding and determines the course of subsequent evaluation and management.

Unfortunately, when the ability of clinicians to take an organized and accurate history has been previously studied, the results have been disappointing.6 For this reason, the use of standardized history and physical forms, with or without the aid of diagnostic computer programs, has been recommended.7–10 A large-scale study that included 16,737 patients with acute abdominal pain demonstrated that integration of computer-aided diagnosis into management yielded a 20% improvement in diagnostic accuracy, as well as statistically significant improvements in the delivery of quality care.7 An example of a structured data sheet is a standardized pain chart assessment developed by the World Organization of Gastroenterology (OMGE) [see Figure 2]. Because this pain chart is not exhaustive, individual surgeons may want to add to it; however, they would be well advised not to omit any of the symptoms and signs on the OMGE data sheet from their routine examination of patients with acute abdominal pain.11

The patient’s own words often provide important clues to the correct diagnosis. The examiner should refrain from suggesting specific symptoms, except as a last resort. Any

* The authors and editors gratefully acknowledge the contributions of the previous authors, Alex Nagle, MD, FACS, and Michael E. Zenilman, MD, FACS, to the development and writing of this topic review.

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DOI 10.2310/7800.2001

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Assessment of Acute Abdominal Pain and Abdominal Mass

Generate working diagnosis
Proceed with subsequent management on the basis of the working diagnosis. Reevaluate patient repeatedly. If patient does not respond to treatment as expected, reassess working diagnosis and return to differential diagnosis.

Obtain clinical history
Assess mode of onset, duration, frequency, character, location, chronology, radiation, and intensity of pain. Look for aggravating or alleviating factors and associated symptoms. Use structured data sheets if possible.

Perform basic investigative studies
Laboratory: complete blood count, hematocrit, electrolytes, creatinine, blood urea nitrogen, glucose, liver function tests, amylase, lipase, urinalysis, pregnancy test, ECG (if patient is elderly or has atherosclerosis)
Imaging: plain abdominal radiographs, US, CT, MRI, PET
Tissue Diagnosis: percutaneous image–guided biopsy or endoscopic ultrasound–guided biopsy

Patient presents with acute abdominal pain and mass

Acute surgical abdomen
Conditions necessitating immediate laparotomy include ruptured abdominal aortic or visceral aneurysm, ruptured ectopic pregnancy, spontaneous hepatic or splenic rupture, major blunt or penetrating abdominal trauma, and hemoperitoneum from various causes. Severe hemodynamic instability is the essential indication.

Emergent laparotomy
Definitive operative management as indicated

Subacute surgical abdomen
Conditions necessitating urgent laparotomy include perforated hollow viscus, appendicitis, Meckel diverticulitis, strangulated hernia, mesenteric ischemia, and ectopic pregnancy (unruptured). Laparoscopy is recommended for acute appendicitis and perforated ulcers (provided that surgeon has sufficient experience and competence with the technique).

Urgent laparotomy or laparoscopy
Definitive operative management as indicated
Generate tentative differential diagnosis

Remember that the majority of patients will turn out to have nonsurgical diagnoses.
Take into account effects of age and gender on diagnostic possibilities.

Perform physical examination

Evaluate general appearance and ability to answer questions; estimate degree of obvious pain: note position in bed; identify area of maximal pain; look for extra-abdominal causes of pain and signs of systemic illness.
Perform systematic abdominal examination: (1) inspection, (2) auscultation, (3) percussion, (4) palpation.
Perform rectal, genital, and pelvic examinations.
Evaluate an abdominal mass in terms of location, size, shape, consistency, contour, presence or absence of tenderness, pulsatility, and fixation.

Nonsurgical abdomen

Nonsurgical conditions causing acute abdominal pain include intraperitoneal [see Table 1] and extraperitoneal [see Table 2] disorders.

Observation

Observe patient carefully and reevaluate condition periodically.
Consider additional investigative studies (e.g., CT, US, diagnostic peritoneal lavage, radionuclide imaging, angiography, MRI, and GI endoscopy).

Indeterminate surgical abdomen

Staging Laparoscopy: In select patients, this strategy can avoid the morbidity of a large laparotomy and allow earlier initiation of systemic or locoregional therapy for abdominal mass associated with malignancy.
Diagnostic Laparoscopy: Recommended when surgical cause of abdominal pain is suspected but its probability is not high enough to warrant open laparotomy. It is also useful for assessing acute abdominal pain in acutely ill patients in the intensive care unit.
Laparoscopy reveals pathology
Definitive treatment depending on findings

Symptoms fail or investigative studies inconclusive
Reclassify patient as an indeterminate surgical abdomen.

Patient should be hospitalized and observed
Provide narcotic analgesia as appropriate.
Observe patient carefully and reevaluate condition periodically.
Consider additional investigative studies.

Diagnosis is uncertain or patient has suspected surgical abdomen
Reevaluate patient as appropriate (see above, left, and facing).

Diagnosis is nonsurgical
Refer patient for medical management.
### Table 1 Intraperitoneal Causes of Acute Abdominal Pain

<table>
<thead>
<tr>
<th>Inflammatory</th>
<th>Mechanical (obstruction, acute distention)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peritoneal</td>
<td>Hollow visceral</td>
</tr>
<tr>
<td></td>
<td>Appendicitis</td>
</tr>
<tr>
<td></td>
<td>Cholecystitis</td>
</tr>
<tr>
<td></td>
<td>Peptic ulcer</td>
</tr>
<tr>
<td></td>
<td>Gastroenteritis</td>
</tr>
<tr>
<td></td>
<td>Gastritis</td>
</tr>
<tr>
<td></td>
<td>Duodenitis</td>
</tr>
<tr>
<td></td>
<td>Inflammatory bowel disease</td>
</tr>
<tr>
<td></td>
<td>Meckel diverticulitis</td>
</tr>
<tr>
<td></td>
<td>Colitis (bacterial, amebic)</td>
</tr>
<tr>
<td></td>
<td>Diverticulitis</td>
</tr>
<tr>
<td></td>
<td>Solid visceral</td>
</tr>
<tr>
<td></td>
<td>Pancreatitis</td>
</tr>
<tr>
<td></td>
<td>Hepatitis</td>
</tr>
<tr>
<td></td>
<td>Pancreatic abscess</td>
</tr>
<tr>
<td></td>
<td>Hepatic abscess</td>
</tr>
<tr>
<td></td>
<td>Splenic abscess</td>
</tr>
<tr>
<td>Mesenteric</td>
<td>Lymphadenitis (bacterial, viral)</td>
</tr>
<tr>
<td></td>
<td>Epiploic appendagitis</td>
</tr>
<tr>
<td>Pelvic</td>
<td>Pelvic inflammatory disease (salpingitis)</td>
</tr>
<tr>
<td></td>
<td>Tubo-ovarian abscess</td>
</tr>
<tr>
<td></td>
<td>Endometritis</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Inflammatory**
  - Chemical and nonbacterial peritonitis
  - Perforated peptic ulcer/biliary tree, pancreatitis, ruptured ovarian cyst, mittelschmerz
  - Bacterial peritonitis
  - Primary peritonitis
  - Pneumococcal, streptococcal, tuberculous
  - Spontaneous bacterial peritonitis
  - Perforated hollow viscus
  - Esophagus, stomach, duodenum, small intestine, bile duct, gallbladder, colon, urinary bladder

- **Hollow visceral**
  - Appendicitis
  - Cholecystitis
  - Peptic ulcer
  - Gastroenteritis
  - Gastritis
  - Duodenitis
  - Inflammatory bowel disease
  - Meckel diverticulitis
  - Colitis (bacterial, amebic)
  - Diverticulitis
  - Solid visceral
  - Pancreatitis
  - Hepatitis
  - Pancreatic abscess
  - Hepatic abscess
  - Splenic abscess

- **Mesenteric**
  - Lymphadenitis (bacterial, viral)
  - Epiploic appendagitis
  - Pelvic inflammatory disease (salpingitis)
  - Tubo-ovarian abscess
  - Endometritis

- **Solid visceral**
  - Pancreatitis
  - Hepatitis
  - Pancreatic abscess
  - Hepatic abscess
  - Splenic abscess

- **Hemoperitoneum**
  - Ruptured hepatic neoplasm
  - Spontaneous splenic rupture
  - Ruptured mesentery
  - Ruptured uterus
  - Ruptured graffian follicle
  - Ruptured ectopic pregnancy
  - Ruptured aortic or visceral aneurysm

- **Ischemic**
  - Mesenteric thrombosis
  - Hepatic infarction (toxemia, purpura)
  - Splenic infarction
  - Omental ischemia
  - Strangulated hernia
  - Neoplastic
  - Primary or metastatic intraperitoneal neoplasms

- **Traumatic**
  - Blunt trauma
  - Penetrating trauma
  - Iatrogenic trauma
  - Domestic violence
  - Miscellaneous
  - Endometriosis

questions that must be asked should be open-ended—for example, “What happens when you eat?” rather than “Does eating make the pain worse?” Leading questions should be avoided. When a leading question must be asked, it should be posed first as a question that calls for an answer in the negative because a negative answer to a question is more likely to be honest and accurate. For example, if peritoneal inflammation is suspected, the question asked should be “Does coughing make the pain better?” rather than “Does coughing make the pain worse?”

**Mode of Onset**

The mode of onset of abdominal pain may help the examiner determine the severity of the underlying disease. Pain that has a sudden onset suggests an intra-abdominal catastrophe, such as a ruptured abdominal aortic aneurysm (AAA), a perforated viscus, or a ruptured ectopic pregnancy; a near-loss of consciousness or stamina associated with sudden-onset pain should heighten the level of concern for such a catastrophe. Rapidly progressive pain that becomes intensely focused in a well-defined area within a period of a few minutes to an hour or two suggests a condition such as acute cholecystitis or pancreatitis. Pain that has a gradual onset over several hours, usually beginning as slight or vague discomfort and slowly progressing to steady and more localized pain, suggests a subacute process and is characteristic of processes that lead to peritoneal inflammation. Numerous disorders may be associated with this mode of onset, including acute appendicitis, diverticulitis, pelvic inflammatory disease (PID), and intestinal obstruction. Acute abdominal pain generally refers to previously undiagnosed pain that arises suddenly and is of less than 48 hours’ duration.13 Abdominal pain that persists for 6 hours or longer is usually caused by disorders of surgical significance.13

**Time Course of Pain**

Pain can be either intermittent or continuous. Intermittent or cramping pain (colic) is pain that occurs for a short period (a few minutes), followed by longer periods (a few minutes to 1 half-hour) during which there is no pain at all. Intermittent pain is characteristic of obstruction of a hollow viscus and results from vigorous peristalsis in the wall of the viscus proximal to the site of obstruction. This pain is perceived as
Table 2  Extraperitoneal Causes of Acute Abdominal Pain

<table>
<thead>
<tr>
<th>Genitourinary</th>
<th>Neurogenic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pyelonephritis</td>
<td>Herpes zoster</td>
</tr>
<tr>
<td>Perinephric abscess</td>
<td>Tabs dorsalis</td>
</tr>
<tr>
<td>Renal infarct</td>
<td>Nerve root compression</td>
</tr>
<tr>
<td>Nephrolithiasis</td>
<td>Spinal cord tumors</td>
</tr>
<tr>
<td>Ureteral obstruction (lithiasis, tumor)</td>
<td>Abdominal epilepsy</td>
</tr>
<tr>
<td>Acute cystitis</td>
<td>Abdominal migraine</td>
</tr>
<tr>
<td>Prostatitis</td>
<td>Multiple sclerosis</td>
</tr>
<tr>
<td>Seminal vesiculitis</td>
<td>Inflammatory</td>
</tr>
<tr>
<td>Epididymitis</td>
<td>Schönlein-Henoch purpura</td>
</tr>
<tr>
<td>Orchitis</td>
<td>Systemic lupus erythematosus</td>
</tr>
<tr>
<td>Testicular torsion</td>
<td>Polyarteritis nodosa</td>
</tr>
<tr>
<td>Dysmenorrhea</td>
<td>Dermatomyositis</td>
</tr>
<tr>
<td>Threatened abortion</td>
<td>Scleroderma</td>
</tr>
<tr>
<td>Pulmonary</td>
<td>Infectious</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>Bacterial</td>
</tr>
<tr>
<td>Empyema</td>
<td>Parasitic (malaria)</td>
</tr>
<tr>
<td>Pulmonary embolus</td>
<td>Viral (measles, mumps, infectious mononucleosis)</td>
</tr>
<tr>
<td>Pulmonary infarction</td>
<td>Rickettsial (Rocky Mountain spotted fever)</td>
</tr>
<tr>
<td>Pneumothorax</td>
<td>Hematologic</td>
</tr>
<tr>
<td>Cardiac</td>
<td>Sickle cell crisis</td>
</tr>
<tr>
<td>Myocardial ischemia</td>
<td>Acute leukemia</td>
</tr>
<tr>
<td>Myocardial infarction</td>
<td>Acute hemolytic states</td>
</tr>
<tr>
<td>Acute rheumatic fever</td>
<td>Coagulopathies</td>
</tr>
<tr>
<td>Acute pericarditis</td>
<td>Pernicious anemia</td>
</tr>
<tr>
<td>Metabolic</td>
<td>Other dyscrasias</td>
</tr>
<tr>
<td>Acute intermittent porphyria</td>
<td>Vascular</td>
</tr>
<tr>
<td>Familial Mediterranean fever</td>
<td>Vasculitis</td>
</tr>
<tr>
<td>Hypolipoproteinemia</td>
<td>Periarteritis</td>
</tr>
<tr>
<td>Hemochromatosis</td>
<td>Toxins</td>
</tr>
<tr>
<td>Hereditary angioneurotic edema</td>
<td>Bacterial toxins (tetanus, <em>Staphylococcus</em>)</td>
</tr>
<tr>
<td>Endocrine</td>
<td>Insect venom (black widow spider)</td>
</tr>
<tr>
<td>Diabetic ketoacidosis</td>
<td>Animal venom</td>
</tr>
<tr>
<td>Hyperparathyroidism (hypercalcemia)</td>
<td>Heavy metals (lead, arsenic, mercury)</td>
</tr>
<tr>
<td>Acute adrenal insufficiency (addisonian crisis)</td>
<td>Poisonous mushrooms</td>
</tr>
<tr>
<td>Hyperthyroidism or hypothyroidism</td>
<td>Drugs</td>
</tr>
<tr>
<td>Musculoskeletal</td>
<td>Withdrawal from narcotics</td>
</tr>
<tr>
<td>Rectus sheath hematoma</td>
<td>Retroperitoneal</td>
</tr>
<tr>
<td>Arthritis/diskitis of thoracolumbar spine</td>
<td>Retroperitoneal hemorrhage (spontaneous adrenal hemorrhage)</td>
</tr>
<tr>
<td>Psychogenic</td>
<td>Pain Patterns</td>
</tr>
<tr>
<td>Hypochondriasis</td>
<td>Certain types of pain are generally held to be typical of certain pathologic states. For example, the pain of a perforated ulcer is often described as burning, that of a dissecting aneurysm as tearing, and that of bowel obstruction as gripping. One may imagine that the first type of pain is explained by the efflux of acid, the second by the sudden expansion of the retroperitoneum, and the third by the churning of hyperperistalsis. Colorful as these images may be, in most cases, the pain begins in a nondescript way. It is only by carefully following the patient’s description of the evolution and time course of the pain that such images may be formed with confidence. For several reasons—atypical pain patterns, dual innervation by visceral and somatic afferents, normal variations in organ position, and widely diverse underlying pathologic states—the location of abdominal pain is only a rough guide to diagnosis. It is nevertheless true that in most disorders,</td>
</tr>
<tr>
<td>Somatization disorders</td>
<td></td>
</tr>
<tr>
<td>Factitious</td>
<td></td>
</tr>
<tr>
<td>Munchhausen syndrome</td>
<td></td>
</tr>
<tr>
<td>Malingering</td>
<td></td>
</tr>
</tbody>
</table>

depth in the abdomen and is poorly localized. The patient is restless, may writhe about incessantly in an effort to find a comfortable position, and often presses on the abdominal wall in an attempt to alleviate the pain. Whereas the intermittent pain associated with intestinal obstruction (typically described as gripping and mounting) is usually severe but bearable, the pain associated with obstruction of small conduits (e.g., the biliary tract, the ureters, and the uterine tubes) often becomes unbearable. Obstruction of the gallbladder or the bile ducts gives rise to a type of pain often referred to as biliary colic; however, this term is a misnomer in that biliary pain is usually constant because of the lack of a strong muscular coat in the biliary tree and the absence of regular peristalsis. Continuous or constant pain is that present for hours or days without any period of complete relief; it is more common than intermittent pain. Continuous pain is usually indicative of a process that will lead, or has already led, to peritoneal inflammation or ischemia.
In most disorders that give rise to acute abdominal pain, the pain tends to occur in specific locations. (a) Diffuse pain suggests a certain set of diagnostic possibilities. (b) Differing groups of disorders give rise to abdominal pain in the epigastric, umbilical, and hypogastric regions. (c) Disorders that give rise to acute abdominal pain may be grouped according to the quadrant of the abdomen in which pain tends to occur.
## ABDOMINAL PAIN CHART

<table>
<thead>
<tr>
<th>Site of Pain</th>
<th>Aggravating Factors</th>
<th>Progression of Pain</th>
<th>Mode of Arrival Date</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>At Onset</td>
<td>movement</td>
<td>better</td>
<td></td>
<td></td>
</tr>
<tr>
<td>At Present</td>
<td>coughing</td>
<td>same</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>respiration</td>
<td>worse</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>food</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>other</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>none</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Radiation</td>
<td>lying still</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>vomiting</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>antacids</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>food</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>other</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>none</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### PAIN

#### Aggravating Factors
- movement
- coughing
- respiration
- food
- other
- none

#### Relieving Factors
- lying still
- vomiting
- antacids
- food
- other
- none

#### Progression of Pain
- better
- same
- worse

#### Duration
- intermittent
- steady
- colicky

#### Severity
- moderate
- severe

### HISTORY

#### Nausea
- yes
- no

#### Vomiting
- yes
- no

#### Anorexia
- yes
- no

#### Indigestion
- yes
- no

#### Jaundice
- yes
- no

### EXAMINATION

#### Temp.  Pulse

#### BP

#### Mood
- normal
- upset
- anxious

#### Color
- normal
- pale
- flushed
- jaundiced
- cyanotic

#### Intestinal Movement
- normal
- poor/nill
- peristalsis

#### Scars
- yes
- no

#### Distention
- yes
- no

### Location of Tenderness

#### Rebound
- yes
- no

#### Guarding
- yes
- no

#### Rigidly
- yes
- no

#### Mass
- yes
- no

#### Murphy’s Sign Present
- yes
- no

#### Bowel Sounds
- normal
- absent
- increased

#### Rectal-Vaginal Tenderness
- left
- right
- general
- mass
- none

### Initial Diagnosis & Plan

#### Results
- amylase
- blood count (WBC)
- urine
- x-ray

#### Other

### Diagnosis & Plan after Investigation

#### Discharge Diagnosis

### Figure 2
Shown is a data sheet modified from the abdominal pain chart developed by the World Organization of Gastroenterology (OMGE). Adapted from American College of Emergency Physicians. **BP** = blood pressure; **LMP** = last menstrual period; **Temp.** = temperature; **WBC** = white blood cells.
the pain tends to occur in characteristic locations, such as the right upper quadrant (cholecystitis), the right lower quadrant (appendicitis), the epigastrium (pancreatitis), or the left lower quadrant (sigmoid diverticulitis) [see Figure 3]. It is important to determine the location of the pain at onset because this may differ from the location at the time of presentation (so-called shifting pain). In fact, the chronological sequence of events in the patient's history is often more important for diagnosis than the location of the pain alone. For example, the classic pain of appendicitis begins in the periumbilical region and settles in the right lower quadrant. Another example is the pain from a perforated ulcer, which can shift to the right lower quadrant as escaping gastroduodenal content tracks down the right paracolic gutter.

**Radiation and Referral**

Radiation or referral of the pain tends to occur in characteristic patterns [see Figure 4]. For example, biliary pain is referred to the right subscapular area, and the boring pain of pancreatitis typically radiates straight through to the back. Pain from obstruction of the small intestine and the proximal colon is referred to the umbilicus, as commonly manifested in acute appendicitis, which later localizes to the right lower quadrant due to peritoneal inflammation from appendiceal obstruction [see Figure 5]. Likewise, obstruction distal to the splenic flexure is often referred to the suprapubic area. Spasm in the ureter often radiates to the suprapubic area and into the groin. The more severe the pain is, the more likely it is to be associated with referral to other areas.

**Intensity**

The intensity or severity of the pain is related to the magnitude of the underlying insult. It is important to distinguish between the intensity of the pain and the patient’s reaction to it because there appears to be significant individual difference with respect to pain tolerance. Pain that is intense enough to awaken the patient from sleep usually indicates a significant underlying organic cause. Past episodes of pain and factors that aggravate or relieve the pain often provide useful diagnostic clues. For example, pain caused by peritonitis tends to be exacerbated by motion, deep breathing, coughing, or sneezing, and patients with peritonitis tend to lie quietly in bed and avoid any movement. The typical pain of acute pancreatitis is exacerbated by lying down and relieved by sitting up. Pain that is relieved by eating or taking antacids suggests duodenal ulcer disease, whereas diffuse abdominal pain that appears 30 minutes to 1 hour after meals suggests intestinal angina.

**Associated Symptoms**

Associated gastrointestinal symptoms (e.g., nausea, vomiting, anorexia, diarrhea, and constipation) often accompany abdominal pain; however, these symptoms are nonspecific and therefore may not be of great value in the differential diagnosis of an abdominal mass by quadrant or region. Fundamental knowledge of normal anatomy and clinical presentations is the basis for distinguishing the various disease processes. Abdominal wall hernia is considered a possibility in every region or quadrant.
diagnosis. Vomiting in particular is common: when sufficiently stimulated by pain impulses traveling via secondary visceral afferent fibers, the medullary vomiting centers activate efferent fibers and cause reflex vomiting. Once again, the chronology of events is important in that pain often precedes vomiting in patients with conditions necessitating operation, whereas the opposite is usually the case in patients with medical (i.e., nonsurgical) conditions. This is particularly true for adult patients with acute appendicitis, in whom pain almost always precedes vomiting by several hours. In children, vomiting is commonly observed closer to the onset of the pain, although it is rarely the initial symptom.

Similarly, constipation may result from a reflex paralytic ileus when sufficiently stimulated visceral afferent fibers activate efferent sympathetic fibers (splanchnic nerves) to reduce intestinal peristalsis. Diarrhea is characteristic of gastroenteritis but may also accompany incomplete intestinal or colonic obstruction. More significant is a history of obstipation that should be noted include jaundice, melena, hematochezia, hematemesis, and hematuria. These symptoms are much more specific than the ones just discussed and can be extremely valuable in the differential diagnosis. Most conditions that cause acute abdominal pain of surgical significance are associated with some degree of fever if they are allowed to continue long enough. Fever suggests an inflammatory process; however, it is usually low grade and often absent altogether, particularly in elderly and immunocompromised patients. The combination of a high fever with chills and rigors indicates bacteremia, and concomitant changes in mental status (e.g., agitation, disorientation, and lethargy) suggest impending septic shock.

**Other Considerations**

A history of trauma (even if the patient considers the traumatic event trivial) should be actively sought in all cases of unexplained acute abdominal pain; such a history may not be readily volunteered (as is often the case with trauma resulting from domestic violence). The history may be
particularly relevant in a patient taking anticoagulants and presenting with acute onset of abdominal pain accompanied by an enlarging tender mass but no clear signs of inflammation. Hematoma within the rectus muscle sheath can easily be mistaken for appendicitis or other lower abdominal illnesses; hematoma elsewhere can produce symptoms of obstruction or acute bleeding into the peritoneum and the retroperitoneum.

In female patients, it is essential to obtain a detailed gynecologic history that includes the timing of symptoms within the menstrual cycle, the date of the last menses, previous and current use of contraception, any abnormal vaginal bleeding or discharge, an obstetric history, and any risk factors for ectopic pregnancy (e.g., PID, use of an intrauterine device, or previous ectopic or tubal surgery). Pregnancy should be excluded in all women of childbearing age with abdominal pain.

A complete history of previous medical conditions must be obtained because associated diseases of the cardiac, pulmonary, and renal systems may give rise to acute abdominal symptoms and may also significantly affect the morbidity and mortality associated with surgical intervention. The use of regular and as-needed medications must also be obtained. Weight changes, past illnesses, recent travel, and environmental exposure to toxins or infectious agents used should also be investigated. A history of previous abdominal operations should be obtained but should not be relied on too heavily in the absence of operative reports. A careful family history is important for detection of hereditary disorders that may cause acute abdominal pain. A detailed social history should also be obtained that includes any history of tobacco, alcohol, or illicit drug use, as well as a sexual history.

**Abdominal Mass**

The same tenets of obtaining a history for a chief complaint of abdominal pain hold true for abdominal masses. A focused, comprehensive interview usually provides all the information necessary for making the correct diagnosis. Our practice is to start by asking nondirective questions—for example, “When did you first notice the mass on your left side?” It is important to allow patients to describe the history in their own words. It is also important to avoid questions with a built-in degree of bias—for example, “Didn’t you know the mass was on your left side?” or “The pain must have been there for some time?” Such questions can lead to biased answers that may misrepresent the chronology or the true natural history of the disease. In most cases, we then proceed to ask questions designed to elicit more specific information (e.g., previous operations, previous medical conditions or therapies, family medical history, or recent travel). It is sometimes necessary to fill in the details by asking direct questions about particular points not already mentioned by the patient. For example, an inquiry regarding gastrointestinal symptoms associated with the abdominal mass may be either nonspecific (e.g., concerned with nausea, vomiting, diarrhea, or constipation) or specific (e.g., concerned with jaundice, melena, hematochezia, hematemesis, hematuria, or changes in stool caliper). Non-gastrointestinal symptoms (including urologic, gynecologic or obstetric, vascular, and endocrinologic symptoms) should not be overlooked. A history of surgery, trauma, or neoadjuvant or adjuvant cancer therapy may be diagnostically important. For instance, the presence of an abdominal mass representing recurrent cancer raises important clinical questions concerning the advisability of additional therapy or palliative measures, which may carry significant morbidity and mortality.

**TENTATIVE DIFFERENTIAL DIAGNOSIS**

Based on the history obtained in the careful history, the examiner should begin to generate a tentative differential diagnosis from the extensive lists provided [see Table 1 and Table 2]. A physical examination is then performed in search of specific signs or findings that either rule out or confirm the diagnostic possibilities. It is worthwhile to keep in mind the truism that common things are common. Given the diversity of conditions that can cause acute abdominal pain, with or without an associated abdominal mass, there is no substitute for general awareness of the most common causes of acute abdominal pain and the influence of age, gender, and geography on the likelihood of any of these potential causes. Specifically, although acute abdominal pain is the most common surgical emergency and most non–trauma-related surgical admissions (and 1% of all hospital admissions) are accounted for by patients complaining of abdominal pain, little information is available regarding the clinical spectrum of disease in these patients. Nevertheless, detailed epidemiologic information can be an invaluable asset in generating this differential diagnosis. Now that patients from different parts of the world are increasingly being seen in North American emergency departments, it is important to consider endemic diseases, including tuberculosis, parasitic diseases, bezoars from unusual dietary habits, and unusual malignancies.

For example, in patients with AIDS, a number of unusual diagnoses may be related to or coincide with abdominal pain or abdominal mass. The differential diagnosis includes lymphoma, Kaposi sarcoma, tuberculosis and variants thereof, and opportunistic bacterial, fungal, and viral (especially cytomegaloviral) infections. It is important to note that patients who are infected with HIV but have no clinical manifestations of AIDS are evaluated and managed in the same fashion as patients without HIV infection when they present with acute abdominal pain. The differential diagnosis and the outcomes are essentially no different, unless there are reasons to think that the new onset of pain in an HIV-infected patient is a manifestation of AIDS.

**Epidemiology of Abdominal Pain**

Regarding which things are common, the most extensive information currently available comes from the ongoing survey begun in 1977 by the Research Committee of the OMGE. As of the last progress report on this survey, which was published in 1988, more than 200 physicians at 26 centers in 17 countries had accumulated data on 10,320 patients with acute abdominal pain [see Table 3]. The most common
The frequency of specific diagnoses in patients with acute abdominal pain is shown in Table 3. The most common diagnosis was nonspecific abdominal pain (NSAP) — that is, the retrospective diagnosis of exclusion in which no cause for the pain can be identified. NSAP accounted for 34% of all patients seen; the four most common diagnoses accounted for more than 75%. In patients who required surgery, the most common causes were acute appendicitis (42.6%), acute cholecystitis (14.7%), small bowel obstruction (6.2%), perforated peptic ulcer (3.7%), and acute pancreatitis (4.5%). These findings have been amply confirmed.

This picture does not take into account the effect of age on the relative likelihood of the various potential diagnoses. This variation in the disease spectrum is readily apparent when the 10,320 patients from the OMGE survey are segregated by age. In the OMGE survey, well over 90% of cases of acute abdominal pain in children were diagnosed as having acute appendicitis (32%) or NSAP (62%). In patients 50 years of age or older, cholecystitis was more common than either NSAP or acute appendicitis; small bowel obstruction, diverticular disease, and pancreatitis were all approximately five times more common than in patients younger than 50 years. Hernias were also a much more common problem in older patients. Cancer was 40 times more likely to be the cause of acute abdominal pain in patients 50 years of age or older; vascular diseases (including myocardial infarction, mesenteric ischemia, and ruptured AAA) were 25 times more common in patients 50 years of age or older and 100 times more common in patients older than 70 years. What is more, outcome was clearly related to age: mortality was significantly higher in patients older than 70 years (5%) than in those younger than 50 years (< 1%). Whereas the peak incidence of acute abdominal pain occurred in patients in their teens and twenties, the great majority of deaths occurred in patients older than 70 years.

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Table 4  Frequency of Specific Diagnoses in Younger and Older Patients with Acute Abdominal Pain in the OMGE Study

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Frequency (% of Patients)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Age &lt; 50 yr</td>
</tr>
<tr>
<td>Nonspecific abdominal pain</td>
<td>39.5</td>
</tr>
<tr>
<td>Appendicitis</td>
<td>32.0</td>
</tr>
<tr>
<td>Cholecystitis</td>
<td>6.3</td>
</tr>
<tr>
<td>Obstruction</td>
<td>2.5</td>
</tr>
<tr>
<td>Pancreatitis</td>
<td>1.6</td>
</tr>
<tr>
<td>Diverticular disease</td>
<td>&lt; 0.1</td>
</tr>
<tr>
<td>Cancer</td>
<td>&lt; 0.1</td>
</tr>
<tr>
<td>Hernia</td>
<td>&lt; 0.1</td>
</tr>
<tr>
<td>Vascular disease</td>
<td>&lt; 0.1</td>
</tr>
</tbody>
</table>

Adapted from Dombal FT and Telfer S et al. OMGE = World Organization of Gastroenterology.
**Abdominal Mass**

Similarly to abdominal pain, a tentative diagnosis for an abdominal mass can also be made. For example, the presence or absence of pain or tenderness may distinguish an inflammatory or nonneoplastic process from a neoplastic one (e.g., cholecystitis from Courvoisier gallbladder or, perhaps, diverticulitis from carcinoma of the colon). Likewise, the acuteness of the condition may help eliminate diagnostic possibilities, as when an incarcerated abdominal wall hernia is distinguished from a lipomatous mass. So too may the nature of the process, as when a pulsatile mass such as an aneurysm is distinguished from a nonpulsatile one such as a hematoma or a cyst.

Likewise, masses of the abdominal wall are commonly subcutaneous lipomas, and care should be taken to differentiate them from neoplastic lesions such as desmoid tumors, dermatofibrosarcoma protuberans (DFSP), and other tumors. When an abdominal mass is associated with uncommon or unexpected findings, the surgeon must be alert to the possibility of an uncommon or unexpected disease process. Knowledge of the most common disease processes associated with region-specific abdominal masses, combined with familiarity with the characteristic signs and symptoms, is the foundation of generating a differential diagnosis.

**Physical Examination**

In the physical examination of a patient, as in the taking of the history, there is no substitute for organization and patience.

The physical examination begins with a brief but thorough evaluation of the patient’s general appearance and ability to answer questions. Before attention is directed to the patient’s abdomen, signs of systemic illness should be sought. Systemic signs of shock (e.g., diaphoresis, pallor, hypothermia, tachypnea, tachycardia with orthostasis, and frank hypotension) usually accompany a rapidly progressive or advanced intra-abdominal condition and, in the absence of extra-abdominal causes, are indications for immediate laparotomy. The absence of any alteration in vital signs, however, does not necessarily exclude a serious intra-abdominal process.

The degree of obvious pain should be estimated. The patient’s position in bed should be noted. A patient who lies motionless with flexed hips and knees is more likely to have generalized peritonitis. A restless patient who writhes about in bed is more likely to have colicky pain.

Examination of the abdomen begins with the patient resting in a comfortable, supine position. A right-handed examiner should stand on the patient’s right side, and the patient’s abdomen should be level with the elbow at rest. To allay patient anxiety, the examiner may find it useful to sit at the bedside. The examination should include inspection, auscultation, percussion, and palpation of all areas of the abdomen, the flanks, and the groin (including all hernia orifices) in addition to rectal and genital examinations (and, in female patients, a full gynecologic examination). A systematic approach is crucial: an examiner who methodically follows a set pattern of abdominal examination every time will be rewarded more frequently than one who improvises haphazardly with each patient.

Before the physical examination is begun, the area of maximal pain should be identified by simply asking the patient to cough and then to point with two fingers to the area where pain seems to be focused. This allows the examiner to avoid the area in the early stages of the examination and to confirm it at a later stage without causing the patient unnecessary discomfort in the meantime.

**Inspection**

The first step in the abdominal examination is careful inspection of the anterior and posterior abdominal walls, the flanks, the perineum, and the genitalia for previous surgical scars (possible adhesions), hernias (incarceration or strangulation), distention (intestinal obstruction), obvious masses (distended gallbladder, abscesses, or tumors), ecchymosis or abrasions (trauma), striae (pregnancy or ascites), an everted umbilicus (increased intra-abdominal pressure), visible pulsations (aneurysm), visible peristalsis (obstruction), limitation of movement of the abdominal wall with ventilatory movements (peritonitis), or engorged veins (portal hypertension).

**Auscultation**

The next recommended step in the abdominal examination is auscultation. Although it is important to note the presence (or absence) of bowel sounds and their quality, auscultation is probably the least rewarding aspect of the physical examination. In general, however, the absence of bowel sounds suggests a paralytic ileus; hyperactive or hypoactive bowel sounds are often variations of normal activity; and high-pitched bowel sounds with splashes, tinkles (echoing as in a large cavern), or rushes (prolonged, loud gurgles) indicate mechanical bowel obstruction.

**Percussion**

The third step is percussion to search for any areas of dullness, fluid collections, sections of gas-filled bowel, or pockets of free air under the abdominal wall. Tympany may be present in patients with bowel obstruction or hollow viscus perforation. Percussion can be useful as a way of estimating organ size and of determining the presence of ascites (signaled by a fluid wave or shifting dullness). Gentle percussion over the four quadrants of the abdomen can also be used to elicit a sign of peritoneal irritation, and patients tolerate this maneuver reasonably well. In general, however, maneuvers associated with palpation are best for determining whether peritonitis is present.

**Palpation**

The last step, palpation, is the most informative aspect of the physical examination. Palpation of the abdomen must be done very gently to avoid causing additional pain early in the examination. It should begin as far as possible from the area of maximal pain and then should gradually advance toward this area, which should be the last to be palpated. The examiner should place the entire hand on the patient’s
abdomen with the fingers together and extended, applying pressure with the pulps (not the tips) of the fingers by flexing the wrists and the metacarpophalangeal joints. It is essential to determine whether true involuntary muscle guarding (muscle spasm) is present. This determination is made by means of gentle palpation over the abdominal wall while the patient takes a long, deep breath. If guarding is voluntary, the underlying muscle immediately relaxes under the gentle pressure of the palpating hand. If, however, the patient has true involuntary guarding, the muscle remains in spasm (i.e., taut and rigid) throughout the respiratory cycle (so-called boardlike abdomen). True involuntary guarding is indicative of localized or generalized peritonitis. It must be remembered that muscle rigidity is relative; for example, muscle guarding may be less pronounced or absent in debilitated and elderly patients who have poor abdominal musculature. In addition, the evaluation of muscle guarding is dependent on the patient’s cooperation.

Palpation is also useful for determining the extent and severity of the patient’s tenderness. Diffuse tenderness indicates generalized peritoneal inflammation. Mild diffuse tenderness without guarding usually indicates gastroenteritis or some other inflammatory intestinal process without peritoneal inflammation. Localized tenderness suggests an early stage of disease with limited peritoneal inflammation. Rebound tenderness is elicited by applying gentle but deep pressure to the region of interest and then letting go abruptly. As a means of distraction, the examiner may use the stethoscope to apply the pressure. The main difficulties associated with palpation are that the deep pressure may increase anxiety and that the surprise of the sudden withdrawal may elicit pain where peritoneal irritation is not the cause.

Careful palpation can elicit several specific signs [see Table 5], such as the Rovsing sign (pain in the right lower quadrant when the left lower quadrant is palpated deeply), which is associated with acute appendicitis, and the Murphy sign (arrest of inspiration when the right upper quadrant is deeply palpated), which is associated with acute cholecystitis. The psoas sign is elicited by placing the patient in the left lateral decubitus position and extending the right leg. In settings where appendicitis is suspected, pain on extension of the right leg indicates that the psoas is irritated and thus that the inflamed appendix is in a retrocecal position. The obturator sign is elicited by raising the flexed right leg and rotating the thigh internally. In settings where appendicitis is suspected, pain on rotation of the right thigh indicates that the obturator is irritated and thus that the inflamed appendix is in a pelvic position. The Kehr sign is elicited when the patient is placed in the Trendelenburg position. Pain in the shoulder indicates irritation of the diaphragm by a noxious fluid (e.g., gastric contents from a perforated ulcer, pus from a ruptured appendix, or free blood from a fallopian tube pregnancy). Another useful maneuver is the Carnett test, in which the patient elevates his or her head off the bed, thus tensing the abdominal muscles. When the pain is caused by abdominal wall conditions (e.g., rectal sheath hematoma), tenderness to palpation persists, but when the pain is caused by intraperitoneal conditions, tenderness to palpation decreases or disappears (the Carnett sign).

Other Considerations in the Physical Examination

Rectal, genital, and (in women) pelvic examinations are essential to the evaluation of all patients with acute abdominal pain. The rectal examination should include evaluation of sphincter tone, tenderness (localized versus diffuse), and prostate size and tenderness, as well as a search for the presence of hemorrhoids, masses, fecal impaction, foreign bodies, and gross or occult blood. The genital examination should search for adenopathy, masses, discoloration, edema, and crepitus. The pelvic examination in women should check for vaginal discharge or bleeding, cervical discharge or bleeding, cervical mobility and tenderness, uterine tenderness, uterine size, and adnexal tenderness or masses. Although a carefully performed pelvic examination can be invaluable in differentiating nonsurgical conditions (e.g., PID and tubo-ovarian abscess) from conditions necessitating prompt operation (e.g., acute appendicitis), the possibility that a surgical condition is present should not be prematurely dismissed solely on the basis of a finding of tenderness on a pelvic or rectal examination.

Palpable or discrete masses should always be localized with respect to the previously described landmarks (see above), and they should, if possible, be described in terms of size, shape, consistency, contour, presence or absence of tenderness, pulsatility, and fixation. Further recognition of such masses can be facilitated by repeating the abdominal examination after analgesics have been administered or after the patient has been anesthetized in preparation for a procedure. Distinguishing a normal abdominal mass or swelling from an abnormal one remains a common challenge for the surgeon. Physical findings on examination are sometimes variable and can be affected by factors such as obesity, body habitus, associated medical conditions, and the patient’s ability to cooperate. For example, the normal aorta is often palpable within the epigastrium and may be slightly tender; in elderly, asthenic patients, the normal aorta may be mistaken for an aneurysm. Likewise, the cecum and the descending colon, both of which are usually palpable in thin patients (especially when they contain feces), sometimes masquerade as a cancerous mass; subsequent disimpaction causes such “masses” to resolve. Obesity and adiposity may preclude evaluation of a potential abdominal mass. Transient gaseous distention or intestinal bloating occasionally presents a similar problem, but it usually resolves spontaneously, except in cases of intestinal obstruction. Either gastric dilatation or intestinal obstruction may lead to abdominal distention that is severe enough to necessitate nasogastric decompression. In women of childbearing age, a lower abdominal mass may represent a gravid uterus. In such cases, a gynecologic examination must be conducted and a pregnancy test performed before further studies are ordered. The multiplicity of potential benign causes notwithstanding, the possibility of a neoplasm (single or multiple) clearly remains a matter of considerable concern in the evaluation of any patient with abdominal distention. A convenient method of recalling the main causes of generalized enlargement or distention of the abdomen is to use the so-called “six Fs” mnemonic device: fat, fluid, flatus, fetus, feces, and fatal growths.
<table>
<thead>
<tr>
<th>Sign or Finding</th>
<th>Description</th>
<th>Associated Clinical Condition(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aaron sign</td>
<td>Referred pain or feeling of distress in epigastrium or precordial region on continued firm pressure over the McBurney point</td>
<td>Acute appendicitis</td>
</tr>
<tr>
<td>Ballance sign</td>
<td>Presence of dull percussion note in both flanks, constant on left side but shifting with change of position on right side</td>
<td>Ruptured spleen</td>
</tr>
<tr>
<td>Bassler sign</td>
<td>Sharp pain elicited by pinching appendix between thumb of examiner and iliacus muscle</td>
<td>Chronic appendicitis</td>
</tr>
<tr>
<td>Beevor sign</td>
<td>Upward movement of umbilicus</td>
<td>Paralysis of lower portions of rectus abdominis muscles</td>
</tr>
<tr>
<td>Blumberg sign</td>
<td>Transient abdominal wall rebound tenderness</td>
<td>Peritoneal inflammation</td>
</tr>
<tr>
<td>Carnett sign</td>
<td>Disappearance of abdominal tenderness when anterior abdominal muscles are contracted</td>
<td>Abdominal pain of intra-abdominal origin</td>
</tr>
<tr>
<td>Chandelier sign</td>
<td>Intense lower abdominal and pelvic pain on manipulation of cervix</td>
<td>Pelvic inflammatory disease</td>
</tr>
<tr>
<td>Charcot sign</td>
<td>Intermittent right upper quadrant abdominal pain, jaundice, and fever</td>
<td>Choledocholithiasis</td>
</tr>
<tr>
<td>Chaussier sign</td>
<td>Severe epigastric pain in gravid female</td>
<td>Prodrome of eclampsia</td>
</tr>
<tr>
<td>Claybrook sign</td>
<td>Transmission of breath and heart sounds through abdominal wall</td>
<td>Ruptured abdominal viscus</td>
</tr>
<tr>
<td>Courvoisier sign</td>
<td>Palpable, nontender gallbladder in presence of clinical jaundice</td>
<td>Periampullary neoplasm</td>
</tr>
<tr>
<td>Cruveilhier sign</td>
<td>Varicose veins radiating from umbilicus (caput medusae)</td>
<td>Portal hypertension</td>
</tr>
<tr>
<td>Cullen sign</td>
<td>Perumbilical darkening of skin from blood</td>
<td>Hemoperitoneum (especially in ruptured ectopic pregnancy)</td>
</tr>
<tr>
<td>Cutaneous hyperesthesia</td>
<td>Increased abdominal wall sensation to light touch</td>
<td>Parietal peritoneal inflammation secondary to inflammatory intra-abdominal pathology</td>
</tr>
<tr>
<td>Dance sign</td>
<td>Slight retraction in area of right iliac fossa</td>
<td>Intussusception</td>
</tr>
<tr>
<td>Danforth sign</td>
<td>Shoulder pain on inspiration</td>
<td>Hemoperitoneum (especially in ruptured ectopic pregnancy)</td>
</tr>
<tr>
<td>Direct abdominal wall tenderness</td>
<td>—</td>
<td>Localized inflammation of abdominal wall, peritoneum, or an intra-abdominal viscus</td>
</tr>
<tr>
<td>Fothergill sign</td>
<td>Abdominal wall mass that does not cross midline and remains palpable when rectus muscle is tense</td>
<td>Rectus muscle hematoma</td>
</tr>
<tr>
<td>Grey Turner sign</td>
<td>Local areas of discoloration around umbilicus and flanks</td>
<td>Acute hemorrhagic pancreatitis</td>
</tr>
<tr>
<td>Iliopsoas sign</td>
<td>Elevation and extension of leg against pressure of examiner’s hand causes pain</td>
<td>Appendicitis (retrocecal) or an inflammatory mass in contact with psoas</td>
</tr>
<tr>
<td>Kehr sign</td>
<td>Left shoulder pain when patient is supine or in the Trendelenburg position (pain may occur spontaneously or after application of pressure to left subcostal region)</td>
<td>Hemoperitoneum (especially ruptured spleen)</td>
</tr>
<tr>
<td>Kustner sign</td>
<td>Palpable mass anterior to uterus</td>
<td>Dermoid cyst of ovary</td>
</tr>
<tr>
<td>Mannkopf sign</td>
<td>Acceleration of pulse when a painful point is pressed on by examiner</td>
<td>Absent in factitious abdominal pain</td>
</tr>
<tr>
<td>McClintock sign</td>
<td>Heart rate &gt; 100 beats/min 1 hr postpartum</td>
<td>Postpartum hemorrhage</td>
</tr>
<tr>
<td>Murphy sign</td>
<td>Palpation of right upper abdominal quadrant during deep inspiration results in right upper quadrant abdominal pain</td>
<td>Acute cholecystitis</td>
</tr>
<tr>
<td>Obturator sign</td>
<td>Flexion of right thigh at right angles to trunk and external rotation of same leg in supine position result in hypogastric pain</td>
<td>Appendicitis (pelvic appendix); pelvic abscess; an inflammatory mass in contact with muscle</td>
</tr>
<tr>
<td>Puddle sign</td>
<td>Alteration in intensity of transmitted sound in intra-abdominal cavity secondary to percussion when patient is positioned on all fours and stethoscope is gradually moved toward flank opposite percussion</td>
<td>Free peritoneal fluid</td>
</tr>
<tr>
<td>Ransohoff sign</td>
<td>Yellow pigmentation in umbilical region</td>
<td>Ruptured common bile duct</td>
</tr>
</tbody>
</table>
diagnosis of an acute inflammatory condition. An important protein assay, may be useful for increasing confidence in the gastroenteritis, or NSAP. Other tests, such as C-reactive protein, are mandatory when abdominal pain is suspected of hepatobiliary in origin. Similarly, amylase and lipase levels have been shown to possess greater predictive value than single observations.52

Laboratory Tests

In all patients except those in extremis, a complete blood cell count, blood chemistries, and a urinalysis are routinely obtained before a decision to operate. The hematocrit is important in that it allows the surgeon to detect significant changes in plasma volume (e.g., dehydration caused by vomiting, diarrhea, or fluid loss into the peritoneum or the intestinal lumen), preexisting anemia, or bleeding. An elevated white blood cell (WBC) count is indicative of an inflammatory process and is a particularly helpful finding if associated with a marked left shift; however, the presence or absence of leukocytosis should never be the single deciding factor as to whether the patient should undergo an operation. A low WBC count may be a feature of viral infections, gastroenteritis, or NSAP. Other tests, such as C-reactive protein assay, may be useful for increasing confidence in the diagnosis of an acute inflammatory condition. An important consideration in the use of any such test is that derangements develop over time, becoming more likely as the illness progresses; thus, serial examinations might be more useful than a single test result obtained at an arbitrary point. Indeed, for the diagnosis of acute appendicitis, serial observations of the leukocyte count and the C-reactive protein level have been shown to possess greater predictive value than single observations.52

Serum electrolyte, blood urea nitrogen, and creatinine concentrations are useful in determining the nature and extent of fluid losses. Blood glucose and other blood chemistries may also be helpful. Liver function tests (serum bilirubin, alkaline phosphatase, and transaminase levels) are mandatory when abdominal pain is suspected of being hepatobiliary in origin. Similarly, amylase and lipase determinations are mandatory when pancreatitis is suspected, although it must be remembered that amylase levels may be low or normal in patients with pancreatitis and may be markedly elevated in patients with other conditions (e.g., intestinal obstruction, mesenteric thrombosis, and perforated ulcer).

Urinalysis may reveal red blood cells (RBCs) (suggestive of renal or ureteral calculi), WBCs (suggestive of urinary tract infection or inflammatory processes adjacent to the ureters, such as retrocecal appendicitis), increased specific gravity (suggestive of dehydration), glucose, ketones (suggestive of diabetes), or bilirubin (suggestive of hepatitis). A pregnancy test should be obtained in any woman of childbearing age who is experiencing acute abdominal pain.

Electrocardiography is mandatory in elderly patients and in patients with a history of cardiomyopathy, dysrhythmia, or ischemic heart disease. Abdominal pain may be a manifestation of myocardial disease, and the physiologic stress of acute abdominal pain can increase myocardial oxygen demands and induce ischemia in patients with coronary artery disease.

An abnormal laboratory value sometimes plays an important role in establishing the identity or pathogenesis of an abdominal mass. For example, an elevated alkaline phosphatase or liver transaminase level may suggest metastasis to the liver. Likewise, an elevated serum amylase concentration may be suggestive of a pancreatic pseudocyst rather than a cystic neoplasm or an adenocarcinoma; however, an elevated total serum bilirubin level (i.e., > 10 mg/dL) may be more suggestive of a malignant process secondary to adenocarcinoma of the pancreatic head or cholangiocarcinoma. Routine testing for occult blood in the stool should not be overlooked. Tumor markers (e.g., carcinoembryonic antigen [CEA], the cancer antigens CA 19-9 and CA 125, and α-fetoprotein [AFP]) may also help differentiate between benign disease processes and malignant ones, distinguish high-level disease from low-level disease, and, in some cases, establish a disease diagnosis (e.g., elevated AFP levels in patients with hepatocellular carcinoma). Similarly, an elevated serum lactate dehydrogenase (LDH) level may prove invaluable in the staging and prognosis of certain diseases (e.g., melanoma) connected with an abdominal mass.53 Furthermore, the ability to distinguish between functional

### Table 5  Continued

<table>
<thead>
<tr>
<th>Sign or Finding</th>
<th>Description</th>
<th>Associated Clinical Condition(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rovsing sign</td>
<td>Pain referred to the McBurney point on application of pressure to descending colon</td>
<td>Acute appendicitis</td>
</tr>
<tr>
<td>Subcutaneous crepitation</td>
<td>Palpable crepitus in abdominal wall</td>
<td>Subcutaneous emphysema or gas gangrene</td>
</tr>
<tr>
<td>Summer sign</td>
<td>Increased abdominal muscle tone on exceedingly gentle palpation of right or left iliac fossa</td>
<td>Early appendicitis; nephrolithiasis; ureterolithiasis; ovarian torsion</td>
</tr>
<tr>
<td>Ten Horn sign</td>
<td>Pain caused by gentle traction on right spermatic cord</td>
<td>Acute appendicitis</td>
</tr>
<tr>
<td>Toma sign</td>
<td>Right-sided tympany and left-sided dullness in supine position as a result of peritoneal inflammation and subsequent mesenteric contraction of intestine to right side of abdominal cavity</td>
<td>Inflammatory ascites</td>
</tr>
</tbody>
</table>

Adapted from Hickey MS et al.6
abdominal masses and nonfunctional ones (e.g., adrenal tumors) also has important implications for evaluation and management [see Figure 6].

**Imaging**

Diagnostic radiology is a dynamic specialty that has undergone rapid change in conjunction with the ongoing evolution of imaging technology for these diagnoses. Not only has the number of imaging modalities increased, but each modality continues to be improved and refined for use in evaluating abdominal masses. The appropriate use of different imaging modalities in the evaluation of the palpable abdominal mass is well described by the American College of Radiology guidelines, which are updated every 6 years. Employing an integrative assessment approach (which includes the clinical history, physical examination, and investigative studies) should lead to more targeted, efficient, and cost-effective strategies for evaluating abdominal complaints. Each imaging modality has unique strengths and weaknesses.

**Plain films** Until relatively recently, initial radiologic evaluation of the patient with an acute abdominal complaint included plain films of the abdomen in the supine and standing positions and chest radiographs. When performed in the correct clinical setting, simple radiography may confirm diagnoses such as pneumonia (signaled by pulmonary infiltrates); intestinal obstruction (air-fluid levels and dilated loops of bowel); intestinal perforation (pneumoperitoneum); biliary, renal, or ureteral calculi (abnormal calcifications); appendicitis (fetalith); incarcerated hernia (bowel protruding beyond the confines of the peritoneal cavity); mesenteric infarction (air in the portal vein); chronic pancreatitis (pancreatic calcifications); acute pancreatitis (the so-called colon cutoff sign); visceral aneurysms (calcified rim); retroperitoneal hematoma or abscess (obliteration of the psoas shadow); and ischemic colitis (so-called thumbprinting on the colonic wall).

Abdominal plain films may reveal nonspecific or indirect evidence of an abdominal mass, such as variations in the size and density of an organ or displacement of normal structures or fat planes. Furthermore, the radiolucency of air within the bowel may also prove helpful for recognizing worrisome displacement of viscera as a result of a large abdominal mass. Occasionally, a simple plain radiograph can assist the surgeon in making a specific diagnosis, such as calcified aortic aneurysm, acute gastric distention, fecal impaction, porcelain gallbladder, and certain malignancies [see Figure 7].

A variant of the plain radiograph, the gastrointestinal contrast study is now largely relegated to more adjunctive roles in the evaluation of abdominal masses and has been supplanted by cross-sectional imaging and endoscopy. In the upper and middle portions of the abdomen, we occasionally use upper gastrointestinal studies, small bowel follow-through (SBFT), or enteroclysis to evaluate inflammatory masses (e.g., lesions arising from Crohn disease), masses that are inaccessible to endoscopy, or unusual

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**Figure 6** Bilateral adrenal masses representing pheochromocytomas in a patient with multiple endocrine neoplasia type IIA. Biochemical determination of pheochromocytoma is essential in the perioperative management of these patients.

**Figure 7** Plain abdominal radiograph showing a 10 cm functional left adrenocortical carcinoma. Calcifications creating a rim enhancement are easily identified. The diagnosis was confirmed by means of laboratory analysis and abdominal computed tomography.
masses with uncertain diagnoses. In the lower portion of the abdomen, barium studies still play a significant role in the evaluation of masses whose history is suggestive of a colonic neoplasm or inflammatory mass.

**Computed tomography (CT)** At present, helical (spiral) CT is the most efficient and cost-effective imaging modality for the evaluation of abdominal masses.\textsuperscript{56–59} CT provides cross-sectional images with excellent spatial resolution and exquisite density discrimination that are unaffected by bowel gas, bone, or excessive abdominal fat. CT routinely visualizes the abdominal wall, the viscera, the mesentery, and the retroperitoneum, clearly defining important tissue planes and delineating the relations between the abdominal mass and adjacent structures [see Figure 8]. Such data are essential for establishing the likely diagnosis, guiding diagnostic procedures, determining whether operative management is indicated, and selecting the optimal operative approach [see Figure 9].

The use of contrast during the acquisition of CT scans is vital. Opacification of the bowel enables the examiner to distinguish the abdominal mass from surrounding viscera or other adjacent structures. Contrast-enhanced scans also allow delineation of the relevant vascular anatomy; in fact, CT angiography has now relegated conventional angiography to a minimal role in the evaluation of certain abdominal masses.\textsuperscript{60,61} Moreover, arterial and venous phase abdominal mass enhancement patterns may aid in the diagnosis and preoperative planning.\textsuperscript{62}

The advent of multidetector computed tomography (MDCT) technology offers the possibility of even better imaging of abdominal masses than standard contrast CT provides. MDCT scanners can image specific organs or masses with 1 mm slices in less than 20 seconds, and the resultant data not only can be displayed as axial, coronal, and sagittal images but can also be reconstructed in a three-dimensional representation that includes detailed vascular mapping.\textsuperscript{59} Studies suggest that MDCT may be the most useful modality for preoperative assessment of the resectability of pancreatic and other abdominal masses.\textsuperscript{60} MDCT has a sensitivity of 90% and a specificity of 99%, respectively, and it is not observer dependent. At our institution, we routinely employ dedicated 256 × 256 matrix MDCT cross-sectional imaging with arterial and venous phases for diagnostic and preoperative planning.

**Ultrasoundography (US)** Compared with other modalities, US has several advantages in the evaluation of suspected abdominal masses, including widespread availability, speed of use, the absence of ionizing radiation, low cost, and the ability to document the size, consistency (solid or cystic), and origin of a mass with real-time images.\textsuperscript{57,63} The necessary equipment can easily be transported to the patient’s bedside or another clinical setting; thus, no patient preparation is required, and only minimal patient cooperation is needed.

There are certain settings in which US should be considered in the workup of abdominal pain. When gallstones are considered a likely diagnosis, US is more apt to be diagnostic than CT is, given that about 85% of gallstones are not detectable by x-rays. In disorders of the female genitourinary tract, US is also quite sensitive and specific for diagnoses such as ovarian cyst, fallopian tube pregnancy, and intrauterine pregnancy. Although there are reassuring reports that the risks of radiation from CT scanning can be managed in children and pregnant women with abdominal pain,\textsuperscript{64,65} theoretical concerns regarding the teratogenicity of the radiation dose make US advantageous for initial assessment.\textsuperscript{66}

One disadvantage of US is the extent to which the quality of the results depends on the technical proficiency and diligence of the operator or technician (although this disadvantage can become an advantage when personnel are well
trained and experienced). In an effort to help minimize this problem, we encourage the surgeons at our institution (who are trained in US) to perform their own studies in the clinic and the operating room. This approach further expedites recognition of disease [see Figure 10], positively influences management, and facilitates operative decision making regarding abdominal masses [see Figure 11].

Another disadvantage of US is its inability to visualize the entire abdominal cavity as a consequence of the acoustic barriers presented by gas-containing structures (e.g., the bowel) and the absorptive interfaces (acoustic shadowing) provided by soft tissue and bone. For optimal visualization of abdominal masses, US should be performed through “acoustic windows” that allow adequate transmission of sound.

**Magnetic resonance imaging (MRI)** Since its introduction in the mid-1980s, MRI has become one of radiology’s great success stories (although, because it is still not as widely available as US or CT, its cost-effectiveness has yet to be determined). Whereas MRI has clear advantages over CT in evaluating pathologic conditions of the brain, the spine, and the musculoskeletal system, this is not the case in the abdomen. Nevertheless, MRI is a better choice than CT for evaluating an abdominal mass when the use of iodinated contrast material is contraindicated. The extracellular gadolinium chelates used in MRI are very safe and can be given to patients with mild to moderate azotemia without causing renal impairment. MRI has unique characteristics that can be effectively employed to distinguish normal from pathologic tissue in a patient with an abdominal mass. Detailed information about the principles and practices of abdominal MRI is beyond the scope of this topic review and is readily available elsewhere. By convention, tissues with short T1 values (such as solid structures) appear bright on T1-weighted images, whereas structures with long T1 values (e.g., fluid-containing tissues) appear bright on T2-weighted images [see Figure 12]. The tissue contrast and multiplanar capabilities of MRI allow surgeons and radiologists to distinguish not only obvious but also subtle differences between abdominal masses and normal anatomy. For example, T1-weighted images may be valuable for detecting abdominal masses that contain fluid (e.g., cystic masses or masses containing necrotic tissue), whereas T2-weighted images may be useful for characterizing these masses as either benign or malignant [see Figure 6]. Magnetic resonance cholangiopancreatography (MRCP) uses T-weighted images to distinguish masses with different signal intensities in the pancreas, the liver, and the biliary tract. Conventional pulse sequences and tissue weightings as well as techniques for fat saturation and diffusion-weighted imaging (DW-MRI) can commonly...
enable the diagnosis of abdominal diseases without the use of intravenous contrast agents.70

**Positron emission tomography (PET)** In 1930, Warburg reported that cancer cells show higher rates of glycolysis than normal cells do.71 This discovery now serves as the theoretical rationale for the use of [18F]fluorodeoxyglucose ([18F]FDG) PET imaging to assess abdominal masses caused by cancer. Briefly, [18F]FDG is a glucose analogue that crosses the cell membrane by sharing the glucose transporter molecules used by glucose. Like glucose, it undergoes phosphorylation by the enzyme hexokinase, becoming a polar molecule that both accumulates in and is retained by cancer cells.

The molecular information obtained from PET, as measured by standardized uptake values (SUVs), allows identification of hypermetabolic ([18F]FDG-avid) abdominal masses (typically arising from lymphomas, melanomas, or certain gastrointestinal malignancies).72 PET may also prove to be an important surrogate modality for distinguishing malignant abdominal masses from benign ones.73 When PET is used alone, it is unable to provide sufficient anatomic information to guide biopsy or further therapy. When PET is used with CT in PET/CT fusion imaging, however, the functional advantages of PET and the structural advantages of CT combine to enhance the detection rate for abdominal masses [see Figure 13].72 One limitation of PET imaging is that FDG uptake is not always tumor specific as metabolically active benign processes such as infection and inflammation show increased glucose use.74

The role of PET in guiding the management of colorectal cancer patients is well established,75,76 but significant data are being published on the use of PET in other cancers of the abdomen and pelvis, particularly ovarian and cervical cancer.77 PET/CT has shown utility in identifying peritoneal metastases of several types of abdominal and pelvic tumors.78 In many other cancers of the abdomen, such as gastric carcinoma or pancreatic cancer, PET may be helpful as an adjunctive diagnostic test.79,80

Newer targeted oncologic therapies are aimed at oncogenic molecular pathways, and novel non-FDG PET radiotracers can allow imaging of intracellular molecular processes, other than glycolysis. [18F]Fluorothymidine is a marker of malignant cell proliferation that relies on thymidine kinase activity and can be used to detect cellular amino acid use and DNA synthesis.81 [11C]Choline images a marker of cellular proliferation that is involved in cell membrane synthesis. [18F]Fluoromisonidazole assesses the degree of tumor hypoxia and may allow response evaluation to antiangiogenesis agents.82

Pathology

In many cases, the pathologist is the surgeon’s greatest teacher. Despite the surgeon’s most strenuous efforts, the biology of the disease or lesion will inevitably dictate the outcome. Nowhere is this statement more true than in the evaluation of the abdominal mass, and its truth becomes increasingly evident as ongoing refinements in molecular diagnosis permit ever more sophisticated discrimination among different tumor types and their respective behaviors.83 The decision of whether to perform a biopsy (as well as when and how to do so) rests on the surgeon’s understanding of the probable disease. For example, surgeons who treat pancreatic cancer usually proceed to surgery without biopsy if the evidence for malignancy is strong. In other cases, biopsy is performed to confirm what is already suspected on the basis of clinical and radiographic findings. Moreover, establishing the type of tumor or mass present

*Figure 12* (a) Gadolinium-enhanced, T1-weighted magnetic resonance image (MRI) shows a large mass that appears dark and well circumscribed in comparison with the normal-appearing enhanced liver and spleen. This abnormal mass clearly contains some fluid. The fluid-filled stomach also appears dark. (b) T2-weighted MRI of the same patient details subtle inhomogeneities characteristic of a malignant mass (less organized appearance with an enhanced necrotic component). Subsequent biopsy showed this mass to be a poorly differentiated adenocarcinoma from recurrent colon cancer.
has important implications for the use of neoadjuvant or adjuvant therapy, as well as for the planning of the surgical approach. We view the biopsy of an abdominal mass as the first stage of surgery. The surgeon must possess a thorough understanding of the various methods of obtaining an accurate and safe biopsy.

**Percutaneous biopsy** The value of image-guided percutaneous biopsy in the evaluation of the abdominal mass is well established. In practice, the procedure begins with identification of the mass by means of a cross-sectional imaging modality such as US, CT, or MRI. The biopsy needle is then inserted percutaneously under the image guidance. The choice among the different modalities depends on several factors, including the size and location of the mass, the surgeon’s judgment, institutional availability, and, most importantly, the personal preference and experience of the radiologist performing the biopsy.

In general, we prefer US-guided biopsy for large, superficial, and cystic masses. This technique is also appropriate for lesions lying at moderate depths in thin to average-size persons. However, US-guided biopsy of deep-seated masses (as well as of masses in obese patients) often proves difficult because of inadequate visualization resulting from the acoustic properties of intervening soft tissues, bone, or gas-filled bowel.

The strengths of US as a guidance modality include ready availability, inexpensiveness, and portability. Moreover, it offers real-time visualization of the needle tip as it passes through tissue planes into the target area, thereby allowing the surgeon to place the needle precisely. In addition, color flow Doppler imaging can help prevent complications of needle placement by identifying nearby blood vessels.

The utility of US notwithstanding, CT remains indispensable at our institution as a guidance method for percutaneous biopsy. It is particularly useful when an abdominal mass is in a location that is inaccessible to US as a result of bowel gas or body habitus. CT provides excellent spatial resolution of all structures between the skin and the mass. We favor CT guidance for abdominal masses that are located deep in the abdomen or in the retroperitoneum. The only limitation of CT in this setting is that it does not offer continuous visualization of the needle during insertion and biopsy. In most cases, however, CT guidance can reliably establish the direction and depth of the needle [see Figure 14].
Figure 14  In a percutaneous biopsy of a large abdominal mass, computed tomography guidance is a reliable means of determining the direction and depth of the needle. R is the right side of the patient and P is posterior.

For convenience, needles for biopsy can be grouped into two main size categories: small caliber (20 to 25 gauge) and large caliber (14 to 19 gauge). Small-caliber needles are used primarily for cytologic analysis. The flexible shaft of small-caliber needles allows them to be passed with minimal risk of tissue damage. Such needles are often used to confirm tumor recurrence or metastasis in patients with a pathologically confirmed primary malignancy. Large-caliber needles (core biopsy) are typically used to obtain greater amounts of material that provides histologic architectural preservation provided by substantial tissue biopsies to differentiate variant histologic subtypes (e.g., mesenchymal tumors) to render an accurate diagnosis.

The reported accuracy of US-guided biopsy ranges from 66 to 97%. The location, size, and histologic origin of the abdominal mass appear to influence the diagnostic accuracy of the procedure. In a series that included 126 consecutive small (< 3 cm) solid masses distributed among various anatomic locations and histologic types, US-guided biopsies showed an overall accuracy of 91%. Another study found US-guided biopsy to be 91% accurate for abdominal masses less than 2.5 cm in diameter. Two organ-specific reviews concluded that US-guided biopsy of hepatic masses had an accuracy of 94% and that US-guided biopsy of pancreatic masses had an accuracy of 95%.

The reported accuracy of CT-guided biopsy ranges from 80 to 100%. As with US-guided biopsy, the size, location, and histologic origin of the mass influence the results. In a study of 200 consecutive CT-guided needle biopsies, the overall accuracy for all sites biopsied was 95%. The reported organ-specific accuracy was as follows: kidneys, 100%; liver, 99%; retroperitoneum, 87.5%; and pancreas, 82%. In a prospective study of 1,000 consecutive CT-guided biopsies, the reported sensitivity was 91.8% and the specificity was 98.9%. At our institution, as well as others, CT-guided biopsy is now considered a reliable tool for the diagnosis and classification of malignant abdominal lymphomas.

The safety of image-guided percutaneous biopsy is well documented. Several large multi-institutional reviews reported major complication rates ranging from 0.05 to 0.18% and mortality ranging from 0.008 to 0.031%. A large prospective study of 3,393 biopsies (1,825 US guided; 1,568 CT guided) documented an overall mortality of 0.06%, a major complication rate of 0.34% (0.3% with US; 0.5% with CT), and a minor complication rate of 2.9% (2.4% with US; 3.3% with CT).

Needle-track seeding remains an important theoretical consideration when an abdominal mass appears likely to be malignant. According to some investigators, percutaneous needle biopsy has the potential to seed between $10^3$ to $10^4$ tumor cells into the needle track. Nevertheless, tumor dissemination after percutaneous biopsy remains exceedingly rare: with fewer than 100 cases reported in the world literature, it has an estimated frequency of 0.005%. In mostly occurring after biopsy of pancreatic, hepatic, or retroperitoneal masses.

**Endoscopic ultrasonography (EUS)-guided biopsy**  EUS provides unique imaging because it involves the close apposition of a high-frequency ultrasound transducer, called an echoendoscope, to the structures being studied, providing higher resolution and greater anatomic detail than standard transcutaneous US. The most frequently used EUS device is the radial echoendoscope, which creates a 360° tomographic image perpendicular to the scope. The circumferential view obtained with this instrument facilitates orientation and therefore is more efficient for diagnostic imaging. Alternatively, the linear-array echoendoscope, which generates an image parallel to the shaft of the scope, may be used. This instrument produces high-quality grayscale images, as well as color and duplex images. In general, EUS-guided biopsy is well suited for abdominal masses that are too small for visualization by conventional imaging modalities or that are inaccessible to percutaneous biopsy. EUS-guided biopsy with a linear scanning system offers clear and consistent visualization of the biopsy needle along its entire path in real time.

EUS has proven to be an important modality used in conjunction with other cross-sectional imaging modalities for the detection and staging of pancreatic, gastric, and esophageal masses. For instance, in a patient with a pancreatic mass, EUS identifies the size of the mass, the peri-pancreatic lymph nodes, and the relationship to major blood vessels. Furthermore, the availability of high-frequency catheter-based intraductal ultrasonography (IDUS) now enables surgeons to visualize masses within the biliary tree and obtain biopsy specimens from them.

Advantages notwithstanding, EUS technology has several important limitations. As with all forms of US, EUS is highly operator dependent. If an operator obtains only one view of a mass in the head of the pancreas, the mass may appear to be invading vascular structures when it is not actually doing so; the operator should always obtain multiple views. It cannot be overemphasized that EUS and EUS-guided biopsy require personnel with sufficient experience and skill in both US and endoscopy.
Several studies have confirmed the high sensitivity and specificity of EUS-guided biopsy (especially for the diagnosis of extraluminal abdominal masses) and verified the safety of the procedure (reported complication rates range from 0.3 to 2%).\textsuperscript{105-108,110} It is worth noting that in the resection of a potentially curable abdominal mass, concern about needle-track contamination is obviated when the path of the needle is removed as part of the surgical specimen (as in pancreaticoduodenectomy for a pancreatic head mass or gastrectomy for a stomach mass). Whether a lesion is cystic or solid may impact on the diagnostic accuracy following biopsy. A recent meta-analysis studying EUS-guided aspirations of cystic pancreatic neoplasms showed that of nearly 1,500 patients undergoing this procedure, the pooled diagnostic sensitivity and specificity were 54% and 93%, respectively.\textsuperscript{111} Additionally, a meta-analysis studying EUS-guided fine-needle aspirations of solid pancreatic neoplasms showed diagnostic sensitivity and specificity of 85% and 98%, respectively.\textsuperscript{112}

We consider EUS-guided biopsy for the diagnosis of masses that are not readily accessible to percutaneous biopsy, on the grounds that it can obviate more invasive procedures (e.g., laparoscopy and laparotomy). In a 10-year study of the impact of EUS on patient management, 86% of patients required no further imaging, and 25% were able to avoid unnecessary laparotomy.\textsuperscript{110} Overall, EUS changed clinical management significantly in as many as one third of the 537 patients studied.\textsuperscript{110} Nevertheless, despite the high diagnostic yield achieved with EUS-guided biopsy, results that are negative for tumor should not always be interpreted as proving that no tumor is present; laparoscopic or open biopsy may still be indicated.

Management

**WORKING DIAGNOSIS**

In general, the working diagnosis determines the course of management and follows five basic pathways, depending on whether the patient (1) has an acute surgical condition that necessitates immediate laparotomy; (2) is believed to have an underlying subacute surgical condition that does not necessitate immediate laparotomy but does call for urgent or early operation; (3) has an uncertain, indeterminate diagnosis that does not necessitate immediate or urgent laparotomy but that may require surgical intervention as part of the workup; (4) has an uncertain diagnosis that does not necessitate immediate or urgent laparotomy and that warrants active observation; or (5) is believed to have an underlying nonsurgical condition.

It must be emphasized that the patient must be constantly reevaluated (preferably by the same examiner) even after the working diagnosis has been established. If the patient does not respond to treatment as expected, the working diagnosis must be reconsidered, and the possibility that another condition exists must be immediately entertained and investigated by returning to the differential diagnosis.

**ACUTE SURGICAL ABDOMEN**

A thorough but expeditious approach to patients with acute abdominal pain is essential because in some patients, action must be taken immediately and there is not enough time for an exhaustive evaluation. As outlined (see above), such an approach should include a brief initial assessment, a complete clinical history, a thorough physical examination, and targeted laboratory and imaging studies. These steps can usually be completed in less than 1 hour and should be insisted on in the evaluation of most patients. It is wise to resist the temptation to rush to the operating room with an incompletely evaluated, unprepared, and unstable patient.

Very few abdominal crises mandate immediate operation, and even with these conditions, it is still necessary to spend a few minutes on assessing the seriousness of the problem and establishing a probable diagnosis. Among the most common of the abdominal catastrophes that necessitate immediate operation are ruptured AAAs or visceral aneurysms, ruptured ectopic pregnancies, and spontaneous hepatic or splenic ruptures. The relative rarity of such conditions notwithstanding, it must always be remembered that patients with acute abdominal pain may have a progressive underlying intra-abdominal disorder causing the acute pain and that unnecessary delays in diagnosis and treatment can adversely affect outcome, often with catastrophic consequences.

**SUBACUTE SURGICAL ABDOMEN**

When immediate operation is not called for, the physician must decide whether urgent laparotomy or nonurgent but early operation is necessary. Urgent laparotomy implies operation within 4 hours of the patient’s arrival; thus, there is usually sufficient time for adequate resuscitation, with proper rehydration and restoration of vital organ function, before the procedure. The surgical dictum “rush to resuscitate, then operate” holds true in many clinical situations. Indications for urgent laparotomy may be encountered during the physical examination, may be revealed by the basic laboratory and radiologic studies, or may not become apparent until other investigative studies are performed. Involuntary guarding or rigidity during the physical examination, particularly if spreading, is a strong indication for urgent laparotomy. Other indications include increasing severe localized tenderness, progressive tense distention, physical signs of sepsis (e.g., high fever, tachycardia, hypotension, and mental status changes), and physical signs of ischemia (e.g., fever and tachycardia). Basic laboratory and radiologic indications for urgent laparotomy include pneumoperitoneum, massive or progressive intestinal distention, signs of sepsis (e.g., marked or rising leukocytosis, increasing...
the answer to this question remains unclear. In many clinical settings or that it is necessarily more cost-effective than an open approach. These advantages, although significant, do not indicate that the site of the lesion or to associated anatomic pitfalls. In cases in which ischemic bowel is suspected, the site of vascular blockage can be localized by using a CT angiogram imaging protocol. In each of these examples, the information gained may permit the surgeon to plan the operation, to optimize the time spent under anesthesia, and to minimize postoperative discomfort after laparotomy. The use of preoperative imaging has become increasingly important as an operative planning tool, particularly when laparoscopic approaches are contemplated for management of subacute abdominal emergencies. This topic has been reviewed extensively in the literature and in a 2010 update of a Cochrane meta-analysis. In some environments, the answer to this question remains unclear. In many settings, however, the current consensus is that uncomplicated appendicitis can be treated laparoscopically, with a clear expectation of less postoperative pain, a shorter hospital stay, and an earlier return to work and regular activities. These advantages, although significant, do not indicate that a laparoscopic approach is to be preferred in all or most clinical settings or that it is necessarily more cost-effective than an open approach.

The advantages of laparoscopy in the management of other abdominal emergencies are less clear-cut. With this caveat in mind, various investigators have demonstrated that laparoscopy can be employed safely and with good clinical results in selected patients with perforated peptic ulcers. Two prospective, randomized, controlled trials comparing open repair of perforated peptic ulcers with laparoscopic repair found that the latter was safe and reliable and was associated with shorter operating times, less postoperative pain, fewer chest complications, shorter postoperative hospital stays, and earlier return to normal daily activities than the former. It is important that the surgeon determine not only whether the particular clinical scenario is amenable to a laparoscopic approach but also whether the experience of the entire team and that of the institution as a whole are sufficient for what may be an advanced procedure performed in an acute situation. “INDETERMINATE” SURGICAL ABDOMEN Staging Laparoscopy An indeterminate abdominal condition that does not require emergent or urgent operative intervention may benefit from a minimally invasive evaluation. The available evidence now clearly supports the role of laparoscopy in the diagnosis and management of abdominal masses. We and others advocate the liberal use of laparoscopy as a primary staging tool for upper and lower gastrointestinal malignancies, believing it to be a safe, cost-effective tool that offers a clear benefit in more than 20% of patients with these diseases. Preventing unnecessary laparotomy in selected patients by performing diagnostic laparoscopy is associated with shorter hospital stays and earlier initiation of locoregional or systemic therapy. Moreover, laparoscopic US and peritoneal cytology are known to provide added value in the staging of disease. Furthermore, diagnostic laparoscopy can safely provide tissue samples from suspected lymphomatous masses for full diagnostic analysis. With the growth of dedicated minimally invasive fellowships and the improved quality and availability of laparoscopic training for general surgery residents and related subspecialties, the skill sets required for diagnostic laparoscopy are coming to be more widely mastered, and the concerns once commonly expressed regarding intra-abdominal adhesions and effective biopsy techniques for abdominal masses now appear to be less problematic. In addition to a minimally invasive approach, another development that offers the possibility of improved surgical intervention for malignancies is optical image–guided surgery. Real-time imaging technologies could offer the possibility to differentiate between malignant and normal tissues intraoperatively. To detect malignant cells or tissues, the various hallmarks of cancer can be used as a target for imaging strategies: increased growth and growth factor signaling receptors, limitless replicative potential, sustained angiogenesis, and increased proteolytic activity. In optical imaging, the properties of light emitted from a light source (e.g., laser, light-emitting diode [LED], xenon) are exploited to image anatomic or chemical characteristics of tissue. Imaging of optical contrast can be performed using either the properties intrinsic to the tissue, or, analogous to many radiolabeled agents, using ligands conjugated to an optically active reporter to target a recognized disease...
biomarker. Perhaps the most intriguing of these emerging technologies is near-infrared (NIR) optical imaging. The intrinsic optical absorption signals of blood, water, and lipid, correlated with increased hemoglobin concentration due to angiogenesis and decreased hemoglobin saturation due to hypermetabolism, can be used in NIR spectroscopy to detect and localize cancer.

**Diagnostic Laparoscopy**

An early 1998 report showed that diagnostic laparoscopy had the same diagnostic yield as open laparotomy in 55 patients with acute abdomen; 34 (62%) of these patients were safely managed with laparoscopy alone, with no increase in morbidity and with a shorter average hospital stay. More recently, diagnostic laparoscopy is recommended when the surgical cause of abdominal pain is suspected but its probability is not high enough to warrant open laparotomy. An example of this would be when either PID or appendicitis is suspected and cannot be definitively distinguished on a preoperative workup. Diagnostic laparoscopy has also been shown to be useful for assessing acute abdominal pain in acutely ill patients in the intensive care unit.

From the surgeon’s point of view, an optimal outcome for laparoscopic exploration in these settings is one in which a diagnosis is established, and therapy can be instituted, resulting in alleviation of symptoms. Patients, on the other hand, are more concerned with symptom relief rather than a precise diagnosis. Indeed, a number of reports have emphasized that laparoscopy often leads to improvement in symptoms even if no lesion is identified or treated. This point may be illustrated by considering pelvic adhesions, a frequent finding on diagnostic laparoscopy.

It is unclear whether adhesiolysis is therapeutically beneficial when there is no firm evidence that the adhesions are contributing to the pain syndrome. In one prospective, randomized trial, 100 patients with laparoscopically identified adhesions were randomly allocated to either a group that underwent adhesiolysis or one that did not. Both groups reported substantial pain relief and a significantly improved quality of life, but there were no differences in outcome between them, which suggested that the benefit of laparoscopy could not be attributed to adhesiolysis. Longer-term studies also failed to support the hypothesis that pelvic adhesions are responsible for chronic pelvic pain.

In the setting of a systematic and thorough diagnostic laparoscopy that yields no discernible cause of symptoms, there is controversy as to whether appendectomy should or should not be performed when no other source of the abdominal pain can be identified. However, it is noteworthy that standard surgical teaching is to perform an appendectomy when a normal appendix is found during laparoscopy for suspected appendicitis. No randomized trial of appendectomy for chronic abdominal pain has been performed in a clearly defined patient group, as has been done for adhesiolysis. At present, the surgeon can only use his or her best judgment. It should be remembered that unnecessary or potentially meddlesome interventions are always best avoided. Thus, if adhesiolysis or appendectomy can be performed with the expectation of low morbidity and without conversion to laparotomy, it seems reasonable to perform these procedures during laparoscopy if no other source of pain can be identified.

**Observation**

It is widely recognized that of all patients admitted for acute abdominal pain, only a minority require immediate or urgent operation. The traditional wisdom has been that spending time on observation opens the door for complications (e.g., perforating appendicitis, intestinal perforation associated with bowel obstruction, or strangulation of an incarcerated hernia). However, previous clinical trials evaluating active in-hospital observation of patients with acute abdominal pain of uncertain origin have demonstrated that such observation is safe, is not accompanied by an increased incidence of complications, and results in fewer negative laparotomies. Many institutions continue to employ CT scanning liberally in patients with uncertain diagnoses; this practice has been shown to minimize the incidence of diagnostic failures or delays in patients with acute conditions necessitating surgical intervention. Even so, caution is warranted when excessively using CT scanning due to increased radiation exposure.

The initial resuscitation and assessment are followed by appropriate imaging studies and serial observation. Specific monitoring measures are chosen (e.g., examination of the abdomen, measurement of urine output, a WBC count, and repeat CT scans), and end points of therapy should be identified. Active observation allows the surgeon to identify most of the patients whose acute abdominal pain is caused by NSAP or by various specific nonsurgical conditions. It must be emphasized that active observation involves more than simply admitting the patient to the hospital and passively watching for obvious problems: it implies an active process of thoughtful, discriminating, and meticulous reevaluation (preferably by the same examiner) at intervals ranging from minutes to a few hours, complemented by appropriately timed additional investigative studies.

A major point of contention in the management of patients with acute abdominal pain is the use of narcotic analgesics during the observation period. Opponents of analgesia argue that it may obscure the evolution of specific findings that would lead to the decision to operate. Proponents contend that in a controlled setting where patients are being observed by experienced clinicians, outcomes are not compromised and patients are more comfortable. It has also been suggested that providing early pain relief may allow the more critical clinical signs to be more clearly identified and that severe pain persisting despite adequate doses of narcotics suggests a serious condition for which operative intervention is likely to be necessary.

In our view, the decision whether to provide or withhold narcotic analgesia must be individualized. The current consensus remains that for most patients undergoing evaluation and observation for acute abdominal pain, it is safe to provide medication in doses that would “take the edge off” the pain without rendering the patient unable to cooperate during the observation period. On occasion, however, reflex
administration of pain medication solely with the aim of relieving pain may be undesirable or even harmful. For example, in situations for which advanced imaging is unavailable, physical examination may be so crucial to decision making that any risk of obscuring important physical findings is deemed unacceptable; therefore, pain medication should be withheld. In addition, narcotic analgesia should be used cautiously in patients with acute intestinal obstruction when strangulation is a concern.

If the abdominal pain persists after a reasonable period of active observation, diagnostic laparoscopy is an additional diagnostic avenue to consider at the surgeon’s discretion.

Suspected Nonsurgical Abdomen

Numerous disorders cause acute abdominal pain but do not call for surgical intervention. These nonsurgical conditions are often extremely difficult to differentiate from surgical conditions that present with almost indistinguishable characteristics. For example, the acute abdominal pain of lead poisoning or acute porphyria is difficult to differentiate from the intermittent pain of intestinal obstruction in that marked hyperperistalsis is the hallmark of both. As another example, the pain of acute hypolipoproteinemia may be accompanied by pancreatitis, which, if not recognized, can lead to unnecessary laparotomy. Similarly, acute and prostrating abdominal pain accompanied by rigidity of the abdominal wall and a low hematocrit may lead to unnecessary urgent laparotomy in patients with sickle cell anemia crises. To further complicate the clinical picture, cholelithiasis is also often found in patients with sickle cell anemia.

In addition to numerous extraperitoneal disorders, nonsurgical causes of acute abdominal pain include a wide variety of intraperitoneal disorders, such as acute gastroenteritis (from enteric bacterial, viral, parasitic, or fungal infection), acute gastritis, acute duodenitis, hepatitis, mesenteric adenitis, salpingitis, Fitz-Hugh–Curtis syndrome, mittlemscherz, ovarian cyst, endometritis, endometriosis, threatened abortion, spontaneous bacterial peritonitis, and tuberculous peritonitis. As noted (see above), acute abdominal pain in immunosuppressed patients or patients with AIDS is now encountered with increasing frequency and can be caused by a number of unusual conditions (e.g., cytomegalovirus enterocolitis, opportunistic infections, lymphoma, and Kaposi sarcoma), as well as by the more usual ones.

Conclusion

The best approach to diagnosis in patients with abdominal pain or an abdominal mass is to use a methodical, systematic, standardized approach grounded in the fundamental understanding of abdominal anatomy. This approach involves time-honored practices in clinical examination as well as novel investigative studies. Determining the best management approach involves incorporating the aforementioned information to determine the role surgery might play in the treatment of such a patient.

References


64. Wagner LK, Huda W. When a pregnant woman with suspected appendicitis is referred for a CT scan, what should a radiologist do to minimize potential radiation risks? Pediatr Radiol 2004;34:589–90.


Acknowledgments

Figures 1, 3, and 4  Tom Moore
Figure 7  Courtesy of Bimal C. Ghosh, MD, FACS.