Aims and Scope
The *Journal of the American Osteopathic College of Radiology (JAOCR)* is designed to provide practical up-to-date reviews of critical topics in radiology for practicing radiologists and radiology trainees. Each quarterly issue covers a particular radiology subspecialty and is composed of high quality review articles and case reports that highlight differential diagnoses and important teaching points.

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In This Issue

Refky Nicola, D.O.
Assistant Professor, Department of Imaging Services, University of Rochester Medical Center, Rochester, NY

This quote clearly summarizes the hard work by all the authors to make this an interesting and exciting edition of the JAOCR.

I would like to begin by saying that it is my honor and pleasure to be selected as the guest editor for an Emergency Radiology edition of the JAOCR. As an Emergency Radiologist, I am excited to share this issue with all the readers. Even though Emergency Radiology is a relatively new subspecialty in radiology, it has quickly gained tremendous popularity and interest within the radiology community. Academic institutions, as well as private practices, throughout the country have realized the significance of Emergency Radiology with regards to its invaluable service to physicians and surgeons. The uniqueness within the specialty is that it does not focus on one particular organ system, but encompasses a myriad of subspecialties. Therefore, it provides for a challenging and enriching work experience for residents and radiologists.

First, I am grateful to be working with Lt Col (Dr.) William O’Brien, Editor-In-Chief of the Journal, who granted me this invitation. Bill is an excellent radiologist and good friend who I have had the pleasure of knowing since our years at Philadelphia College of Osteopathic Medicine. Even as a medical student, he was always extremely motivated and hardworking. A visionary who I am confident will propel this journal to great heights and will continue to bring exciting and interesting topics to the Journal. Also, this publication could not have been possible with the editorial staff at JAOCR.

This issue was the labor of several authors from different subspecialties to provide you with essential and thought-provoking topics, which are not only encountered in the emergency department, but also in everyday practice. Each author is highly acclaimed within his or her subspecialty. The majority of the authors are from the University of Rochester Medical Center, a national recognized tertiary referral center and Level 1 Trauma Center.

We begin this edition by covering the two most common topics in Emergency Radiology - the mimickers of acute appendicitis and acute stroke. Dr. Shweta Bhatt and her colleague, Hamad Ghazle, submitted an interesting case of acute testicular pain. Afterwards, James Kovacs, D.O., my mentor during my residency at the UMDNJ-Cooper University Hospital, submitted a case report on an important yet sometimes overlooked cause of diffuse abdominal pain. In addition, I have selected an interesting case report for acute hip pain. For our Viewbox cases, Dr. Apeksha Chatuvurdi and Dr. Vaseem Chengazi have identified crucial topics in emergency pediatric and nuclear medicine, which may be encounter in the emergency room but should never be overlooked. Finally, Drs. Finnila and Sherman discuss important imaging manifestations of sore throat. I am grateful to all authors who sacrificed their time and effort to help make this an exciting Emergency Radiology edition of JACOR.

Last, but certainly not least, I am extremely grateful to my lovely wife and two beautiful children for their endless love and support throughout this project.

We hope that you will enjoy reading this Emergency Radiology Edition of the JAOCR and find the information invaluable to your current practice.
Update on Emergency Imaging of Acute Ischemic Stroke

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Division of Emergency Imaging, University of Rochester Medical Center, Rochester, NY

Introduction

The term acute stroke refers to a constellation of symptoms and clinical signs that indicate the presence of a sudden neurological injury secondary to vascular occlusion or injury. As many as 20 million people are afflicted by stroke annually worldwide, and the prevalence of stroke survivors is at least 60 million by some estimates. Stroke is a significant cause of mortality, resulting in more than 140,000 deaths annually in the US alone, and stroke survivors suffer long-term neurological impairment, decreased quality of life, and represent a significant burden to society in both expense of management and loss of productivity.

The underlying causes of acute stroke are commonly grouped into three categories: ischemic, hemorrhagic, and venous. Ischemic stroke, arising from acute arterial occlusion and subsequent ischemic injury and infarct, accounts for approximately 80% of acute strokes and will be the primary focus of this review. The other 20% of acute strokes are classified as hemorrhagic stroke, which includes primary intracranial parenchymal and subarachnoid hemorrhages, and venous stroke, which is caused by occlusion of the intracranial venous sinuses and cortical veins and results in distinctive patterns of congestive injury and hemorrhage.

Emergency imaging plays a key role in the management of acute stroke. The initial goal of imaging in acute stroke is to exclude the presence of intracranial hemorrhage prior to the initiation of intravenous tissue plasminogen activator (IV tPA) in eligible patients. After hemorrhage is excluded, the secondary goals are to identify the location of the arterial occlusion and to characterize the affected brain parenchyma as irreversibly damaged (infarct) or “at risk” for infarction (ischemic penumbra) when endovascular therapy is available. Finally, global assessment of the arteries of the head and neck is recommended in all patients following acute stroke to help identify the mechanism of the stroke and stratify future risk, and to identify the location of occlusion for possible endovascular revascularization, where available.

Commonly used imaging modalities for stroke include computed tomography (CT) and magnetic resonance (MR) techniques, including nonenhanced CT (NECT); abbreviated MR protocols using T2 fluid attenuated inversion recovery (FLAIR)-weighted sequences, T2*-weighted gradient-echo (GRE) and susceptibility-weighted (SWI) sequences, and diffusion weighted (DWI, DTI) and apparent diffusion coefficient (ADC) MR; CT angiography (CTA) and MR angiography (MRA); and CT or MR perfusion (pCT and pMR, respectively). Doppler ultrasound (DUS) is appropriate for evaluation of the vessels of the neck, although review of carotid ultrasound is beyond the scope of this article.

Nonenhanced Computed Tomography

Computed tomography is the initial imaging evaluation of choice in patients with clinically suspected acute stroke due to its wide availability, short exam duration, and high presumed negative predictive value for acute intracranial hemorrhage.
(ICH). The presence of acute intracranial hemorrhage is an absolute contraindication for administration of IV tPA and must be performed and interpreted rapidly in order to prevent delays in therapy for eligible patients. In addition, other possible etiologies of the patient’s neurological deficits (e.g. intracranial mass, hydrocephalus, etc.) may be suggested at the time of the initial NECT exam.

Initial scans are often grossly normal or nonspecific following acute ischemic stroke prior to the onset of parenchymal edema and swelling. The hyperdense (or dense) MCA sign (Fig. 1) and related dot sign (Fig. 2) are insensitive but specific early findings in M1 or M2 segment MCA ischemic strokes, representing high attenuation thrombus within the affected vessel. These signs are of particular importance, because they may be present from the very onset of the vascular insult prior to any additional NECT findings. Hyperdense thrombus may also be seen in less commonly involved vessels, including the intracranial ICAs, anterior cerebral arteries (ACAs), posterior cerebral arteries (PCAs), and basilar artery.

A later, but early sign of proximal M1 or proximal M2 occlusion is the insular ribbon sign (Fig. 3), representing loss of normal grey-white matter attenuation differentiation in the insula due to cytotoxic edema. Developing cytotoxic edema may also result in an indistinct or hypoattenuated appearance of the architecture of the basal ganglia relative to the contralateral side referred to as a “disappearing” basal ganglia sign (Fig. 4).

As the ischemia progresses to infarction and cytotoxic edema continues to develop, occlusions involving larger vascular territories will be evident as geographic regions of decreased attenuation in a vascular distribution with associated loss of normal grey-white matter differentiation (Fig. 5). Accurate description of the size of the region has prognostic significance. The Alberta Stroke Program Early CT Score (ASPECTS) criteria divides the subcortical and cortical brain into 10 standardized zones; MCA strokes scoring 7 or more affected zones are associated with higher risk for symptomatic hemorrhage and a poor functional outcome. Similarly, the “one-third” rule stipulates that if greater than 1/3 of the MCA territory is affected, there is a greater risk of symptomatic stroke.6,7
Some institutions use protocols in which MRI is used in initial evaluation of suspected acute stroke. Acute stroke MRI protocols are typically abbreviated relative to protocols for non-acute stroke and other disease entities, and are often limited to DWI/ADC, T2*, and T2 FLAIR sequences. There are several disadvantages of MRI relative to NECT. Even stroke-specific MRI scan times are longer than NECT exams and protocols must not overly delay (or prevent) tPA administration for eligible patients. MRI is more likely to be degraded by patient motion and may be nondiagnostic in patients who are unable to fully cooperate. Patients with metallic hardware in the head and/or neck and patients with implanted electronic devices (e.g. pumps, pacemakers, nerve simulators) are similarly poor candidates for MR based imaging. Benefits of MR protocols include decreased exposure to ionizing radiation, improved detection of posterior fossa stroke, better characterization of stroke mimics, and superior differentiation between acute and chronic ischemic changes.3

In the initial evaluation for evidence of intracranial hemorrhage, T2* sensitive sequences (i.e. GRE and SWI) are highly sensitive8, appearing as low signal “blooming” caused by local magnetic field inhomogeneity (Fig. 6). Despite high sensitivity for the presence of blood, residual hemosiderin from prior hemorrhage and benign intracranial calcifications are confounding (Fig. 7) and may be indistinguishable from acute blood products if comparison imaging is not available. Punctate regions of suspected “microhemorrhages” may be present and should be reported; these commonly represent sequelae of prior hypertensive or amyloid angiopathy and hemorrhage, and it has been suggested that a large number of these lesions may increase the risk of hemorrhage following thrombolysis.9,10,11

There is a high degree of concordance between MR and NECT findings in acute cerebral ischemic stroke, although MRI is more sensitive than NECT for detecting anterior circulation stroke in the first 24 hours after vessel occlusion.12 T2 FLAIR is more sensitive for early cerebral edema than conventional T2 sequences, demonstrating coarsening of the cortical sulci, increased parenchymal volume, and abnormal signal hyperintensity (Fig. 8A and B), and will be almost universally abnormal 6-7 hours following stroke onset, compared to 12-24 hours for T2.

DWI is superior to NECT in the detection of acute ischemia in the brain, with a sensitivity reported up to 99% by 24 hours.13,14 Ischemia results in rapid cytotoxic edema and decreased membrane permeability, leading to a decrease in ADC values and corresponding increase in DWI signal characteristic of restricted diffusion (Fig. 8C and D) which correspond with late acute appearance of NECT (Fig. 8E). DWI will detect smaller infarctions than NECT and is the

**Figure 6. “Blooming” on susceptibility-weighted MRI.**
GRE is highly sensitive for blood products. GRE image in a patient with subarachnoid hemorrhage (A) demonstrates “blooming” or susceptibility phenomenon, which increases conspicuity of SAH not clearly seen on CT. Axial CT (B) and GRE (C) in different patient shows increased conspicuity of blood products within the medial right cerebellar hemisphere on GRE compared to CT.

**Figure 7. GRE hemorrhage mimics.**
Califications of the basal ganglia (A, circled), pineal gland (B, arrowhead), and falx (B, arrow) demonstrate susceptibility that may be difficult to definitively distinguish from hemorrhage at times. Calcified choroid plexus commonly demonstrates “blooming.”
preferred modality for evaluation of patients presenting with TIA\textsuperscript{15}, potentially demonstrating small infarcts that would otherwise remain undiagnosed. The presence of restricted diffusion in patients presenting with TIA is associated with higher incidence of future ischemic events,\textsuperscript{16,17,18} and the distribution of findings may be used to identify the etiology of the ischemic injury. Specifically, lesions in multiple vascular distributions suggest thromboembolic disease; bilateral strokes are associated with cardioembolic disease; and “watershed” infarcts suggest proximal high-grade vascular stenosis (Fig. 9).

In posterior fossa ischemia, the large volume and proximity of high density compact bone in the skull base causes local beam hardening, which severely limits detection of subtle brain attenuation changes in the posterior fossa and brainstem with NECT. DWI is largely unaffected, and even small regions of restricted diffusion may be readily evident (Fig. 10).

**MR and CT Angiography**

Early angiography of the head and neck is increasingly a component of acute stroke imaging. CT angiography is more widely used; eligible patients may be administered IV tPA while still in the scanner following initial NECT imaging to exclude hemorrhage and immediately be rescanned with contrast for angiography of the head and neck with or without pCT, depending on the institutional protocol.

Although both CTA and MRA have similar accuracy
in identifying proximal anterior circulation occlusions, each modality has its limitations. Although more widely used, CT angiography is contraindicated in patients with a history of severe contrast reaction and is relatively contraindicated in patients with severe renal insufficiency, although contrast induced nephropathy (CIN) may be an acceptable risk in stroke patients. CT-based imaging is degraded by metallic artifact and posterior fossa beam hardening. MRI/MRA may expedited in patients with suspected posterior fossa stroke, as discussed above; however, MRA presents its own limitations. In addition to general MR considerations discussed above, risk of nephrogenic systemic fibrosis (NSF) limits the use of gadolinium-based contrast for contrast-enhanced MRA, although noncontrast time-of-flight techniques may still be applied. Time-of-flight noncontrast MRA, however, is subject to flow-related loss of signal which may simulate or overestimate stenosis in affected vessels.

In patients with intracranial hemorrhage, CTA of the head is routinely performed to evaluate for a causative lesion (e.g. aneurysm, tumor, vascular malformation, etc.). In institutions where endovascular therapy is available, head and neck CTA allows for identification of the site of occlusion to guide possible endovascular therapy in patients ineligible for IV tPA (e.g. outside the 0-4.5 hour treatment window) or with large ICA and MCA occlusions, as discussed below.

MR and CT Perfusion Imaging

Both pCT and pMR are techniques available to further characterize a suspected region of ischemia. Both techniques attempt to delineate irreversibly damaged or infarcted parenchyma from potentially retrievable “at risk” non-infarcted brain tissue. The leading motivation for this distinction is two-fold: large regions of “at risk” brain outside the IV tPA window and proximal occlusions that are less likely to respond to IV tPA alone may be indications for endovascular therapy.

It is important to note the current state of the literature regarding the use of both endovascular revascularization therapy and the use of perfusion imaging in evaluating stroke. Some evidence exists for therapeutic benefit of intra-arterial tPA administered up to 6 hours post onset or mechanical thrombectomy even after the 0-4.5 hour IV tPA window has passed. Subsequent trials, however, have challenged the efficacy of these therapies, and additional trials are necessary to more accurately identify patients who may benefit from intrarterial thrombolysis and mechanical thrombectomy. In addition, although perfusion imaging is often performed prior to endovascular therapy as a component of patient selection, to date several trials have not demonstrated strong prognostic value of perfusion imaging in predicting IV or endovascular therapy outcomes. Institution-specific and clinical trial guidelines, however, are used to determine reperfusion eligibility based on the size of the infarct core, largely based on the known increased risk of hemorrhage in patients based on established NECT criteria.

Perfusion imaging is proposed as a potentially useful assessment of remaining viable ischemic tissue that may benefit from reperfusion, and the basis of perfusion imaging is the different imaging characteristics of ischemic and infarcted brain. Prolonged ischemia may progress to infarct, although the time from ischemia to infarction varies by patient. Quantitatively, cerebral ischemia is associated with

![Figure 11. Penumbra on pCT.](image-url)
CBF of less than 20-25 ml/100g/min\textsuperscript{33,34} and values of 12-25 ml/100g/min are more likely to recover with return of normal perfusion.

In pCT, quantification of inflow of contrast material allows calculation of blood flow (cerebral blood flow, CBF, and mean transit time, MTT) and blood volume (cerebral blood volume, CBV). Brain parenchyma with decreased CBF, increased MTT, and normal CBV suggests ischemia without infarct, or a vascular penumbra of brain “at risk” of infarct. Decreased CBV is associated with greater degree of cerebral edema and cell death. The “mismatch” between decreased CBF and decreased CBV is believed to represent brain that may recover if perfusion is normalized (Figs. 11 and 12A-C).

Although less widely used, in pMR, the penumbra is determined by the mismatch between the region of decreased CBF (calculated during dynamic imaging during administration of gadolinium-based contrast) and the size of the core infarct determined by DWI. This is analogous in interpretation to CT-based perfusion techniques.

**Summary**

Imaging of acute stroke is routine practice in emergency radiology. Although institutional variation exists, established evidence-driven guidelines direct the standard of care in order to enable timely and effective medical management. Both CT and MR based techniques are effective in the diagnosis and characterization of both ischemic and hemorrhagic stroke and vascular imaging of the head and neck is routinely performed at the time of initial presentation for prognostic purposes and to guide possible endovascular therapy. At 48 hours, DWI (E) and NECT (F) demonstrate evolution of infarction progressing from the infarct core identified in CBV to involve the entire region of ischemia initially indicated by decreased CBF.
References


Introduction

Acute abdominal pain is the most common reason for an emergency department visit among patients age 15 and older, a large portion of them will complain of pain localizing to the right lower quadrant. While appendicitis is the most common cause of the surgical abdomen, a wide variety of acute gastrointestinal, genitourinary, and gynecological pathologic processes can present in similar fashion (Table 1). Acute gastrointestinal diseases, such as Crohn's disease, infectious enterocolitis, mesenteric adenitis, cecal diverticulitis, Meckel's diverticulitis, epiploic appendagitis, and omental infarcts can present with right lower quadrant. In addition, acute genitourinary diseases, such as pyelonephritis and ureterolithiasis, can present with similar symptoms. In a young woman, acute gynecological disease processes, such as ovarian torsion, hemorrhagic ovarian cyst, pelvic inflammatory disease, and ectopic pregnancy, should also be considered within the differential diagnosis.

Imaging modalities utilized in the emergency setting to evaluate right lower quadrant pain include computed tomography (CT), ultrasound (US), and magnetic resonance imaging (MRI). These modalities may be value-added for patients with nonspecific symptoms, thus it is useful to triage surgical and nonsurgical patients. It is important for the practicing radiologist to be familiar with the various acute disease entities which can cause right lower quadrant pain in order to determine the best approach or modality to make an accurate diagnosis.

Imaging of the appendix

The most common imaging modality for the evaluation of the right lower quadrant pain is MDCT. MDCT has a sensitivity of 97%, specificity of 98%, and accuracy of 98% in diagnosing acute appendicitis, with the additional benefit of suggesting an alternative diagnosis for acute abdominal pain in up to two-thirds of patients. The presence of intravenous and enteric contrast aids in identification of the appendix. The appendix arises from the cecum inferior to the ileocecal junction (Fig. 1). MDCT signs of acute appendicitis include appendiceal diameter > 7 mm with peri-appendiceal stranding of the mesenteric fat (Fig. 2A). Both findings are present in up to 93% of appendicitis cases identified on MDCT. The diagnosis of appendicitis should not be made using appendiceal diameter alone; wall thickening and increased enhancement should also be present. Additional findings include the presence of an appendicolith, cecal apical thickening (“arrowhead sign”), mesenteric adenopathy, fluid in the paracolic gutter, and the presence of phlegmon. A focal wall defect, extraluminal air, or presence of an abscess are signs of perforation. While MDCT is currently the preferred imaging modality, in the pediatric and pregnant patient ultrasound as well as MRI has been shown to perform comparable to CT.

Ultrasound has a sensitivity and specificity of 78% and 83%, respectively. The most common findings in appendicitis are diameter > 6 mm, lack of compressibility, hyperemia of the appendiceal wall on Doppler imaging, peri-appendiceal inflammatory changes, and the presence of peritoneal fluid (Fig. 2B). Occasionally, a calcified appendicolith may be seen with posterior shadowing (Fig. 2C). However, ruling out appendiceal pathology is often difficult with US if the appendix cannot be visualized. One study reported positive ultrasound findings for appendicitis in about 20% of cases, but equivocal findings in almost 50% of cases (i.e. inability to identify the appendix). Evaluation of the right lower quadrant is particularly difficult in pregnant women due to distorted abdominal and pelvic anatomy (particularly in the third trimester). MRI has been shown to be superior at localizing the appendix in comparison to ultrasound, with a sensitivity and specificity of up to 89% and 99%.
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<th>Imaging Appearance</th>
<th>Treatment</th>
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<td><strong>Gastrointestinal</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crohn’s Disease</td>
<td>Bowel wall thickening and mural stratification, most commonly involving the terminal ileum. Chronic inflammation may result in fibrofatty proliferation along the mesenteric side of the bowel wall. Fistulas and abscesses may form.</td>
<td>Initially medical. Indications for surgery include obstruction due to fibrotic stricture, perforation, abscess formation, and fistulas not able to managed medically.</td>
</tr>
<tr>
<td>Diverticulitis</td>
<td>Thick-walled diverticulum with adjacent infiltrative changes; short or long-segment bowel wall thickening. Abscesses may form.</td>
<td>Medical. Surgical intervention may be necessary for medically refractory cases, large abscesses, and fistula formation.</td>
</tr>
<tr>
<td>Infectious Enterocolitis</td>
<td>Long-segment circumferential wall thickening, usually without mesenteric fat stranding.</td>
<td>Medical.</td>
</tr>
<tr>
<td>Mesenteric Adenitis</td>
<td>Cluster of 3 or more right lower quadrant lymph nodes &gt;5 mm in shortest diameter, without identifiable cause.</td>
<td>Medical.</td>
</tr>
<tr>
<td>Neutropenic Colitis (Typhlitis)</td>
<td>Distended and thick-walled cecum, infiltrative changes, pericolic fluid.</td>
<td>Medical. High risk of bowel perforation; CT may be used to monitor treatment response.</td>
</tr>
<tr>
<td>Meckel’s Diverticulitis</td>
<td>Blind-ending tubular structure in the right lower quadrant arising from the distal ileum; infiltrative changes, wall thickening, and hyperenhancement may be seen.</td>
<td>Surgical resection.</td>
</tr>
<tr>
<td>Epiploic Appendagitis</td>
<td>Pericolic fatty mass with surrounding inflammatory changes, most commonly in the transverse and descending colon. A central thrombosed vein may be identified.</td>
<td>Medical.</td>
</tr>
<tr>
<td>Omental Infarct</td>
<td>Pericolic fatty mass with surrounding inflammatory changes, most commonly in the right hemiabdomen between the colon and the anterior abdominal wall.</td>
<td>Medical.</td>
</tr>
<tr>
<td><strong>Genitourinary/Gynecological</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urolithiasis</td>
<td>Obstructing calculus with hydronephrosis +/- hydroureter.</td>
<td>Medical, unless calculus large.</td>
</tr>
<tr>
<td>Pyelonephritis</td>
<td>Imaging most often normal. May see striated nephrogram or delayed contrast excretion on CT. US may show loss of corticomedullary differentiation.</td>
<td>Medical.</td>
</tr>
<tr>
<td>Ovarian Torsion</td>
<td>US: Enlarged and heterogeneous ovary; may be midline. May see reduced or absent venous flow.</td>
<td>Surgical detorsion.</td>
</tr>
<tr>
<td>Hemorrhagic Ovarian Cyst</td>
<td>US: Finely septated “fishnet” pattern of fibrin bands; retractile clot or avascular peripheral nodule non-acutely.</td>
<td>None.</td>
</tr>
<tr>
<td>Pelvic Inflammatory Disease</td>
<td>Dilated tubular structures representing Fallopian tubes with wall thickening. Ipsilateral ovary may be enlarged.</td>
<td>Medical.</td>
</tr>
<tr>
<td>Ectopic Pregnancy</td>
<td>Non-visualization of an intrauterine pregnancy with positive beta-hCG. US: May see yolk sac, detect fetal heartbeat, or see “ring of fire” sign of peripheral hypervascularity around adnexal mass.</td>
<td>Medical but may require surgical intervention.</td>
</tr>
<tr>
<td>Mittelschmerz</td>
<td>Normal. May see physiologic fluid in the pelvis.</td>
<td>None.</td>
</tr>
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**Table 1.** Overview of gastrointestinal and genitourinary causes of right lower quadrant pain.
On MRI, the appearance of acute appendicitis includes an appendiceal diameter > 7 mm and adjacent fat stranding that is often best appreciated on T2 fat saturated sequences. An inflamed appendix demonstrates restricted diffusion. The appendix may be filled with high T2 fluid or edema, which decreases in signal intensity if the fluid is purulent (higher debris and protein content). Appendicoliths are low in T1 and T2 signal intensity, with blooming artifact on GRE images. A periappendiceal abscess is identified as a walled-off high T2 fluid collection with restricted diffusion. An appendix filled with high T2 fluid and diameter of 6-7 mm is indeterminate (if no adjacent fat stranding of fluid) and should be closely followed up.

Differential Diagnosis

Crohn's Disease

Crohn's disease can involve any segment of the gastrointestinal tract, but the most common location is within the terminal ileum. Patients often present with abdominal cramps localized within right lower quadrant and bloody stools. The initial presentation typically occurs between 15 and 30 years of age.

The imaging features of Crohn's disease consist of bowel wall thickening (greater than 4 mm), mural stratification ("target" or stratified appearance of the bowel wall due to submucosal edema), and abnormal enhancement (Fig. 3). Active inflammation leads to engorgement of vasa recta (the "comb sign"). Chronic inflammation results in fibrofatty proliferation along the mesenteric side of the bowel wall, creating the "creeping fat" sign. Over time, the chronic...
The inflammatory process of Crohn's disease can result in intramural or interloop abscesses. Fistulous anastomosis with the bowel, bladder, skin, and vagina can occur. This is best evaluated by MDCT or MRI enterography, which utilize IV contrast during the late arterial phase and low density oral contrast to facilitate evaluation of the small bowel mucosa. Bowel wall thickening (>3mm) and stratification, mucosal hyperenhancement, wall thickening, and adjacent inflammatory changes. The appendix is normal (yellow arrow). MR enterography in the same patient 2 years later (B) demonstrates wall thickening and fibrosis without adjacent inflammatory changes, consistent with sequela of multiple prior Crohn’s flares.

Mesenteric Adenitis
Mesenteric adenitis, or right lower quadrant lymphadenopathy, is defined as a cluster of 3 or more lymph nodes greater than 5 mm in shortest diameter in the right lower quadrant mesentery (Fig. 4). Primary mesenteric adenitis is thought to be due to an underlying ileitis. Secondary mesenteric adenitis has an identifiable cause on MDCT, such as appendicitis or Crohn's disease. Patients present with abdominal pain, fever, and leukocytosis. This is an uncommon diagnosis, but may be considered in patients whose only imaging abnormality is focal mesenteric lymphadenopathy.

Infectious Enterocolitis
Infectious enterocolitis can present clinically similar to appendicitis, particularly if caused by pathogens such as _Yersinia_, _Campylobacter_, or _Salmonella_, which may cause ileoceitis. The imaging findings on MDCT involve a long-segment circumferential wall thickening with homogenous enhancement, usually without stranding of the adjacent fat. In addition, mesenteric adenopathy and surrounding free fluid may be present.
Neutropenic Colitis (Typhlitis)

Neutropenic colitis has a similar presentation of acute appendicitis, but occurs particularly in immunosuppressed patients with leukemia, post-transplantation status, or acquired immunodeficiency. Mucosal damage secondary to both infection and ischemia is typically confined to the cecum and ascending colon. A prompt diagnosis is necessary due to the high risk of perforation. MDCT findings includes a distended cecum with circumferential wall thickening, peri-colonic infiltration, and peri-colic fluid (Fig. 5). Pneumatosis can also be present. Treatment includes bowel rest and antibiotics. MDCT is used to follow the progression of therapy, as evidenced by the improvement in the thickening of cecal wall. The extent of cecal wall thickening into the ascending colon as well as the patient’s history helps to differentiate neutropenic colitis from cecal wall thickening associated with appendicitis.

Diverticulitis

Diverticulitis is a common cause of abdominal pain, particularly in patients over 40 years of age. Diverticula form in the weakest portion of the colonic wall where vasa recta, the nutrient arteries, penetrate and extend into the submucosal layer. While diverticulitis most commonly involves the descending and sigmoid colon, diverticula may also form along the ascending colon and present with right-sided abdominal pain. Diverticulitis is thought to be caused by microperforation of a diverticulum.

On MDCT, diverticulitis is associated with wall thickening of the colon with infiltration of the adjacent mesenteric fat (Fig. 6). The vasa recta is engorged due to inflammation. Complications of acute diverticulitis include colonic perforation and abscess formation. Long-standing diverticulitis can result in colovesical or colovaginal fistula formation. Treatment of acute diverticulitis includes bowel rest and antibiotics; complicated diverticulitis requires drain placement or partial colectomy. It can be difficult to exclude an underlying neoplasm in the setting of acute diverticulitis. However, signs concerning for malignancy include a short-segment of involved colon (< 10 cm), colonic mass with overhanging shoulders, and peri-colic lymphadenopathy. Colonoscopy is recommended as a follow-up examination once the patient’s symptoms subside to exclude an underlying neoplasm. CT colonoscopy can be performed; however, the discussion of CT colonoscopy is beyond the scope of this review article.
Meckel’s Diverticulitis

Meckel’s diverticulum is a congenital anomaly due to the persistence of the omphalomesenteric (vitelline) duct, which connects the yolk sac to the midgut lumen in the developing fetus. Meckel’s diverticula are located 60-100 cm from the ileocecal valve, typically in the right lower quadrant or lower central abdomen. Inflammation occurs due to mucosal ulceration from ectopic gastric mucosa or due to luminal obstruction by an enterolith. Meckel’s diverticulum may also act as a lead point for intussusception. Meckel’s diverticulum are identified on MDCT as a blind-ending tubular structure arising from the anti-mesenteric side of the distal ileum. Wall thickening, hyperenhancement, and adjacent mesenteric fat stranding suggest active inflammation (Fig. 7). A Meckel’s diverticulum can also be identified using radionuclide scanning with $^{99m}$Tc-pertechnetate; however, sensitivity and specificity are lower in adults patients when compared to children due to the decreased prevalence of ectopic gastric mucosa. Management is surgical resection.

Epiploic Appendagitis

Epiploic appendages are small fat protrusions arising from the serosal surface of the colon; these are not usually identifiable on cross sectional imaging. Torsion of an epiploic appendix causes vascular occlusion, ischemia, and acute onset abdominal pain. An inflammatory process within the abdomen can also extend to the epiploic appendages, causing secondary epiploic appendagitis. Since the number and size of epiploic appendages increase from the cecum to the sigmoid colon, epiploic appendagitis usually results in left-sided abdominal pain. However, epiploic appendagitis can occur in the ascending colon and even the cecum. On ultrasound, epiploic appendagitis is seen as a hyperechoic mass with a hypoechoic rim deep to the abdominal wall. The MDCT findings include a peri-colic fatty mass with surrounding infiltrative changes; a high-attenuation central dot may be seen, which represents a thrombosed vein (Fig. 8). Treatment is usually supportive with anti-inflammatory agents.
Omental Infarction

In contrast to epiploic appendagitis, omental infarction is most commonly a right-sided entity, perhaps due to longer length and mobility of the omentum in the right hemiabdomen compared to the left.\textsuperscript{17,23} Omental infarction is caused by torsion or vascular thrombosis secondary to postoperative omental adhesions, trauma, or increased intra-abdominal pressure (coughing, obesity, strenuous exercise).\textsuperscript{23} The most common presenting symptom is acute-onset abdominal pain. MDCT imaging findings vary from an ill-defined, heterogeneous fat-attenuation lesion to a well-defined heterogeneous fatty mass, classically located between the anterior abdominal wall and ascending or transverse colon (Fig. 9).\textsuperscript{12,23} Omental infarction may be differentiated from epiploic appendagitis by location (between the colon and anterior abdominal wall), larger size (often greater than 5 cm in diameter), absence of a peripheral rim, and absence of a central dot sign.\textsuperscript{17,23} Management is typically supportive; complications are rare.

Acute Genitourinary Diseases

Urolithiasis

Urolithiasis may present with right lower quadrant pain, particularly if an obstructing calculus is present in the right ureterovesicular junction. Ultrasound evaluation of the abdomen may demonstrate hydrourerter, which can be differentiated from bowel due to the lack of bowel signature (alternating hyperechoic and hypoechoic tissue layers) (Fig. 10). If the bladder is distended, the obstructing calculus may be visualized as an echogenic focus in the region of the ureterovesicular junction. Identification is improved by creation of the twinkle artifact on Doppler images, which is rapidly changing red and blue colors behind the calcification due to "phase jitter" within the machine.\textsuperscript{24}

CT images demonstrate a high attenuation calculus within the ureter, with or without proximal ureteral dilatation. Ureteral wall thickening and adjacent fat stranding may be present. Pelvic phleboliths may simulate distal ureteral calculi. If the ureter cannot be followed in its entirety and the calcification is indeterminate, the presence of a soft tissue rim ("rim sign" due to inflamed ureteral walls) and the absence of a soft tissue tail ("tail sign" due to thrombosed vein leading into the calcification) may help characterize urolithiasis.\textsuperscript{25,26} Treatment for ureteral calculi less than 4 mm in diameter is supportive.

Pyelonephritis

Pyelonephritis is most commonly associated with an ascending genitourinary tract infection and is a clinical diagnosis; often times, the sonographic and MDCT findings are normal.\textsuperscript{27} However, imaging is useful in excluding complications, such as abscess formation, emphysematous pyelonephritis (typically in diabetics and immunocompromised patients), or xanthogranulomatous pyelonephritis. Findings of pyelonephritis on CT include nephromegaly due to edema, a striated or delayed nephrogram, perinephric fat stranding, and wall-thickening and enhancement of the renal collecting system (Fig. 11).\textsuperscript{28} Delayed appearance of the calices may also be seen; however, since pyelonephritis is often bilateral, comparison between the two kidneys may not be helpful.
Ultrasound may show nephromegaly and loss of renal sinus fat due to inflammation, as well as loss of the corticomedullary junction. The kidneys may be abnormally hyperechoic or hypoechoic. In the absence of complications, treatment includes antibiotics and supportive measures.

**Gynecologic Diseases**

Gynecologic emergencies, especially those affecting the right adnexa, are important in the differential diagnosis of acute appendicitis in young women. Screening the right ovary is routinely performed along with ultrasound evaluation of the appendix in pediatric patients. Commonly encountered pathologies include ovarian torsion, hemorrhagic ovarian cyst, pelvic inflammatory disease, ectopic pregnancy, and Mittelschmerz. Ultrasound, preferably transvaginal, is the preferred initial imaging evaluation in these cases.

**Ovarian Torsion**

Ovarian torsion results from twisting of the ovary on its supporting ligaments. Patients are usually in the reproductive age group and present with acute onset lower abdominal pain on the side of the ovary involved. Torsion usually occurs in the presence of underlying pathology, such as enlarged ovaries from...
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cysts, tumors, enlarged corpus luteum, or ovulation induction for infertility. Ultrasound is performed as the first line of imaging, demonstrating increased size (>4 cm in greatest diameter) and volume of the involved ovary, heterogeneous appearance from edema and hemorrhage, and typically an associated cyst or mass (Fig. 12). Multiple small follicles can be seen in the periphery of the enlarged ovary due to displacement from stromal edema, described as “string of pearls” sign. On Doppler, venous flow is often reduced or absent, but this is less sensitive than gray-scale findings. The arterial blood flow may be dampened or absent as well, but this finding is variable due to dual blood supply (ovarian artery and uterine branch artery). Comparison with the normal unaffected ovary is often helpful. Treatment is surgical detorsion and removal of necrotic tissue.

Hemorrhagic Ovarian Cyst

Hemorrhage into an ovarian cyst can cause abrupt lower abdominal or pelvic pain. Hemorrhagic cysts have a thin wall with posterior through transmission. The internal architecture depends on the stage of evolution of the hemorrhage, from anechoic fluid in the acute stage to echogenic clot in later stages, giving rise to varied sonographic appearances. The most common appearance is a finely septated fishnet pattern resulting from fibrin bands (Fig. 13A). Additional findings include a fluid-debris level, a nodule from retracting clot, or a completely echogenic lesion. These typically do not show internal vascularity. Echogenic fluid can be seen in the cul-de-sac in cases of ruptured cyst (Fig. 13B). In indeterminate cases, MRI may be performed to show the blood products, or a follow-up sonogram can show change in the echo pattern or resolution of the cyst (Fig. 13C). Correlation with menstrual history is helpful as these typically occur in the luteal phase. Treatment is typically supportive.

Pelvic Inflammatory Disease

Acute pelvic inflammatory disease can present with fever and lower abdominal pain, similar to that of acute appendicitis. Neisseria gonorrhoeae and Chlamydia trachomatis are the most commonly implicated organisms. Patients may have additional symptoms relating to the urogenital tract, including dysuria, dyspareunia, and vaginal discharge. On transvaginal ultrasound, enlarged and heterogeneous appearing ovaries, thickened adnexal structures, dilated fallopian tubes containing simple fluid or echogenic contents, and pelvic fluid collections can be seen (Fig. 14). CT findings include enlarged ovaries with abnormal enhancement, dilated and fluid filled fallopian tubes with enhancing wall from pyosalpinx, stranding of the pelvic fat, enhancement of the adjacent peritoneum, and pelvic abscesses in advanced cases (Fig 14C). Similar findings can be seen involving the endometrium and cervix in endometritis and cervicitis. Treatment is supportive, including antibiotic therapy.

Figure 13. Hemorrhagic cyst.
28-year-old woman with acute right lower quadrant and pelvic pain. Transvaginal ultrasound with Doppler of the right ovary (A) shows a complex cyst (arrow) with fine reticular pattern and echogenic areas; no internal vascularity is seen. Transvaginal ultrasound image of the same patient superior to the uterus (B) demonstrates hemoperitoneum with debris (arrow) from rupture of the hemorrhagic cyst. Pregnancy test was negative, excluding the possibility of ectopic pregnancy. Follow up transvaginal ultrasound at a 2 week interval (C) shows decrease in the size of the cyst with changes in the internal architecture from retraction of the clot (arrow).
Ectopic Pregnancy

Ectopic pregnancy needs to be excluded in all women of reproductive age who present with abdominal pain. As with other gynecologic emergencies, transvaginal ultrasound along with serum beta-hCG level plays crucial role in diagnosis. Non-visualization of an intrauterine gestational sac on transvaginal ultrasound with a beta-hCG level greater than 2000 mIU/ml should raise the suspicion for ectopic pregnancy. Ninety-five percent of ectopic pregnancies are tubal, and visualization of a complex mass separate from the ovary helps in differentiating it from a complex ovarian cyst (Fig. 15). Presence of yolk sac or a live embryo with cardiac activity makes the diagnosis. Other findings include the “tubal ring” sign, referring to a hyperechoic ring around the adnexal gestational sac. On Doppler, peripheral vascularity with high velocity and low impedance can be seen around the adnexal mass, separate from the ovary, called the “ring of fire” sign. Echogenic fluid from hemoperitoneum can be seen in the pelvis and abdomen in cases of rupture. If diagnosed early, treatment is medical including methotrexate to terminate the non-viable pregnancy. Surgical treatment may be pursued in the presence of hemodynamic instability, ongoing rupture, or contraindication to methotrexate.

Mittelschmerz

This is pain associated with rupture of the dominant follicle during ovulation, occurring in the mid menstrual cycle, usually felt in the lower abdomen. The laterality of pain varies corresponding to the side of ovulation. Sometimes, the pain can be severe, associated with nausea, and mimic appendicitis if occurring on the right side. Correlation with menstrual cycle, spotting, and history of prior such episodes can help.
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Figure 15. Ectopic pregnancy. 30-year-old woman with severe lower abdominal pain. Patient’s last menstrual period was 7 weeks prior; urine pregnancy test was positive with a serum beta hCG of 62,157. Transabdominal ultrasound image shows a complex lesion with thick hyperechoic rim (long arrow) in the right adnexal location, seen separate from the right ovary (short arrow). The patient underwent salpingectomy and the diagnosis of ectopic pregnancy was confirmed.

Conclusion

A variety of acute gastrointestinal genitourinary, and gynecological pathologic processes are associated with clinical symptoms similar to that of appendicitis. Imaging with ultrasound, CT, and MRI is useful for identifying appendicitis and associated complications, as well as identifying alternative diagnoses for the patient’s symptoms. Familiarization with various processes causing right lower quadrant pain, such as those covered in this paper, will aid in providing timely and appropriate care to the patient.

References

Case Presentation

A 62-year-old woman presented to the emergency room with diffuse abdominal pain and abdominal distention. White blood cell (WBC) and platelet counts were within normal limits. Radiographs of the abdomen demonstrated no evidence of pneumoperitoneum. Subsequently, CT of the abdomen and pelvis was performed for further evaluation (Fig.).

Figure. Axial (A) and coronal reformatted (B) contrast-enhanced (oral and IV) CT images of the abdomen and pelvis reveal extensive nodular and curvilinear soft tissue deposits in the omental fat anterior to the small bowel and the colon. Free intraperitoneal fluid is seen in both paracolic gutters.
Key Imaging Finding

Diffuse omental thickening and infiltration

Differential Diagnoses

Segmental omental infarction
Omental hematoma
Peritoneal carcinomatosis
Tuberculous peritonitis

Discussion

Interstitial Abdominal pain as a presenting symptom engenders a broad differential diagnosis. The role of imaging for localization and causation of abdominal pain is well-established.

The omentum is a double layer of peritoneum that hangs down like a protective apron from the greater curvature of the stomach and proximal portion of the duodenum and drapes anterior to the small bowel and transverse colon. It is largely composed of a semi-mobile fatty tissue with small intervening vessels which are most commonly the gastroepiploic vessels. Omental thickness varies, primarily in relation to the patient’s BMI.

CT findings of omental fat stranding and infiltration and/or soft tissue density foci are helpful in narrowing a vast differential for abdominal pain to include diseases which primarily affect the omentum. These conditions include segmental omental infarction, omental hematoma, and peritoneal carcinomatosis, and tuberculous peritonitis. Solid neoplasms of the omentum containing fat are rare. Liposarcoma, which is typically found in the retroperitoneum, is rare in the peritoneal cavity. Certain imaging characteristics, paired with patient history, help to differentiate between many possible etiologies.

Segmental Omental Infarction.

Compromise of the vascular supply to the omental apron can result in omental infarcts, often hemorrhagic. Etiologies include primary vascular disorders, direct vascular injury and torsion. Primary torsion is idiopathic; secondary torsion results from a leading mass or inflammatory focus or adhesions from previous abdominal surgery. This process often involves the right side of the omentum for various reasons, including redundancy and increased mobility of the tissue on the right side, possibly resulting in a higher risk of torsion. Additionally, an embryologic variant of blood supply to this portion of the omentum may predispose patients to a higher risk of venous thrombosis. The imaging finding of swirling fatty tissue surrounding a central vascular structure may in fact be a specific finding of omental torsion.

Omental Hematoma.

Omental involvement in traumatic injuries results more commonly from penetrating trauma compared to blunt abdominal trauma. Isolated omental or mesenteric injury is uncommon; secondary injuries are typically seen. Just as direct trauma to omental vasculature can cause infarction, it can also result in omental hematoma. CT findings often include a distinct omental fluid collection measuring blood attenuation but can also manifest as an ill-defined hyperdense region of infiltration of the omental fat with associated hemoperitoneum. A careful search for active hemorrhage with high-attenuation extravascular foci is of utmost importance.

The patient’s medical history and clinical presentation are key in identifying patients with omental hematoma. Occasionally, a history of trauma is not elicited, such as in cases of domestic violence or in patients suffering from head injury or the effects of alcohol or illicit drugs.

Peritoneal Carcinomatosis.

Malignant seeding of the peritoneal cavity is a common occurrence in many genitourinary (particularly ovarian) and gastrointestinal cancers. Omental involvement can range from “increased density of fat anterior to the colon or small bowel to large masses, called omental cakes.” When carcinomatosis manifests as ill-defined fatty infiltration or small soft tissue density nodules, it can be especially difficult to distinguish from other omental pathologies, including rare primary neoplasms.

Even in the absence of a known primary at the time of imaging, peritoneal carcinomatosis must rank high
on the differential for omental lesions. Histopathological confirmation with biopsy is often necessary.

**Tuberculous Peritonitis.**

Since the omentum is bathed in peritoneal fluid, it is not uncommonly involved in infectious processes which result in peritonitis. Direct extension of tuberculosis from the gastrointestinal tract or surrounding lymph nodes can result in the uncommon entity of tuberculous peritonitis. There are three subtypes of this disease process, all characterized clinically by abdominal pain. The first, known as wet peritonitis, involves abdominal ascites. The second is coined the fibrotic type and is “characterized by large omental and mesenteric masses.” The third type is dry peritonitis and involves diffuse fibrous scarring of the peritoneal contents, including the mesentery and omentum. A fibrous wall covering the infiltrated omentum, manifesting as a “thin omental line,” is a common finding and suggests peritoneal TB over alternative disease processes. Additionally, adjacent mesenteric lymph nodes with hypoattenuating centers secondary to caseous necrosis may be present, as is true in general in cases of TB. Moreover, findings suggestive of thoracic TB can be quite helpful in suggesting peritoneal TB as a diagnosis, but the benefit of such thoracic findings is absent in approximately 50% of cases.

Because CT findings are not specific or pathognomonic, the patient’s clinical history and laboratory findings, coupled with a high clinical suspicion, are important in securing a diagnosis.

**References**


**Diagnosis**

Peritoneal carcinomatosis

**Summary**

Abdominal pain is one of the most common presenting symptoms in the emergency room. Diffuse omental thickening and/or stranding, or the presence of focal omental nodules on CT examination are useful clues in limiting the differential to disorders which affect the omentum. Correlating these findings with the clinical scenario and medical history aids the practicing radiologist in directing the referring physician to a correct and specific diagnosis.
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Acute Testicular Pain

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Case Presentation

A 35-year-old man presented to the emergency department with acute onset of right testicular pain. He denied any fever, night sweats, chills, dysuria, hematuria or urethral discharge. Physical examination revealed right testicular pain radiating to right inguinal region and swelling with an intact cremasteric reflex. There was testicular asymmetry with the right testicle vertically-oriented. The patient was subsequently referred for an ultrasound examination to exclude torsion or infection. (Fig.)

Figure. Sagittal gray-scale (A) and color Doppler (B) ultrasound images of the right scrotum demonstrate an enlarged, heterogeneous, and hypervascular epididymis. Color and spectral Doppler sonogram (C) of the right testis shows normal blood flow and perfusion. Color Doppler ultrasound image of the contralateral left epididymis (D) demonstrates normal color flow and perfusion.
Key Clinical findings

Testicular pain with intact cremasteric reflex

Key Imaging findings

Edematous, heterogeneous, and hypervascular right epididymis

Differential diagnosis

Acute epididymitis
Acute orchitis
Testicular torsion

Discussion

Acute scrotal pain requires prompt diagnosis for appropriate treatment. Often times, the differential considerations include infection versus torsion in the absence of trauma. Ultrasound is the modality of choice for evaluating the scrotum. Because of the continuous improvement in the ultrasound technology and increasing experience, sonographers, radiologists, and clinicians can often distinguish between different diseases with greater certainty when vascular hyperemia, edema, and distinctive echotextures are observed on both gray-scale and color Doppler sonography.

Acute Epididymitis

Acute epididymitis is the most common cause of acute scrotal pain in post-pubertal men, representing 75% of all acute intra-scorotal inflammatory diseases. It is clinically defined by pain, swelling and inflammation of the epididymis in the acute (up to 6 weeks) or chronic (> 6 weeks) stages. Although epididymitis can occur at any age group, it is most common between 18 and 35 years of age, with an estimated 600,000 cases per year in the United States. In children, epididymitis accounts for 6 to 47% of cases of acute scrotal pain.

Frequently, epididymitis is caused by a retrograde ascent of pathogens from the lower urinary tract, such as the bladder or prostate, via the lymphatics of the spermatic cord to the epididymis. Rarely, epididymitis may result from hematogenous spread. Epididymitis is typically caused by sexually transmitted pathogens such as Neisseria gonorrhoeae or Chlamydia trachomatis in adolescents. Less common pathogens, such as Escherichia coli, Ureaplasma urealyticum, Proteus mirabilis, Klebsiella pneumoniae, Haemophilus influenza, and Pseudomonas aeruginosa are seen with different age groups.3

The risk factors of epididymitis include high-risk sexual behaviors, strenuous physical activities, prolonged sitting periods, prostate invasive procedures, prostate and urinary tract infections, prostate hypertrophy, urinary tract surgeries, urogenital anomalies and posterior urethral valves in prepubertal boys, human immunodeficiency virus (HIV), Mycobacterium tuberculosis, medications (amiodarone), and trauma. Less commonly, epididymitis can be idiopathic.2,4

The signs and symptoms of acute epididymitis are etiologically dependent. Typically, patients present with a more gradual onset of pain. Scrotal tenderness, edema, erythema, dysuria, fever, urethral discharge, and hematospermia have also been reported.1,3 Acute epididymitis can occur anywhere along the epididymis with the head being most commonly affected.5

Although the diagnosis of epididymitis depends on clinical and laboratory findings, ultrasonography has enhanced the evaluation of the scrotal structures, excluded differentials, identified possible complications, and provided clinical monitoring.1 On ultrasonography, patients with mild epididymitis may not show any sonographic findings. In severe cases of epididymitis, high-resolution gray-scale ultrasonography reveals a thickened, enlarged, and edematous epididymis with decreased (hypoechoic) or coarse (heterogeneous) echogenicity with or without abscess formation. Less common sonographic findings, such as focal hyperechoic areas or diffuse hyper-echogenicity of the epididymis, can be seen.9 Other sonographic findings, such as a reactive hydrocele, concomitant orchitis (in 20% to 40% of patients), testicular infarction, and scrotal wall thickening may also be seen.6,7 In addition, increased flow and vascularity secondary to inflammatory changes within the epididymis on color or power Doppler sonography have been reported.1,6,7

In evaluating color flow within the epididymis, it is
important to compare to the other side. The mere presence of blood flow within a normal epididymis should not be considered diagnosis of acute epididymitis. However, it is the asymmetrical increase of blood flow, which is key. Consequently, increased vascularity is used as a distinguishing factor for the diagnosis of acute epididymitis. When compared to the contralateral side, the presence of normal or increased vascularity on the affected side will assist in the differentiation between epididymitis and torsion. On spectral Doppler, the epididymis will demonstrate a low-resistance index (< 0.7) and high-velocity flow pattern when compared to normal flow patterns.6,8,9

Complications of acute epididymitis are testicular infarction, chronic pain, orchitis, abscess, pyocele, gangrene, atrophy, cutaneous scrotal fistula, and infertility.1,3,8,9

The treatment of acute epididymitis often focuses on treating the infection, improving the symptoms, preventing the progression and transmission of disease, and minimizing any future complications by selecting the appropriate antibiotic. Different kinds of antibiotics have been reported to be effective in treating acute epididymitis.4,5 If antibiotic therapy fails to control the disease in the outpatient setting, hospital admission is necessary. In addition to antibiotic therapy, rest, scrotal elevation, analgesics and utilization of cold packs are recommended. Overall, the treatment of acute epididymitis must be tailored to each patient and the severity of the disease.4

Orchitis

Orchitis refers to inflammation of the testes and can occur in association with acute epididymitis. It is characterized by scrotal pain and swelling. The etiologies differ by age group and are similar to those described above for epididymitis.1,2,4,5,8

Orchitis may be focal or diffuse and cause testicular enlargement.5,6 The typical gray-scale ultrasound findings include a diffusely enlarged, homogeneous, and hypoechoic testis or poorly or well-defined focal hypoechoic intra-testicular areas. However, these findings are nonspecific and may also be seen with tumors, infarction, or torsion. Consequently, color and spectral Doppler are important adjuncts to gray-scale Doppler.6,8,10 On color Doppler, increased vascularity or hyperemia, a distinguishing characteristic, is seen when compared to the asymptomatic side. Spectral Doppler demonstrates an increase in diastolic flow in uncomplicated orchitis.6,8,10

If left untreated, severe testicular edema can compromise the venous drainage from the testis and potentially lead to ischemia and subsequently to infarction. Consequently, decreased or absent flow may be seen on color Doppler and high resistance with little, no, or reversed diastolic flow on spectral Doppler.4,6,8,10

Testicular Torsion

Testicular torsion is caused by twisting of the spermatic cord or of the testis itself on its attachments and cessation of testicular blood flow. It is a urological emergency and accounts for 20% of cases of the acute scrotum. Torsion may occur at any age; however, it is most common in adolescent boys.10 Prompt diagnosis, intervention and definitive management are essential for viability. The salvage rates are nearly 80% to 100% within 5 to 6 hours; 70% at 6 to 12 hours; and 20% at 12 to 24 hours.9

Two types of torsion- intravaginal and extravaginal- have been reported, with intravaginal being the most common in puberty.9 Intravaginal torsion, also known as bell-clapper deformity, occurs when the tunica vaginalis completely surrounds the epididymis, distal spermatic cord, and the testis, preventing fixation to the posterolateral aspect of the scrotal wall. This allows the testis to freely move within the scrotum.5,8,9

Typically, patients present with sudden onset of scrotal or inguinal pain, nausea, vomiting, low-grade fever, anorexia, unilateral scrotal swelling and erythema, absence of a cremasteric reflex, negative Prehn’s sign, Brunzel’s sign, and a high-riding testis.1,2,9 Although history and physical examination may suggest the diagnosis, high resolution gray-scale sonography and color Doppler have proven to be reliable and essential in the diagnosis of torsion because of their high sensitivity and specificity.6,8,9

High-resolution gray-scale findings are dependent on the duration of torsion and the severity of ischemia. In early torsion, the testis can be normal. In the acute phase of torsion (4 to 6 hours), the testis becomes enlarged and hypoechoic due to edema. Later (> 24 hours), it becomes heterogeneous due to
hemorrhage and infarction, which often indicates testicular non-viability. Color or power Doppler sonography shows decrease or absence of detectable intra-testicular blood flow with hypervascularity of surrounding thickened scrotal wall tissues.\textsuperscript{1,6,8}

Additionally, increased resistive index, absent or reversed diastolic flow, and monophasic waveforms can be seen.\textsuperscript{2,6,9} False-positive diagnosis of torsion can be avoided by optimizing parameters for slow flow, such as increasing the color gain, decreasing the wall filter, decreasing the pulse repetition frequency, and increasing the frequency of the transducer. Other associated findings, such as epididymal enlargement, reactive hydrocele, scrotal wall thickening, and ipsilateral enlarged twisted spermatic cord (whirlpool sign), have also been reported.\textsuperscript{1,9}

Treatment of testicular torsion involves rapid restoration of blood flow to the affected testis by manual detorsion (by external rotation) of the testis or orchiopexy of the affected testis (definitive treatment).\textsuperscript{5,6,8,9}

**Diagnosis**

Acute epididymitis

**Summary**

Given the continued improvement in sonographic technology and the superior resolution and sensitivity of color and spectral Doppler sonography, the visualization and characterization of scrotal contents is now more advanced. Acute epididymitis should be suspected at sonography when the epididymis is enlarged, edematous, and hypervascular. These sonographic characteristics assist the sonographer and physician in establishing the correct diagnosis, while excluding differential considerations, such as orchitis and testicular torsion. Prompt and accurate diagnosis is necessary to expedite appropriate treatment and avoid complications.

**References**

Acute Hip Pain

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Case Presentation

A 57-year-old man presented with right hip pain which had begun a few months prior and was thought to be related to his work as a truck driver. He denied any history of recent trauma or mechanical symptoms, such as clicking, locking, instability, giving way, or buckling. There is no significant medical or surgical history. Imaging work-up included initial radiographs, followed by MRI (Fig.).

**Figure.** Single radiograph of the right hip (A) demonstrates no evidence of acute fracture or dislocation. Minimal decrease bone mineralization is noted. Coronal proton density weighted sequence (B) reveals hypointense signal within the femoral head and neck with sparing of the acetabulum. A fat-suppressed intermediate sequence (C) shows corresponding hyperintense signal. No fracture is identified. Subsequent MRI was performed after 3 months (D), demonstrating interval resolution of bone marrow edema within the right femoral neck and head.
Key clinical finding

Acute, transient hip pain

Key imaging findings

Localized bony demineralization and edema of the hip

Differential diagnoses

Occult hip fracture
Osteonecrosis
Septic arthritis
Regional migratory osteoporosis (RMO)
Transient osteoporosis of the hip (TOH)

Discussion

Acute onset of hip pain in an adult has a relatively broad differential. Serious and potentially treatable processes, such as hip fractures, osteonecrosis, and a septic joint must be considered and appropriately worked-up or excluded. Less common and often self-limiting processes, such as regional migratory or transient osteoporosis of the hip, are potential considerations, especially in the setting of localized and transient bony demineralization or marrow edema pattern on MRI.

Occult Hip Fracture

An occult fracture of the hip is an essential differential diagnosis to consider in the setting of acute hip pain. A non-displaced fracture can be occult on plain radiographs. On MRI, T1-weighted sequences will show hypointense fracture lines; fluid-sensitive sequences will show associated marrow edema. In the setting of a stress changes/fracture, an incomplete hypointensity at medial cortex may be seen.

Osteonecrosis

Osteonecrosis (avascular necrosis of the hip) is a multifactorial process; common risk factors include trauma, glucocorticoids, alcohol abuse, systemic lupus erythematosus, radiation, pancreatitis, and sickle cell anemia. The femoral head is the most commonly affected site of the hip. Trauma is nearly always unilateral; systemic, non-traumatic cases of osteonecrosis are often bilateral. Early radiographs show patchy sclerosis of the femoral head, while late radiographs show irregularity, fragmentation, and collapse of femoral head articular surface. MR is 97% sensitive and 98% specific for osteonecrosis. The pathognomonic "double line" sign seen on T2-weighted sequences consists of a low signal intensity line at the periphery of the infarct with a bright inner line along the interface with infarcted bone. A circumscribed subchondral “band-like” lesion with low T1 signal intensity is also pathognomonic for osteonecrosis.

Septic arthritis

Septic arthritis may occur at any joint. In adults, the knee is the most commonly affected joint with the majority of cases occurring from hematogenous spread; the hip is less commonly involved. Early in the disease process, plain radiographs are often normal. The earliest sign is typically a small joint effusion, followed by joint space narrowing due to cartilage destruction and marginal erosions. Hyperemia leads to periarticular osteoporosis; however, a sclerotic host reaction can occur if the septic joint is bacterial. MRI has 100% sensitivity and 77% specificity in the diagnosis of a septic joint. Fat-suppressed T2-weighted sequences will show a hyperintense joint effusion and hyperintense subchondral bone. Post contrast fat-suppressed T1-weighted sequences will demonstrate synovial thickening, subchondral bone enhancement, and an occasional adjacent soft tissue abscess.
Regional Migratory Osteoporosis (RMO)

RMO is defined as sequential polyarticular arthralgia of the weight bearing joints associated with severe focal migratory osteoporosis. Men in their fifth and sixth decades of life are most commonly affected. The condition involves only the lower extremities, especially the knee, ankle, and foot, with lesser involvement of the hip joints. This distribution helps differentiate RMO from transient osteoporosis of the hip (discussed below). Migration may occur in the same or at a different joint and occurs at an unpredictable time interval after the onset of symptoms. Usually, the joint nearest the affected joint is the next to be involved. The patient’s clinical examination demonstrates generalized tenderness and a warm, edematous affected joint. The overlying skin is often affected by inflammatory changes, and muscle atrophy is frequently noted. Imaging findings of RMO are indistinguishable from transient osteoporosis of the hip, except for the migratory pattern. Systemic osteoporosis is a more recently recognized accompanying feature that hints at an underlying etiology and an approach to the management of this condition.3,4

Transient Osteoporosis of the Hip (TOH)

TOH is a rare skeletal disorder that usually affects healthy middle-aged men and women during the third trimester of pregnancy or immediate postpartum period.5,6 The condition affects men twice as often as pregnant or postpartum women.7 TOH presents spontaneously with sudden-onset of pain at the affected joint. Pain is worse with weight bearing and may be disabling. Symptoms gradually subside within 4 to 9 months and may recur.3 Although many studies have tried to determine the etiology for TOH, the exact cause remains unknown.

Conventional radiographs are often normal in the early stages of TOH. Within 4 to 8 weeks, however, patients develop variable and often profound osseous demineralization of the femoral head and neck, sometimes extending into the acetabulum. There is a loss of the subchondral bone within the femoral head that can progress to complete absence of the osseous architecture, known as “phantom appearance of the femoral head.”8 Joint effusions develop in most cases, but the joint space remains intact; no subchondral erosions are evident.3 Skeletal scintigraphy shows homogenous increased uptake in the femoral head and neck on all three phases, before demineralization is seen on radiographs.9

Magnetic resonance imaging has become the modality of choice for early diagnosis of TOH, with the typical changes seen within the first 48 hours after the onset of symptoms.3 MR imaging shows diffuse, ill-defined edema (decreased signal on T1 and increased signal on fat-suppressed T2-weighted images) without focal subchondral or articular surface defects. Edema extends from the articular surface of the femoral head to the femoral neck, can involve the intertrochanteric region and the acetabulum, and may spare the subchondral region of the femoral head.10 Fat-suppressed contrast enhanced images show abnormal enhancement with a similar distribution. A joint effusion may be present.

Clinical improvement occurs over several weeks to months without any specific treatment. The radiographic appearance gradually returns to normal, usually lagging behind clinical improvement by 4 to 8 weeks.8 MR imaging and skeletal scintigraphy both show complete resolution within several weeks, but may take up to 11 months.8,10
Diagnosis

Transient osteoporosis of the hip (TOH)

Summary

Transient osteoporosis of the hip (TOH) is a benign self-limiting condition that can be differentiated from other etiologies of a painful hip (hip fracture, osteonecrosis, septic joint, etc.) on the basis of radiologic and clinical findings. Radiographic evidence of focal demineralization is the single most important finding and may become evident within 4 to 8 weeks of symptom onset. MRI often shows characteristic changes within 48 hours of initial symptom presentation and helps exclude other etiologies of bone marrow edema. The treatment of TOH is typically supportive with resolution within several weeks to months.

References

JAOCR at the Viewbox

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Tonsillitis Versus Tonsillar / Peritonsillar Abscess.

An adolescent presents with high fever, sore throat, odynophagia, possibly with neck swelling. A tonsillar infection is suspected, but how severe? In the ED setting, contrast-enhanced CT plays a key role in distinguishing between acute tonsillitis, and tonsillar / peritonsillar abscess, which have divergent treatments. Acute tonsillitis will appear as edematous inflamed lymphoid tissue, without a focal fluid collection. In some cases, a distinctive “tiger stripe” appearance is present, as seen in the right palatine tonsil in this image (Fig.). Treatment with oral antibiotics is appropriate, targeting the most common pathogens: Group A β-hemolytic Streptococcus, Staphylococcus aureus, and Haemophilus influenzae. However, tonsillar / peritonsillar abscess presents as a hypo-attenuating fluid collection with peripheral rim enhancement, as seen above in the left palatine tonsil (Fig.), requiring surgical incision and drainage. An irregular or scalloped contour of the enhancing wall is very specific for abscess. Complications include airway compromise and abscess rupture leading to deep neck space infection and/or aspiration of pus. Ideally, peritonsillar cellulitis or phlegmon, treated with IV antibiotics, should produce an intermediate appearance between tonsillitis and frank abscess; yet the picture is often not so clear-cut. CT is excellent at distinguishing between tonsillitis and abscess, however approximately 25% of CT-suspected abscesses will in fact be phlegmonous and not drainable by I&D. Finally, in a setting other than acute infection, keep in mind the differential diagnosis of lymphoid hyperplasia, and inflammatory conditions such as angioedema and mucositis. In an older adult, squamous cell carcinoma must always be considered.

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Ileocolic Intussusception.

A 9-month-old boy presented to the emergency room with excessive crying and rectal bleeding. A right upper quadrant ultrasound was performed (A), showing the classic “donut/target” like appearance of the bowel (arrowheads), consistent with intussusception. A fluoroscopic spot image from a subsequently performed therapeutic air enema (B) outlines a lobulated “mass” in the ileocecal region (marked by arrows), which signifies a partially reduced, small residual intussusception.

Ileocolic intussusception is one of the most common causes of an acute abdomen between 5 and 24 months of age. Prompt diagnosis and treatment helps prevent obstruction, bowel ischemia, and perforation. The classic clinical triad of abdominal pain, palpable abdominal mass, and red currant-jelly stool is uncommon. Typically, the presentation is more nonspecific.

On a three-view abdominal series (supine, prone, and lateral decubitus), ascending colonic air on all views has a reported sensitivity of 100% to exclude intussusception. Ultrasound is now the modality of choice due to its lack of ionizing radiation, quick examination time, and no requirement for contrast media. A “donut,” “pseudokidney,” or “target” sign on ultrasound is used to diagnose intussusception. Intralional lymph nodes and large lesion diameter suggest ileocolic intussusception.

Air/contrast enemas can be performed to reduce intussusceptions. Rectally introduced air outlines a lobulated mass within the large bowel, proximal to which there is very little gas within the large bowel. The “intussusceptum” progresses towards the cecum; free reflux of air into the terminal ileum indicates successful reduction. Air reduction should be performed with immediate surgical support available.
High Probability for Pulmonary Embolism on VQ Scan.

A 48-year-old man presented to the emergency room with sudden onset of shortness of breath and a history of pulmonary hypertension on echo. Patient was unable to undergo a CT of the chest with contrast due to contrast allergy. Ventilation images were obtained in multiple projections following preparation of 30 mCi of Tc 99m stannous DTPA (diethylene triamine pentaacetic acid) by nebulizer. Perfusion images were obtained in multiple projections following intravenous administration of 2.1 mCi Tc 99m MAA (macroaggregated albumin). The dose of MAA was reduced by 50% in view of the known pulmonary hypertension.

Images above show multiple mismatched segmental perfusion defects. These include the anterior and posterior segments of the right upper lobe, lateral segment of the right middle lobe, and superior and lateral basal segments of the right lower lobe. There is also globally reduced perfusion in the entire right lung relative to the left which is not matched on ventilation images. A few sub-segmental areas of ventilation/perfusion mismatch are noted in the left lung, including the apico-posterior segment of the left upper lobe and superior segment of the left lower lobe.

These findings are consistent with a high probability for acute pulmonary embolism, since there are two or more large mismatched segmental defects, as well as globally reduced perfusion in the entire right lung relative to the left.