Disproportionate Fat Stranding: A Helpful CT Sign in Patients with Acute Abdominal Pain

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Fat stranding adjacent to thickened bowel wall seen at computed tomography (CT) in patients with acute abdominal pain suggests an acute process of the gastrointestinal tract, but the differential diagnosis is wide. The authors observed “disproportionate” fat stranding (ie, stranding more severe than expected for the degree of bowel wall thickening present) and explored how this finding suggests a narrower differential diagnosis, one that is centered in the mesentery: diverticulitis, epiploic appendagitis, omental infarction, and appendicitis. The characteristic CT findings (in addition to fat stranding) of each of these entities often lead to a final diagnosis. Diverticulitis manifests with mild, smooth bowel wall thickening and no lymphadenopathy. Epiploic appendagitis manifests with central areas of high attenuation and a hyperattenuated rim, in addition to its characteristic location adjacent to the colon. In contrast, omental infarction is always centered in the omentum. The most specific finding of appendicitis is a dilated, fluid-filled appendix. Correct noninvasive diagnosis is important because treatment approaches for these conditions range from monitoring to surgery.

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Introduction

In patients with acute abdominal pain, the finding of fat stranding adjacent to thickened bowel wall on computed tomographic (CT) scans suggests a gastrointestinal origin for the patient’s pain, but the differential diagnosis is broad. Anecdotally, we have observed that fat stranding that is “disproportionate”—that is, much greater than the degree of bowel wall thickening—suggests a narrower differential diagnosis: diverticulitis, epiploic appendagitis, omental infarction, and appendicitis. In this article, we introduce “disproportionate fat stranding” as a CT sign that helps in the evaluation of patients with acute abdominal pain. Typical clinical and CT features of the four pathologic entities that characteristically manifest this sign are described. Emphasis is placed on findings that allow differentiation of these processes from other diseases of the mesentery and omentum, including acute and chronic conditions. Correct noninvasive diagnosis is important, as epiploic appendagitis and omental infarction are typically self-limited conditions, whereas appendicitis and many cases of diverticulitis require surgery or other intervention.

Pathophysiology and CT Findings

Most acute inflammatory diseases of the gastrointestinal tract, including infectious, noninfectious, and ischemic disorders, are centered in the bowel wall. For these diseases, the degree of bowel wall thickening typically exceeds the degree of associated fat stranding, and not uncommonly, fat stranding may be subtle despite marked mural abnormality (Fig 1).

In a few acute diseases of the gastrointestinal tract, however, the pathologic process is characteristically centered in the mesentery adjacent to the bowel wall rather than in the bowel wall itself. In these diseases, the fat stranding is often disproportionately greater than the degree of wall thickening (Fig 2). Because the list of diseases that typically manifest disproportionate fat stranding is short—diverticulitis, epiploic appendagitis, omental infarction, and appendicitis—this observation is a helpful diagnostic clue to narrow an otherwise broad differential diagnosis.

Diverticulitis

Diverticula are small sacculations of mucosa and submucosa through the muscularis of the colonic wall. They develop where the nerve and blood vessel pierce the muscularis between the teniae coli and mesentery, an origin that accounts for
their propensity to bleed. Diverticula can be found anywhere in the colon, but they occur predominantly in the descending and sigmoid colon. They do not develop in the rectum. Diverticula also occur in the small intestine, but they are less common than those arising from the colon. A Meckel diverticulum is a congenital outpouching derived from an unobliterated yolk stalk, and it occurs exclusively in the distal ileum.

Diverticulitis occurs when the neck of a diverticulum becomes occluded, resulting in inflammation, erosion, and microperforation. Microperforation results in pericolonic inflammation that typically is more severe than the inflammation of the colon itself. Ninety-five percent of cases occur in the left side of the colon. Right-sided diverticulitis accounts for 5% of cases and occurs more frequently in Asians. Diverticulitis of the transverse colon or small intestine is rare.

The appearance of acute diverticulitis on CT scans parallels the pathologic features. The most common CT finding is paracolic fat stranding. The fat stranding characteristically is disproportionately more severe than the relatively mild, focal colonic wall thickening (Fig 3). Diverticula are typically present. The inflammatory process can result in accumulation of fluid in the root of the sigmoid mesentery, which appears on CT scans as the “comma sign” (Fig 4), and engorgement of the mesenteric vessels, which appears as the “centipede sign” (Fig 5) (1).
Although a diagnosis of diverticulitis from CT findings may be difficult to make when the location is atypical, the combination of diverticula and disproportionate fat stranding suggests the diagnosis, even in unusual locations, such as the right side of the colon, transverse colon, distal ileum, and jejunum (Figs 6–9) (2–5). The most important entity in the differential diagnosis to exclude is colon adenocarcinoma. However, there

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Differentiating Features of Diverticulitis and Colon Adenocarcinoma on CT Scans</th>
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<tbody>
<tr>
<td>Feature</td>
<td>Diverticulitis</td>
</tr>
<tr>
<td>Diver</td>
<td>tcula</td>
</tr>
<tr>
<td>Fat stranding</td>
<td>Disproportionate</td>
</tr>
<tr>
<td>Presence of comma or centipede sign</td>
<td>Yes</td>
</tr>
<tr>
<td>Fluid</td>
<td>Present at mesenteric root</td>
</tr>
<tr>
<td>Colon wall thickening</td>
<td>Mild, smooth, concentric</td>
</tr>
<tr>
<td>Transition from normal to abnormal wall thickness</td>
<td>Gradual</td>
</tr>
<tr>
<td>Length of affected segment</td>
<td>Long (5–10 cm)</td>
</tr>
<tr>
<td>Lymphadenopathy</td>
<td>None</td>
</tr>
</tbody>
</table>

Source.—References 6–8.
are several features that help differentiate the two conditions (6–8), as summarized in Table 1 and shown in Figures 10 and 11.

**Epiploic Appendagitis**

Appendices epiploicae are pedunculated adipose structures protruding from the external surface of the colon into the peritoneal cavity. They are arranged in two separate longitudinal rows that extend from the cecum to the rectosigmoid junction. Approximately 50–100 in number, appendices epiploicae are typically 1–2 cm thick and 2–5 cm long. Appendices epiploicae are normally invisible on CT scans because they blend with the surrounding fat unless they are surrounded by ascites (Fig 12). Each is supplied by one or two small end arteries branching from the vasa recta longa of the colon and is drained by a tortuous vein passing through its narrow pedicle. Their limited blood supply, together with their pedunculated shape and excessive mobility, make appendices epiploicae prone to torsion and ischemic or hemorrhagic infarction (9,10).
Figures 12–14. (12) Axial CT image shows normal appendices epiploicae (arrows) of the sigmoid colon, which appear as fingerlike projections of pericolic fat floating within ascites (*). (13) Epiploic appendagitis in a 23-year-old man. Axial contrast-enhanced CT image shows an ovoid mass (solid arrow) of fat attenuation anterior to the wall of the descending colon. The mass is surrounded by a hyperattenuated rim (representing thickened visceral peritoneum) and contains a central high-attenuation dot (most likely representing thrombosed central vessels). Note the moderate fat stranding (arrowhead) and mild focal thickening of the adjacent colonic wall (open arrow). (14) Epiploic appendagitis in a 46-year-old man. Axial contrast-enhanced CT image shows severe fat stranding (arrowheads) and a fatty ovoid mass (curved arrow) with a hyperattenuated rim and central dot (open arrow). Associated thickening of the colonic wall is mild (solid straight arrow).

Figure 15. Normal greater omentum. Axial contrast-enhanced CT image shows the normal layer of fat attenuation between the transverse colon and anterior abdominal wall (arrowheads). Mesenteric lymph nodes are mildly enlarged (arrows).

Figure 16. Omental infarction. Axial contrast-enhanced CT image of a patient who presented with acute right upper quadrant pain shows an inhomogeneous mass (arrow) in the greater omentum, anterior to the transverse colon. Moderate adjacent wall thickening is also evident (arrowhead). Diverticulitis was a diagnostic consideration, but no diverticula were seen at CT. A barium enema study performed 1 month later (not shown) revealed a normal colonic lumen without diverticula. Cholecystitis was also a consideration, but there was no inflammation of the fat immediately adjacent to the gallbladder, and the gallbladder appeared normal at ultrasonography (not shown) performed immediately after CT.
Acute torsion of an appendage results in a focal inflammatory process called epiploic appendagitis. The condition usually manifests as localized abdominal pain in one of the lower quadrants, since the sigmoid colon and cecum are the main sites of involvement. Epiploic appendagitis clinically mimics acute appendicitis or diverticulitis. CT findings of epiploic appendagitis are usually diagnostic (11,12). Characteristic findings include (a) a paracolic oval fatty mass representing the infarcted or inflamed appendix epiploica, (b) a well-circumscribed hyperattenuated rim that surrounds the mass and represents the inflamed visceral peritoneal lining, and sometimes (c) a high-attenuation central dot representing engorged or thrombosed central vessels or central areas of hemorrhage (Fig 13). Most important, the paracolic inflammatory changes are typically disproportionately more severe than the mild local reactive thickening of the adjacent colonic wall (Fig 14).

Noninvasive diagnosis is important because epiploic appendagitis is self-limiting, and the appropriate management is conservative (13,14).

Omental Infarction

The greater omentum is composed of a double layer of peritoneum that extends inferiorly from the greater curvature of the stomach, turns superiorly on itself to drape over the transverse colon, and extends to the retroperitoneal pancreas. The blood supply of the greater omentum travels largely through the right and left gastroepiploic arteries.

Normally, the greater omentum appears on CT scans as a band of fatty tissue that contains small vessels and is located just anterior to the transverse colon (Fig 15). It has a variable thickness, which depends primarily on the weight of the individual.

Segmental omental infarction typically occurs on the right (mimicking appendicitis or gallbladder disease [15]), a predilection that has been attributed to an embryologic variant of the blood supply of the right portion of the omentum, which predisposes it to venous thrombosis (16). Risk factors include obesity and recent surgery.

On CT scans, the infarcted omentum appears as a large, cakelike, high-attenuation fatty mass centered in the omentum (17) (Figs 16–18). The mass may or may not be immediately adjacent to the colon, depending on the anatomic location of the infarcted omentum relative to the colon. Reactive bowel wall thickening may occur, but the inflammatory process in the omentum usually is disproportionately more severe.
Omental infarction and epiploic appendagitis may have similar appearances on CT scans. Distinguishing features have been described (18) (Table 2); nevertheless, the clinical relevance of such differentiation is limited because the treatment for both conditions is conservative (ie, nonsurgical). Some authors advocate use of the term intraabdominal focal fat infarction for cases in which the two entities cannot be reliably differentiated (18).

Appendicitis
In the Western world, appendicitis is the most common cause of acute abdominal pain that requires surgical intervention. The primary pathogenic event in the majority of cases is luminal obstruction caused by fecaliths and lymphoid hyperplasia. Foreign bodies, parasites, and primary and metastatic tumors are less common causes of obstruction. Once obstruction occurs, the continued secretion of mucus results in elevated intraluminal pressure and luminal distention, with consequent venous engorgement, arterial compromise, and tissue ischemia. Luminal bacteria multiply and invade the appendiceal wall, causing transmural inflammation. Eventually, appendiceal infarction and microperforation occur, and the inflammation extends to the parietal peritoneum and adjacent structures.

Direct visualization of a dilated (>6 mm in maximum diameter), fluid-filled appendix is the most specific CT finding of appendicitis (Fig 19) (19,20). Other direct signs include an abnormally thickened appendix, increased attenuation of the appendix after contrast material administration, and periappendicular fat stranding (21,22). Secondary signs include appendicolith(s) or thickening of the cecal apex (cecal bar sign and the arrowhead sign) (Fig 20) (23–25).

Table 2
Differentiating Features of Epiploic Appendagitis and Omental Infarction on CT Scans

<table>
<thead>
<tr>
<th>Feature</th>
<th>Epiploic Appendagitis</th>
<th>Omental Infarction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hyperattenuated rim</td>
<td>Present</td>
<td>None</td>
</tr>
<tr>
<td>Central area of high attenuation</td>
<td>Present</td>
<td>None</td>
</tr>
<tr>
<td>Anatomic location relative to the colon</td>
<td>Always immediately adjacent</td>
<td>Centered in the omentum</td>
</tr>
<tr>
<td>Location of pain</td>
<td>Right lower quadrant, left lower quadrant</td>
<td>Right lower quadrant, right upper quadrant</td>
</tr>
</tbody>
</table>

Source.—Reference 18.

Figures 19, 20. (19) Appendicitis in a 21-year-old patient. Axial nonenhanced CT image shows a thickened appendix (white arrows) surrounded by marked fat stranding (arrowheads). Note the high-attenuation appendicolith (black arrow). (20) Appendicitis in a 7-year-old boy. Axial contrast-enhanced CT images (a obtained at a higher level than b) show the high-attenuation wall of the dilated fluid-filled appendix (white arrow). Surrounding fat stranding is severe (arrowheads). Note mild posterolateral wall thickening of the cecum (cecal bar sign) (solid straight black arrow) and also the arrowhead-shaped collection of contrast agent (arrowhead sign) (curved arrow) formed as contrast material funnels into the partially coapted cecal wall adjacent to the occluded appendiceal orifice. An appendicolith is also seen (open arrow).
Periappendicular fat stranding is typically mild to moderate (Fig 21), but it can be severe (Fig 22). The diagnosis of appendicitis from CT findings is straightforward if the appendix is easily visualized (26). However, in cases of perforated appendicitis with peritonitis or abscess formation, the appendix may be difficult to see (27,28). In our experience, the finding of severe fat stranding in the right lower quadrant in the absence of substantial cecal or ileal thickening suggests the possibility of appendicitis. A careful search for a thickened or focially perforated appendix will often yield the finding to confirm the diagnosis (Figs 23, 24) (29–32).

Other Causes of Fat Stranding

Fat stranding may arise from other acute and chronic causes that should be considered in the differential diagnosis. The clinical presentation—acute or chronic—is a key diagnostic feature. Acute conditions that cause fat stranding include perforation of the bowel; perforation of colon cancer; inflammation associated with pancreatitis or cholecystitis; trauma; and surgery. Chronic conditions that manifest with fat stranding include neoplasms of the omentum, chronic infections of the omentum, and mesenteric panniculitis.
Acute Causes of Fat Stranding

Acute peritonitis of any cause may manifest with fat stranding or ascites. The fat stranding is usually diffuse or multifocal, which permits it to be differentiated from the stranding caused by uncomplicated cases of diverticulitis, epiploic appendagitis, omental infarction, and appendicitis. Inflammation, infection, or ischemia of bowel may manifest with fat stranding, but these entities typically cause circumferential thickening of the bowel wall that is more severe than the degree of associated fat stranding (Fig 25).

Acute perforation of the colon associated with colon cancer may cause fat stranding that is difficult to differentiate from that seen in cases of diverticulitis. Bowel wall thickening may be a helpful feature, as the mural thickening seen in malignant perforation of the colon tends to be more severe and more focal than that associated with diverticulitis. Other helpful clues are shouldering, whether the wall thickening is concentric or not, adjacent lymphadenopathy, and metastases (Table 1). In some cases, however, differentiation between colon cancer and diverticulitis is not possible with CT alone (Fig 26).

In pancreatitis or cholecystitis, fat stranding is characteristically most severe immediately adja-
cent to the inflamed organ (Fig 27), and this location is atypical compared with those associated with the other causes of fat stranding. Moreover, other signs of pancreatitis or cholecystitis are usually present.

Although trauma can cause fat stranding, trauma to the omentum or mesentery alone is uncommon. Usually, a history of trauma is available and other CT findings of injury (e.g., hemoperitoneum, mesenteric hematoma or interloop fluid, and parenchymal laceration) are present, which allow a straightforward diagnosis.

Focal fat stranding is adjacent to the surgical bed is extremely common after recent abdominal surgery. If the stranding is focal and sufficiently severe, differentiation from omental infarction may be impossible, especially because surgery is a known risk factor for omental infarction. However, differentiation is usually not clinically important, as management of omental infarction is conservative.

**Chronic Causes of Fat Stranding**

Primary omental tumors and metastases can cause fat stranding (Fig 28); however, involvement of the omentum with tumor often results in a more nodular appearance than does omental infarction. Patient history is helpful in the differential diagnosis.

Chronic infection of the omentum, particularly tuberculosis, may appear similar to omental infarction on CT scans (Fig 29). However, the findings of intraabdominal lymph nodes, particularly low-attenuation nodes, and bowel wall thickening, particularly in the ileocecal region, should suggest the diagnosis (33). A history of tuberculosis, positive tuberculin skin test, and characteristic chest radiographic findings would be additional clues but may not be present.

Mesenteric panniculitis is a rare idiopathic disorder characterized by a chronic nonspecific
flammation involving the adipose tissue of the bowel mesentery (34). It has a poorly understood association with underlying malignancy, which suggests that, at least in some patients, it may be a paraneoplastic condition. On CT scans, panniculitis characteristically manifests as a solitary well-defined mass of inhomogeneous fatty tissue at the root of the jejunal mesentery. Because it extends along the root of the jejunal mesentery, panniculitis typically has a leftward orientation (Fig 30a). The fatty mass engulfs superior mesenteric vessels without vascular narrowing. Bowel loops are often displaced but not invaded. Well-defined, soft-tissue nodules less than 5 mm in diameter are often scattered throughout the mass. A distinctive, hypoaettenuated fatty halo typically surrounds the nodules and vessels (Fig 30b) and helps differentiate panniculitis from lymphoma and other malignant causes of mesenteric adenopathy. A hyperattenuating stripe partially surrounding the mass is also suggestive of panniculitis (Fig 31). The characteristic location and appearance of panniculitis, and the asymptomatic or chronic presentation of patients with this disease permit the diagnosis.

Summary
The observation of disproportionate fat stranding is a helpful CT sign in patients with acute abdominal pain. Anecdotally, we observed that the presence of fat stranding that is more severe than expected for the degree of bowel wall thickening suggests that the pathologic process is centered in the mesentery. This sign helps narrow the differential diagnosis of gastrointestinal disorders to four main entities: diverticulitis, epiploic appendagitis, omental infarction, and appendicitis. The characteristic CT findings of each of these entities often lead to a final diagnosis. Other entities, although less common, include acute and chronic processes of the mesentery and bowel wall and should also be considered.
References


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