ORIGINAL ARTICLE

Internal Hernia: Computed Tomography Diagnosis and Differentiation from Adhesive Small Bowel Obstruction

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Background: The goals of this study were to evaluate the specific computed tomography (CT) features of internal hernia (IH), and to verify CT features useful for the differential diagnosis of IH from adhesive small bowel obstruction (ASBO), and for the early detection of intestinal strangulation.

Methods: CT findings for 28 patients with surgically proven IH were retrospectively reviewed and compared with those for 50 patients with surgically proven ASBO.

Results: CT features most suggestive of IH versus ASBO included the following: a cluster of small bowel segments (100% vs 4% of patients; $p < 0.0001$); crowding and convergence of mesenteric vessels (79% vs 4%; $p < 0.0001$); mesenteric vessel engorgement (79% vs 26%; $p = 0.0002$); and mass effect to the surrounding bowels (82% vs 44%; $p = 0.002$). In addition, intestinal strangulation, the most severe complication, occurred more in IH than ASBO (39% vs 10%; $p = 0.002$), whereas proximal small bowel dilation (46% vs 100%; $p < 0.0001$) and small-bowel feces sign (0% vs 26%; $p = 0.0029$) were less common in IH than ASBO. The CT features indicative of intestinal strangulation were localized mesenteric fluid ($p < 0.0001$), mesenteric infiltrates ($p = 0.0005$), bowel wall thickening ($p = 0.003$), intramural hemorrhage ($p = 0.005$), mesenteric vessel engorgement ($p = 0.03$), and abnormal bowel wall enhancement ($p = 0.008$); the first 4 of these features were noted more in patients with IH than ASBO.

Conclusion: The most specific CT criteria for the diagnosis of IH, rather than ASBO, were engorged mesenteric vessels, mass effect to surrounding organs, and bowel wall thickening. When associated mesenteric infiltrates were found, intestinal strangulation was highly suspected. [*J Chin Med Assoc* 2005;68(1):21–28]

Key Words: adhesive small bowel obstruction, computed tomography, intestinal hernia, intestinal ischemia, intestinal strangulation

Introduction

Internal hernia (IH) is defined as herniation of abdominal viscera into one of the fossae, through a postsurgical or congenital defect within the peritoneal cavity, or through an aberrant hiatus formed by a congenital band. Based on autopsy studies, the incidence of IH ranges from 0.2–0.9%,[1] and IH accounts for 0.6–5.8% of all intestinal obstructions.[2,3]

Due to the risk of strangulation of hernia contents, even small IH is dangerous and may be lethal. Crucial for physicians in the early diagnosis of IH are differentiation from adhesive small bowel obstruction (ASBO), and early detection of strangulation in the emergency department, because IH often requires emergency surgery.

To date, the literature about IH mainly comprises case reports,[4–9] and emphasis has been placed on

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radiographic features on plain radiography, barium studies, and angiography. Here, we publish what we believe is the largest series of surgically proven IH and evaluate the specific computed tomography (CT) features of IH, and verify CT features that are useful for the differential diagnosis of IH from ASBO.

Methods

Twenty-eight patients with IH between September 1996 and July 2002 were enrolled in this study. Another 50 patients with ASBO between January 2001 and October 2002 were enrolled as the control group. The final diagnoses were all established by surgery. Time delays between CT study and surgery were all within 1 day, except for 5 patients in the ASBO group (1–2 days), 4 patients in the IH group (> 3 days) and 8 patients in the ASBO group (> 3 days). The CT, surgical and medical records were retrospectively reviewed with consensus by 3 radiologists.

In the IH group, 27 patients underwent helical CT and 1 underwent conventional CT. All patients underwent imaging of the abdomen and pelvis. Fifteen patients received both pre- and post-contrast CT scan. Eleven patients had only a post-contrast CT scan, and 2 had only a non-contrast CT scan. Patients received a rapid intravenous infusion of 100 mL of 30–60% iodinated contrast medium (Conray® 60 [iothalamate meglumine]; Ultravist® 370 [iopromide]) administered at 2–3 mL/sec. Oral administration of a 2% iodinated, water-soluble, contrast material was performed 60 minutes before scanning (600 mL administered) or at the time of scanning (300 mL). CT was performed with a GE HiSpeed Advantage™ scanner (GE Medical Systems, Milwaukee, WI, USA; n = 26) with 7 mm collimation and 1.0 pitch; with a Siemens SOMATOM Plus-4 scanner (Siemens Medical Solutions, Erlangen, Germany; n = 1) with 8 mm collimation and 1.0 pitch; or Picker® IQ (Picker International Inc, Cleveland, OH, USA; n = 1) with contiguous 8 mm scanning.

In the ASBO group, 48 patients underwent helical CT and 2 underwent conventional CT. The amount, injection rate and brand of intravenous contrast medium, and the amount and concentration of oral contrast medium, were the same as for IH patients. All patients underwent imaging of the abdomen and pelvis. Nineteen patients received both a pre-contrast and post-contrast CT scan. However, 27 patients had only a post-contrast CT scan, and 4 had only a non-contrast CT scan. Collimation was 7 or 10 mm. The scan delay, pitch and CT scanners were the same as for the IH group.

All CT features evaluated in this study were based on those reported in previous literature,[4–16] and on our prior imaging experience. Small bowel dilation was defined as bowel-segment diameter > 2.5 cm, with involved segments of small bowel in the IH group categorized as follows: dilation of both proximal and herniated bowel segments; dilation of proximal bowel segments only; dilation of herniated bowel segments only; and no dilation of either proximal or herniated bowel segments. In the ASBO group, only 2 categories, the presence or absence of dilation in proximal bowel segments, were considered. Bowel contents were recorded in dilated bowel segments only, both in proximal bowel segments above herniation, and in herniated, dilated bowels. The contents were categorized as air predominance, fluid predominance, or mixed air and fluid. The associated small-bowel feces sign (gas bubbles mixed with particulate matter in dilated small bowel segments proximal to an obstruction)[16] was also recorded.

The "beak sign" was defined as a triangular configuration of the transition zone between proximal dilated bowels and herniated bowel segments, or between dilated, herniated bowel segments and distal, collapsed bowel segments. The number of beak signs seen on axial CT was also recorded.

We evaluated the mesenteric vessels for the presence of crowding and convergence, engorgement, and an abnormal vessel relationship between the superior mesenteric artery and vein. Small bowel segments were considered clustered when they were gathering together as a bunch. Encapsulation was documented when small bowel segments seemed to be enclosed in a sac (or enveloped by a thin membrane). We also checked for the presence or absence of omental fat between the herniated bowel and adjacent abdominal wall, and for any presence of mass effect to the surrounding bowels.

The CT features implying intestinal strangulation[11–15] were associated with ischemic changes affecting the bowel wall and attached mesentery, and included the following: bowel-wall thickening (≥ 3 mm in a dilated segment); intramural hemorrhage (high attenuation of the bowel wall on unenhanced CT scan); the presence of mesenteric infiltration; localized mesenteric fluid; engorgement of mesenteric vessels; abnormal bowel-wall enhancement, including lack of enhancement, a target pattern of enhancement, or heterogeneous enhancement; ascites; pneumatosis intestinalis; portomesenteric venous air and thrombosis; abscess formation; and intra-abdominal free air.

For logistic regression analyses, we used 5 CT criteria for the IH and ASBO groups (engorged mesenteric vessels, mass effect to surrounding organs, bowel-wall thickening, mesenteric fluid, and mesenteric infiltrates), and 3 for the intestinal strangulation and non-strangulation groups (engorged mesenteric vessels, bowel-wall thickening, mesenteric infiltrates); indeed, some CT criteria presented in only a few cases. Statistical analyses were performed using Fisher's exact Chi-squared test and Pearson's Chi-squared test, using Statistical Package for the Social Sciences version 10.0 (SPSS Inc, Chicago, IL, USA). A p value of less than 0.05 was considered statistically significant.

Results

The IH group comprised 18 male and 10 female patients, aged 17–81 years (mean, 62.3 years), and the ASBO group comprised 39 male and 11 female patients, aged 13–88 years (mean, 65.2 years). No statistically significant differences were noted between the 2 groups regarding age and gender distribution. The postoperative course was smooth for patients in both groups, except for three patients in the ASBO group who died within 1 month of surgery.

Nineteen patients (68%) in the IH group versus 44 (88%) in the ASBO group ($p = 0.03$) had undergone previous major abdominal or pelvic surgery, during which intestinal strangulation was found and bowel resection performed in 11 of 28 (39%) IH patients and five of 50 (10%) ASBO patients ($p = 0.0021$).

Specific CT features for IH and ASBO patients, and p values for differences, are listed in Table 1. In the IH group, small bowel dilation existed in both proximal and herniated bowel segments in 11 patients (39%), only in herniated bowel segments in 13 patients (46%), and only in proximal bowel segments in 2 patients (7%). Two patients (7%) had no small bowel dilation, but because of severe abdominal pain, surgeons decided to perform laparotomy.

The bowel contents in dilated bowel segments proximal to herniated bowels, or in dilated, herniated bowel segments in IH patients, and contents in proximal, dilated bowel segments in ASBO patients, are listed in Table 2. The number of beak signs (Figures 1A, 2A) in both groups is listed in Table 3.

Most patients in the IH and ASBO groups showed normal, homogeneous, bowel-wall enhancement. Among 26 IH patients who underwent post-contrast study, 1 (4%) showed no enhancement (Figure 3), and 2 (8%) showed a target appearance of enhancement (Figure 4B). Among 46 ASBO patients who underwent post-contrast study, 1 (2%) showed no enhancement, and 1 (2%) showed a target appearance of enhancement. All 5 of these patients proved to have intestinal strangulation during surgery, except for one IH patient with a target appearance of enhancement.

Table 1. Computed tomography (CT) features differentiating patients with internal hernia (IH; n = 28) from patients with adhesive small bowel obstruction (ASBO; n = 50)

CT feature	IH, n (%)	ASBO, n (%)	p
Cluster of small bowel segments	28 (100)	2 (4)	< 0.0001
Crowding and convergence of mesenteric vessels	22 (79)	2 (4)	< 0.0001
> 1 beak sign	12 (43)	0 (0)	< 0.0001
Engorged mesenteric vessels	22 (79)	13 (26)	0.0002
Mass effect to surrounding organs	23 (82)	22 (44)	0.002
Intramural hemorrhage*†	6 (35)	0 (0)	0.001
Bowel-wall thickening*	12 (43)	8 (16)	0.01
Mesenteric fluid*	18 (64)	19 (38)	0.023
Mesenteric infiltrates*	18 (64)	20 (40)	0.04
Encapsulation	2 (7)	0 (0)	NS
Lack of omental fat overlying clustered small bowel	2 (7)	0 (0)	NS
Ascites	21 (75)	31 (62)	NS
Abnormal bowel-wall enhancement‡	3 (12)	2 (4)	NS
Abnormal vessel relationship	1 (4)	2 (4)	NS
Proximal small bowel dilation§	13 (46)	50 (100)	< 0.0001
Small-bowel feces sign	0 (0)	13 (26)	0.003

**These 4 CT features were indicative of intestinal strangulation; †non-contrast CT was performed in 17 IH patients and 23 ASBO patients; ‡contrast-enhanced CT was performed in 26 IH patients and 46 ASBO patients; §in the IH group, the total of 13 patients with proximal bowel dilation included 2 patients with only proximal bowel dilation, and 11 patients with both proximal and herniated bowel dilation. NS = not significant.*

Table 2. Bowel contents in proximal and herniated bowel segments in patients with internal hernia (IH; *n* = 28), and in proximal bowel segments in patients with adhesive small bowel obstruction (ASBO; *n* = 50)

	Bowel content, *n* (%)			No dilation, *n* (%)	Small-bowel feces sign*, *n* (%)
	Air predominance	Fluid predominance	Mixed air and fluid		
Proximal segments in IH	0 (0)	8 (29)	5 (18)	15 (54)	0 (0)
Herniated segments in IH	0 (0)	20 (71)	4 (14)	4 (14)	0 (0)
ASBO group	2 (4)	35 (70)	13 (26)	0 (0)	13 (26)*

**Small-bowel feces sign was an associated finding and the 13 cases in the ASBO group have been included in the preceding 4 columns.*

The proportion of patients with abnormal bowel-wall enhancement was not statistically significantly different between the IH and ASBO groups ($p = 0.3$). However, abnormal bowel-wall enhancement was seen in significantly more patients with, rather than without, intestinal strangulation ($p = 0.008$; Table 4).

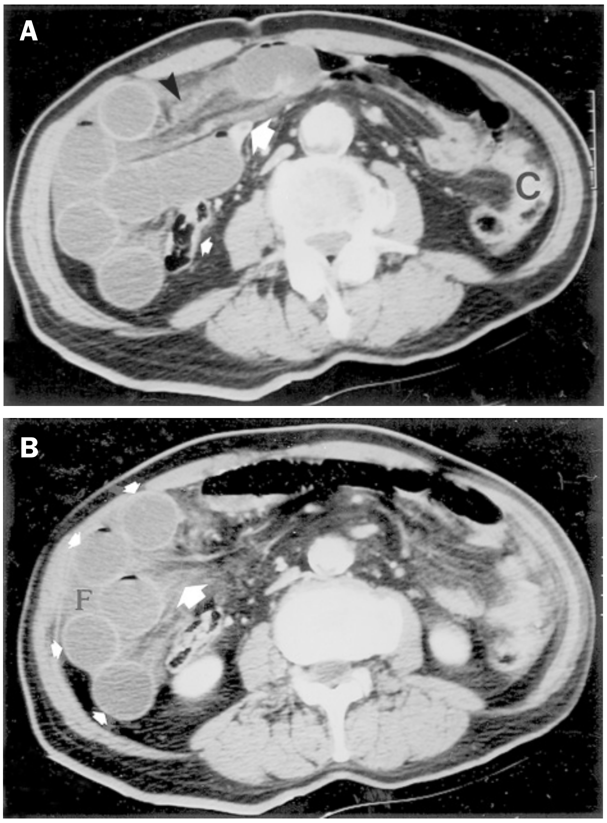

Figure 1. Strangulating transomental internal hernia in an 81-year-old man. (A) A cluster of dilated small-bowel segments in the right abdomen, and distal collapsed small-bowel segments ("C") in the left abdomen, indicated intestinal obstruction. Beak sign (large white arrow) is the triangular configuration of the transition zone on axial computed tomography. Engorged mesenteric vessels, mesenteric infiltrates (black arrowhead) and beak sign converged to a center. The herniated small bowels had mass effect on the nearby ascending colon (small white arrow). (B) A cluster of dilated, fluid-filled, small-bowel segments (small arrows) is depicted with mild bowel-wall thickening, mesenteric infiltrates (large arrow) and inter-loop mesenteric fluid ("F").

Figure 2. Strangulating internal hernia in a 70-year-old man. (A) A cluster of dilated fluid-filled bowel segments (small arrows) with two beak signs (large arrows). (B) At the lower level, a cluster of dilated, fluid-filled, small-bowel segments (white arrows) spanned out, and mixed mesenteric infiltrates and fluid (black arrows) converged towards a point, like a peacock's tail. (C) A precontrast computed tomography scan showed that part of the bowel wall in herniated bowel segments had mild thickening and possessed higher attenuation (black arrowheads) than normal bowel wall (white arrow); this represented intramural hemorrhage.

Table 3. The number of beak signs seen on axial computed tomography scan in patients with internal hernia (IH; n = 28) or adhesive small bowel obstruction (ASBO; n = 50)

	IH, n (%)	ASBO, n (%)	p
Number of beaks			< 0.0001
0	11 (39)	23 (46)	
1	5 (18)	27 (54)	
2	11 (39)	0 (0)	
3	1 (4)	0 (0)	
> 1 beak	12 (43)	0 (0)	< 0.0001

Two patients in the ASBO group (4%) had abscess formation. A total of three patients (IH = 1; ASBO = 2) had an abnormal vessel relationship between the superior mesenteric artery and vein (Figure 5A), and were found to have midgut malrotation during surgery. No patients with IH or ASBO had intramural air, intra-abdominal free air, or portomesenteric venous air and thrombosis.

The statistically significant CT findings of IH included the following: the presence of a cluster of small-bowel segments (p < 0.0001; Figures 1, 2, 5–7); crowding and convergence of mesenteric vessels (p < 0.0001; Figures 1, 2, 4A); more than 1 beak sign (p < 0.0001; Figure 2A); mesenteric vessel engorgement (p = 0.0002; Figure 6); and mass effect to surrounding organs (p = 0.002; Figure 1). However, proximal small-bowel dilation (p < 0.0001), and an associated small-bowel feces sign (p = 0.003), were more commonly seen in ASBO than IH.

Encapsulation (Figures 5B, 6), lack of omental fat overlying clustered small-bowel segments, ascites, and abnormal bowel-wall enhancement, were also seen

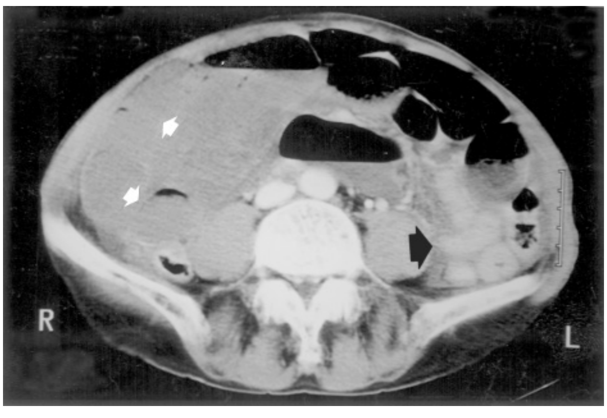

Figure 3. Internal hernia and strangulation in a 78-year-old man. This post-contrast computed tomography scan showed no contrast enhancement in the bowel wall in dilated, herniated segments (white arrows), and normal enhancement in the bowel wall in distal, collapsed bowel segments (black arrow).

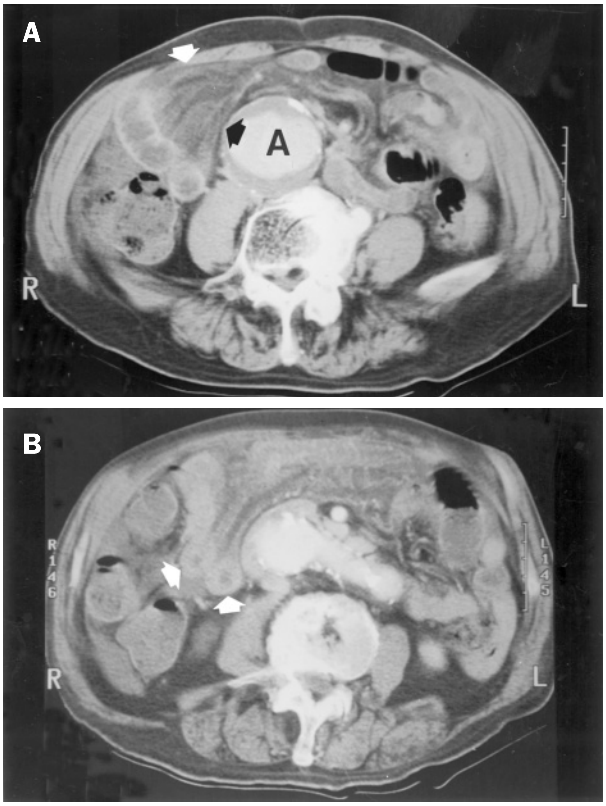

Figure 4. Internal hernia in a 79-year-old man. (A) Mesenteric vessel engorgement, and mesenteric infiltrates mixed with fluid (arrows) converged to a point. ("A" = abdominal aortic aneurysm.) (B) Bowel-wall thickening with a target appearance of contrast enhancement (arrows) was noted.

more commonly in patients with IH than ASBO; however, these differences were not statistically significant.

According to operative records, intestinal strangulation was found in 11 patients with IH (39%) and 5 with ASBO (10%; p = 0.002). Various CT features considered predictive of intestinal strangulation are listed in Table 4. Statistically significant predictive CT features included mesenteric fluid (p < 0.0001; Figures 2B, 4A, 7), mesenteric infiltrates (p = 0.0005; Figure 1), bowel-wall thickening (p = 0.003; Figures 4B, 7), intramural hemorrhage (p = 0.005; Figure 2C), abnormal bowel-wall enhancement (p = 0.008), and mesenteric vessel engorgement (p = 0.03). The first four of these CT features were also noted in more IH than ASBO patients (Table 1).

Logistic regression analyses showed significance for the following CT criteria in predicting IH over ASBO: engorged mesenteric vessels (odds ratio, OR, 7.85; 95% confidence interval, CI, 2.39–25.73; p = 0.001); mass effect to surrounding organs (OR, 5.67; 95% CI, 1.52–21.10; p = 0.010); and borderline significance for bowel-wall thickening (OR, 3.67; 95% CI, 0.97–13.85; p = 0.055). One CT criterion, engorged mesenteric vessels (OR, 11.08; 95% CI,

Table 4. Computed tomography (CT) features in patients with (*n* = 16) versus those without (*n* = 62) intestinal strangulation

CT feature*	Strangulation, *n* (%)	No strangulation, *n* (%)	*p*
Mesenteric fluid	15 (94)	22 (35)	< 0.0001
Mesenteric infiltrates	14 (88)	24 (39)	0.0005
Bowel-wall thickening	9 (56)	11 (18)	0.003
Intramural hemorrhage†	4 (50)	2 (5)	0.005
Abnormal bowel-wall enhancement‡	4 (25)	1 (2)	0.008
Engorged mesenteric vessels	11 (69)	24 (39)	0.03
Ascites	13 (81)	39 (63)	NS

**Other CT features, including pneumatosis intestinalis, portomesenteric venous air and thrombosis, abscess formation, and intra-abdominal free air, are not listed because no, or only very few, patients had such features; †non-contrast CT was performed in eight patients with strangulation and 40 patients without strangulation; ‡contrast-enhanced CT was performed in all 16 patients with strangulation, and in 56 patients without strangulation. NS = not significant.*

2.31–53.13; $p = 0.003$) was also a significant predictor of intestinal strangulation.

The accuracy rates for preoperative CT diagnosis were 50% for IH and 90% for ASBO.

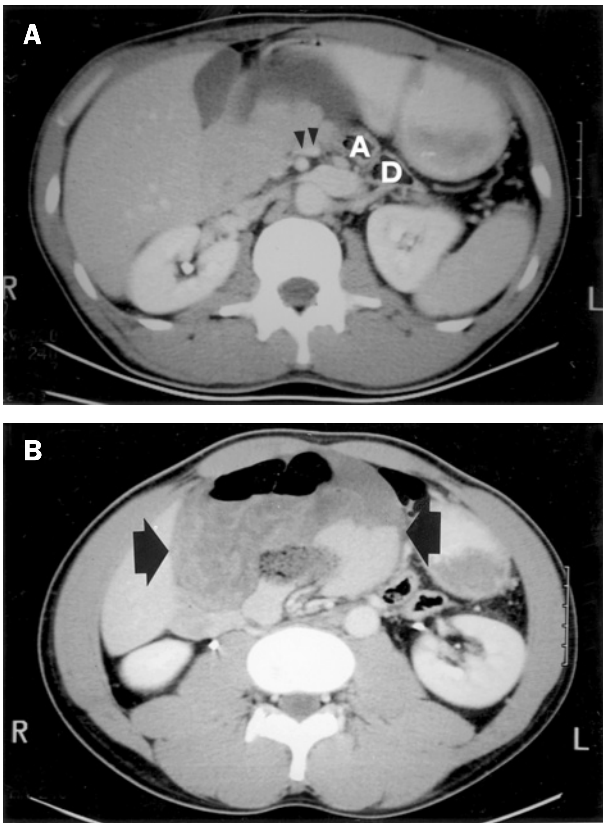

Figure 5. Midgut malrotation in a 33-year-old man with internal hernia via peritoneal defect over the ileocecal valve. (A) Midgut malrotation was suggested by an abnormal vessel relationship between the superior mesenteric vein (arrowheads) and artery, which was located posteriorly, and by bunching of the ascending ("A") and descending ("D") colon. (B) At the lower level, the cluster of small-bowel segments with encapsulation was the herniated bowel segment (arrows).

Discussion

The clinical manifestations of IH range from non-specific symptoms such as abdominal distension and

Figure 6. Internal hernia in a 68-year-old woman. A coffee-bean-shaped mass (large arrow) was found to be an encapsulated, herniated bowel segment during surgery. Mesenteric vessel engorgement (small arrow) was also noted.

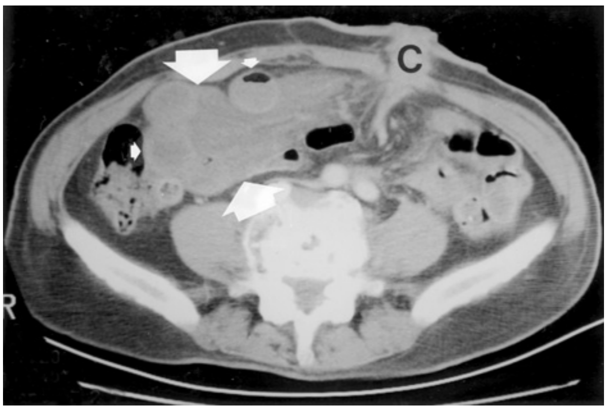

Figure 7. Strangulating internal hernia in a 71-year-old man. A cluster of fluid-filled, dilated bowel segments converging to the colostomy ("C") is evident. Marked mesenteric fluid (large arrows) and mild bowel-wall thickening (small arrows) were noted.

nausea to acute abdomen, and are directly proportional to the severity of obstruction and the presence or absence of intestinal incarceration and strangulation. Such manifestations can be intermittent because herniation of bowel segments through mesenteric defects can be a transient or intermittent phenomenon, thus further complicating the diagnosis.[9]

Although the prevalence of IH is not significantly different between males and females, adults and the elderly seem to have a greater prevalence than children.[9] There are several predisposing factors. Congenital anomalies, such as bands, omental or mesenteric weakness, and abnormal bowel rotation, may contribute to IH. Acquired IH may be caused by postsurgical or traumatic defects of the mesentery or omentum, or by postoperative adhesions. Blachar and Federle[9] reported an exceedingly high incidence of IH, i.e. in more than 50% of patients with small-bowel obstruction after liver transplantation or Roux-en-Y gastric bypass (RGB) surgery. In our report, 8 of 28 patients with IH (29%) had undergone RGB surgery; 2 patients (7%) had midgut malrotation, and 1 patient (4%) with transmesosigmoid IH had a very redundant sigmoid colon. Besides RGB surgery, a history of previous abdominal or pelvic surgery was also more common in the ASBO than IH group (88% vs 68% of patients; $p = 0.03$).

Incarcerated bowel loops in IH are particularly prone to strangulation because of vascular compromise by high pressure in the hernial neck, further aggravated by volvulus of herniated bowel segments. The frequency of strangulation in patients with small-bowel obstruction varies in different studies from 5–42%, with an average of approximately 10%. Although the overall mortality rate in simple obstruction of the small bowel has been reduced to 5–8%, it is still markedly greater (20–37%) in patients with strangulating obstruction.[10] This high mortality rate is mainly attributed to delays in accurate diagnosis and, therefore, in surgery.[10,12] In our study, the rate of strangulation in IH (39%) was significantly greater ($p = 0.002$) than that in ASBO (10%), which was similar to the literature-reported prevalence.[10–14] None of our patients with strangulating obstruction died within 1 month of surgery, except for one patient with ASBO who died from multi-organ failure.

As the clinical diagnosis of IH is difficult, and as mortality rates from IH are high because of the high potential for intestinal strangulation, imaging studies can play a crucial role if accurate and reliable signs of IH can be established. Plain radiography may demonstrate signs of bowel obstruction or, rarely, a mass effect with displacement of other abdominal organs by herniated bowel segments,[1,2,5] but it is nonspecific. Angiography is rarely performed in the diagnosis of IH, although it has proved helpful in a few cases for demonstrating redirection of mesenteric arteries.[4] Conventional gastrointestinal contrast-medium studies, such as small-bowel follow-through studies, may show an abnormally located cluster of small-bowel segments, as these are often contained in a sac or confining border, and usually also show varying degrees of small-bowel obstruction.[7] However, the usefulness of such studies is limited in high-grade, small-bowel obstruction, and such studies cannot reliably differentiate IH from ASBO.[1,2,4,7] Abdominal CT seems to be the imaging modality of choice for the preoperative diagnosis of IH and the detection of intestinal strangulation.

We found the image pattern of IH changed in relation to the duration of obstruction, and had a variable appearance depending on the length of herniated bowel segments. Larger hernias often presented as multiple segments of dilated fluid-filled small-bowel loops fanning out, crowding engorged mesenteric vessels and mixed mesenteric infiltrates and fluid converged to a center, just like a "Peacock's tail" (Figure 2). However, small hernias may resemble coffee-bean-shaped masses (Figure 6), without clusters of small-bowel segments, but rather with small segments of redundant bowel loops. Only mesenteric-vessel abnormalities, including mild engorgement, crowding and convergence, arouse suspicion.

Variable degrees of small-bowel obstruction, and a transition zone (beak sign) between dilated and non-dilated small-bowel loops, were shown in most of our patients. However, there were still 2 patients in our groups without dilation in either proximal or herniated bowel segments. Over half of the IH patients (54%) showed no proximal small-bowel dilation, and almost all patients (86%) showed dilation of herniated bowel segments, probably indicating that bowel dilation often began from the herniated segment. However, it is important to emphasize that herniated small-bowel loops are not always dilated. If no small-bowel dilation attracts attention, mesenteric-vessel abnormalities and an abnormally located cluster of small-bowel segments become very important clues.

The presence of more than 1 beak sign is a statistically significant predictor of IH ($p < 0.0001$). In IH patients, there should be no more than 3 beak signs, which are formed between dilated proximal small-bowel segments and the hernial neck, between the hernial neck and the afferent end of dilated, herniated bowel segments, and between the efferent end of dilated, herniated segments and the hernial neck.

Mayo-Smith et al[15] described a "CT small-bowel feces sign" comprising gas bubbles mixed with particulate matter in dilated segments of the small bowel, and present mostly in patients with small-bowel obstruction (18/22; 82%). This sign probably resulted from delayed transit through the small bowel, implying obstruction or stasis. Thirteen of our patients with ASBO (26%) had this sign, whereas no IH patients did ($p = 0.003$). This level of statistical significance implies that the presence of CT small-bowel feces sign can probably exclude the diagnosis of IH because of the usually sudden onset of symptomatic IH.

The presence of encapsulation (a sac-like mass) is due to a confining sac and the absence of interdigitation between normal bowel segments. It often implies a congenital type of IH, and may not be seen because of the thinness of non-inflamed peritoneum.

To correlate CT findings of IH with a surgical diagnosis may be difficult for the following reasons: spontaneous hernia resolution may occur; hernias are often reduced during surgery by inadvertent traction; the usual laparotomic orifice may not be large enough to evaluate peritoneal or mesenteric defects; IH via a potential hole formed by an adhesion band may be difficult to differentiate from other types of closed-loop obstruction also formed by an adhesive band.[4]

The CT features of intestinal strangulation are well established.[10–14] Balthazar et al reported that the most reliable CT findings were intestinal pneumatosis and hemorrhagic mesenteric changes selectively involving the distribution of the incarcerated bowel loop.[10] Frager et al reported that bowel-wall thickening and high attenuation of the bowel wall were the most important signs of ischemia on unenhanced CT scans, whereas abnormal bowel-wall enhancement and mesenteric fluid correlated best with intestinal ischemia on enhanced CT examinations.[12] In our analysis of 16 patients with intestinal strangulation, similar CT findings were found. In addition, a serrated, beak-like narrowing has been described in patients with intestinal strangulation.[13] Zalcman et al described a new CT sign, "delayed enhancement of bowel wall" for intestinal strangulation.[16] This feature was not included in our study because no delayed scan was performed.

In conclusion, IH represents an important and under-diagnosed condition. Volvulus and strangulation of the herniated small bowel are frequent complications. By using the CT findings we report, the presence and complications of IH can be more accurately and confidently diagnosed and, in most cases, preoperatively.

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