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Original Article

MDCT signs predicting internal hernia and strangulation in patients presented to emergency department with acute small bowel obstruction

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A R T I C L E I N F O

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A B S T R A C T

Objective: We prospectively evaluate multidetector computed tomography (MDCT) criteria of internal hernia, and related complication as intestinal strangulation.
Methods: 27 patients presented to emergency department with acute small bowel obstruction (ASBO) and diagnosed with MDCT as IH were included. Validity of different MDCT criteria in diagnosing IH was compared with surgical diagnosis.
Results: Surgical diagnosis was 22 patients with IH (14 paraduodenal and 8 transmesenteric hernia) and 5 false positive cases. There was excellent agreement between MDCT and surgery in diagnosing paraduodenal hernia ($k = 1$), and good agreement in diagnosing transmesenteric hernia ($k = 0.624$). Significant MDCT criteria include the following: cluster of small-bowel ($p < 0.0001$); mass effect to surrounding ($p = 0.009$); crowding of mesenteric vessels (Swirl's sign) ($p = 0.01$). Sensitivity, specificity, PPV, NPV and accuracy of MDCT in diagnosing strangulation were 83%, 100%, 100%, 95%, and 96% respectively. MDCT signs for detecting strangulation were statistically significant and varied from highly significant for bowel-wall thickening and mesenteric vessel engorgement ($p < 0.001$) to significant for abnormal bowel-wall enhancement, mesenteric infiltrate and mesenteric fluid with p value = 0.001.
Conclusion: MDCT helps in early diagnosis of IH and strangulation, which accounts for appropriate management of such emergent cases.

1. Introduction

Internal hernia (IH) was defined as protrusion of intra abdominal viscera through a peritoneal or mesenteric defect which may be congenital or acquired (surgically created) to the retroperitoneal space or a compartment within the abdominal cavity [1].

Although being rare, internal hernias (IH) incidence was increasing due to the more frequent performance of liver transplantations and gastric bypass surgery [2,3].

Different types of IH have been previously described and arranged according to the incidence of occurrence as follows: paraduodenal hernia, pericecal hernia, hernia through the foramen of Winslow, transmesenteric hernia,

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transmesocolic hernia and intersigmoid hernia [4]. Recently transmesenteric hernia has higher incidence than paraduodenal hernia due to the increased rate of Roux-en-Y and liver transplantation surgery [5,6].

Bowel loops are clustered laterally and inferiorly to the descending duodenum in the right paraduodenal hernia and between the stomach and the pancreas in the left paraduodenal hernia [1]. In pericecal hernia, bowel loops are clustered posteriorly and laterally to the cecum. In hernia through the foramen of Winslow dilated bowel loops are seen in the lesser sac posterior to the stomach between the hepatic hilum and inferior vena cava [5]. Small bowel loops are clustered laterally to the sigmoid colon in the intersigmoid hernia while in transmesenteric hernia the bowel.

Small bowels are clustered lateral to the colon, with displaced omental fat and the bowel seen in direct contact with the abdominal wall [5].

Clinical diagnosis of IH was difficult, and the mortality rates were high because of the high possibility of strangulation of the affected loops, even small hernias are dangerous and may be fatal, thus giving the imaging studies a leading role in diagnosis especially when well established signs of IH and strangulation are confirmed [7,8].

A little was described about radiological signs of different types of internal hernia, except for paraduodenal hernia [6].

Plain radiography may detect signs of bowel obstruction, displacement or mass effect on abdominal organs by the herniated bowel segments. Abdominal computed tomography (CT) has been the imaging modality of choice for preoperative diagnosis of IH and strangulation of the intestinal loops [8].

Current generation multi– detector computed tomography (MDCT) scanners can provide high-resolution multiplanar reformatted (MPR) images and provides substantial improvements in the quality of two- and three-dimensional images, in addition to the axial images, and this increases the diagnostic confidence in the interpretation of bowel obstruction and location of the obstructive point [9].

We aim to prospectively evaluate the role of MDCT in preoperative diagnosis of IH and associated complications in patients presented with acute SBO by evaluating the diagnostic performance of the previously described different CT findings.

2. Patients and methods

This prospective study was carried out in two institutes (Zagazig University hospital and special center; Zagazig, Egypt), after obtaining the approval of the institutional ethics committees, during the period from June 2010 to June 2015 and included patients presented with acute intestinal obstruction who had provisional diagnosis of IH based on MDCT findings.

All patients were selected based on clinical and/or X-ray provisional diagnosis of intestinal obstruction and they scheduled for MDCT examination followed by surgical exploration.

2.1. Study design

Firstly all patients who presented to emergency department with acute abdomen ($n = 2764$) were evaluated. We included only patients confirmed by clinical examination and plain radiograph as ASBO, and those patients were subjected to MDCT examination ($n = 582(21\%)$). Patients with acute intestinal obstruction due to adhesion, tumor, inflammatory or ischemic obstruction were excluded.

An informed written consent was obtained from each patient before MDCT examination.

Based on MDCT internal hernia was diagnosed in 27 (4.6%) patients.

The final included patients ($n = 27$) were 17 (63%) males and 10 (37%) females with their age ranged between 17 and 65 years with a mean of 25 ± 6. Surgical exploration was done for all patients (laparoscopic for 10 patients and open surgery for 17 patients) with an interval of 2–48 h after CT examination.

2.2. Protocols of CT examination

MDCT examination of the abdomen and pelvis was performed using 64 multi-detector CT machine (GE light speed VCT Milwaukee- USA), with the following parameters: 5 mm collimation, 5 mm slice thickness (with 1 mm axial reconstruction), 2.5 mm scan interval, 120 kV, and 250 mAs.

MDCT examination was done for all patients with IV contrast in a dose of 2 ml/kg (range from 100 to 150 ml) of non-ionic contrast media (Omnipaque 300) at a rate of 2–4 ml/s, using power injector (Medrad Stellant injector, Indianola PA, USA) imaging started 20 and 70 s after IV contrast for the arterial and venous phase respectively with scan direction and extension: from the xiphoid process down to the symphysis pubis.

Oral contrast was not routinely used in our institute in examining patients with small bowel obstruction especially in critical patients, depending on the neutral contrast of the fluid filled dilated bowel loops that allowed better interpretation of the enhancement pattern of the mucosa. When oral contrast was recommended it was given in the form of 2% water soluble iodinated contrast media 60 min before the examination. Water soluble iodinated contrast enema was used in selected cases to delineate the distal bowel.

All images were transferred to a workstation for coronal, sagittal multiplanar reformatted images (MPR) at 0.5 or 1 mm thickness, and a 5 mm interval, a curved planar reconstruction was also performed.

2.3. Image interpretation

Image were interpreted by two radiologists on separate sessions, and the images were analyzed for the presence of signs of small bowel obstruction, strangulation, and CT criteria that were previously described in the literature for diagnosing internal hernia [10–15]. The included criteria for either small bowl obstruction or strangulation were as follows: signs of small bowl obstruction include the presence of small bowel dilation (bowel-segment diameter

Table 1
Diagnostic performance of different MDCT signs in diagnosis of internal hernia.

MDCT signs	SN% (95% CI)	SP% (95% CI)	PPV% (95% CI)	NPV% (95% CI)	Acc (95% CI)	+ve LR (95% CI)	−ve LR (95% CI)	DOR (95% CI)
Cluster of small bowel segments	100% (88.9–100)	83.3% (44.7–83.3)	95.5% (84.9–95.5)	100% (53.6–100)	96.3% (88.7–100)	6 (1.6–6)	0.000 (0.00–0.247)	84 (3.07–13601)
Mass effect to surrounding organs	86.4% (75.8–90.7)	80% (33.4–98.9)	95% (83.3–99.7)	57% (24–70.7)	85% (70–98.7)	4.318 1.14–84.2)	0.17 (0.09–0.73)	25.3 (1.57–891.6)
Crowded mesenteric vessels (Swirl's sign)	82% (71–86)	80% (33–98.7)	95% (75.2–99)	50% (21.5–78.5)	82% (54.1–91.3)	4.09 (1.06–80.5)	0.23 (0.14–0.87)	18 (1.22–573.6)
Encapsulation	45.5% (36–52.8)	60% (19.6–92.5)	83.3% (66–96.9)	20% (8.3–30.8)	49% (20.3–61.4)	1.14 (0.4–6.7)	0.9 (05–3.5)	1.3 (0.13–13.7)
Small-bowel feces sign	36.4% (18.3–58.8)	80% (39.6–98.7)	88.9% (56.5–98)	22% (9–45)	44% (24.6–66.2)	1.8 (0.4–38.3)	0.7 (06–2.2)	2.3 (0.1–63.9)
Lack of omental fat overlying clustered small-bowel segments	36.1% (18.3–58.8)	87.5% (39.6–98.7)	92.9% (56.1–99.2)	23.3% (8.9–48.6)	45.4% (24.6–66.2)	2.8 (0.2–41.4)	0.7 (0.4–1.2)	3.9 (0.1–89.1)

SN: Sensitivity, SP: Specificity, PPV: Positive Predictive Value, NPV: Negative Predictive Value, Acc: Accuracy, +ve LR: Positive Likelihood Ratio, −ve LR: Negative Likelihood Ratio, DOR: Diagnostic Odds Ratio, 95% CI: 95% Confidence Interval.

more than 2.5 cm), sac like mass or cluster of dilated bowel loops (when the bowel loops were compressed together as a bunch), and encapsulated bowel at an abnormal anatomic site was considered when small-bowel loops were wrapped by a thin fold; displaced engorged and stretched mesenteric vessels were also seen, Swirl sign (swirled pattern of the vessels and fat at the mesenteric root) and associated small-bowel feces sign (bubbles of gases mixed with dilated small bowel content). The signs of strangulation include thickening of the bowel-wall ($\geqslant$3 mm), the presence of mesenteric infiltration and mesenteric fluid, abnormal bowel-wall enhancement (as absence, a target pattern, or heterogeneous enhancement), ascites, pneumatosis intestinalis, porto-mesenteric venous air or thrombosis, abscess formation, and pneumoperitoneum. All these criteria were assessed and reported and the final CT diagnosis was compared with the operative findings as a gold standard reference.

2.4. Statistical analysis

The validity of MDCT in diagnosis of internal hernia was calculated using the diagnostic performance depending on generation of 2×2 contingency tables using the intraoperative diagnosis as the reference (Gold) standard. Sensitivity, specificity, positive predictive value, negative predictive value, accuracy and other measures of performance were calculated to compare between different MDCT signs. Inter-rater agreement between MDCT and surgeon in detection of internal hernia was analyzed using McNemar, and Kappa (K) statistic. Agreement was obtained if the McNemar was not significant and the Kappa statistic was significant; the criteria to qualify for strength of agreement were as follows: $K < 0.2$: poor; K 0.21–0.40: fair; K 0.41–0.60: moderate; K 0.61–0.80: good; K 0.81–1.00: very good. All tests were two sided, and p-value < 0.05 was considered significant. All statistics were performed using SPSS 22.0 for windows (SPSS Inc., Chicago, IL, USA) & MedCalc 13 for windows (MedCalc Software bvba, Ostend, Belgium).

Table 2
The agreement between MDCT and intraoperative diagnosis as regarding detection of internal hernia.

MDCT signs	Inter-rater agreement		
	Kappa	95%CI[‡]	p-value[*]
Cluster of small bowel segments	0.886	0.357–0.886	<0.001
Mass effect to surrounding organs	0.575	0.079–0.776	0.009
Crowded mesenteric vessels (Swirl's sign)	0.502	0.034–0.690	0.01
Encapsulation	0.031	0.000–0.255	0.8
Small-bowel feces sign	0.082	−0204 to 0.198	0.6
Lack of omental fat overlying clustered small-bowel segments	0.141	0.000–0.315	0.219

[*] p value of kappa statistics; $p < 0.05$ is significant.
[‡] McNemar test; 95%CI: 95% confidence interval.

3. Results

Internal hernia was diagnosed in 27 patients based on findings obtained by MDCT examination (Paraduodenal in 14 (52%) patients and transmesenteric in 13 (48%) patients); they were 17 (63%) males and 10 (37%) females with their age ranged between 17 and 65 years with a mean of 25 ± 6. Clinically, patients presented with signs of acute intestinal obstruction $n = 27$, and associated high grade fever and abdominal rigidity in $n = 8$ (29.6%), while one (3%) patient had signs of septic shock.

The final surgical diagnosis was correct for internal hernia in 22 (paraduodenal $n = 14$ (64%) patients and transmesenteric $n = 8$ (36%) patients) and the other 5 false positive cases were diagnosed intraoperatively as having adhesive intestinal obstruction ($n = 4$) and cocoon syndrome in one patient.

There was excellent agreement between MDCT and surgery in diagnosing paraduodenal hernia ($k = 1$), and good agreement in diagnosis of transmesenteric hernia ($k = 0.624$).

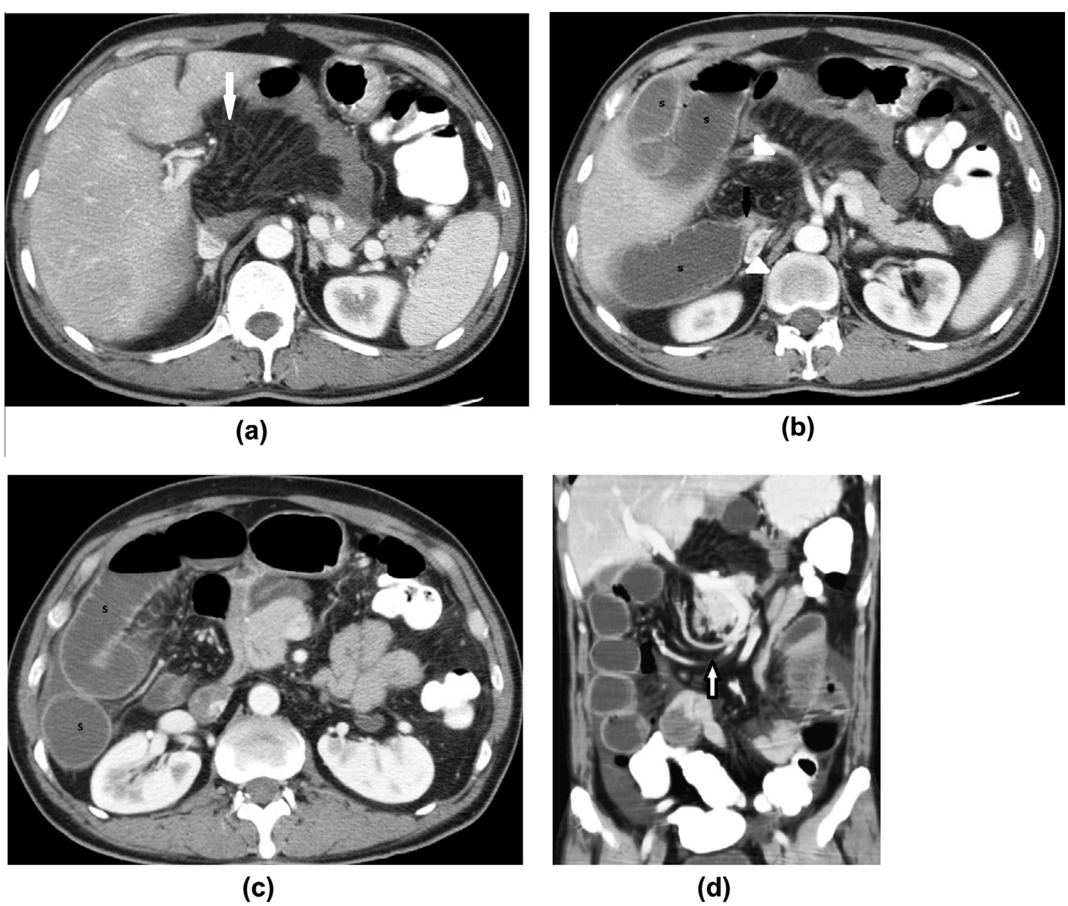
History of previous abdominal or pelvic surgery was recorded in 12 (44%) patients, 7 true positive cases of internal hernia while the other 5 were false positive.

Operative outcome was satisfactory in all patients except for two (7%) patients with strangulation who developed postoperative atelectasis and pleural effusion and had a long hospital stay.

Analysis of the MDCT findings in the 22 true positive cases had shown small bowel dilatation in all cases involving the proximal segment only in 7 (32%) patients, the herniated segment only in 10 (45%) patients and the proximal and herniated segment in 5 (23%) patients. The sensitivity, specificity, PPV, NPV, and accuracy of different MDCT signs in diagnosing IH are listed in Table 1.

Measuring the diagnostic Odds ratio (DOR) showed strong association between various MDCT signs and intraoperative diagnosis of IH as cluster of small bowel (DOR = 84; 95%, CI, 3.07–13601.09), followed by mass effect on the surrounding organs (DOR = 25.3; 95%, CI, 1.57–891.6), and crowded mesenteric vessels (Swirl's sign) (DOR = 18; 95%, CI, 1.22–573.6), and DOR of various MDCT findings is listed in Table 1.

Different CT findings were found to be significant in diagnosing IH including the following: the presence of cluster of small-bowel segments ($p < 0.0001$); mass effect on surrounding organs ($p = 0.009$), crowding and convergence



Case 1. Right PDH in a 40-year-old man with acute onset of severe abdominal pain. Contrast enhanced MDCT of the abdomen (oral, intravenous and enema contrast), (a) axial CT image shows herniation of mesenteric fat with radial configuration of the mesenteric vessels (white arrow), (b) axial CT image obtained at lower level shows small bowel dilatation (s) with beak sign at site of hernial orifice (located between IVC posteriorly and PV anteriorly) (arrowheads), (c) axial CT image at more lower level shows proximal jejunal loops (s) dilatation, and (d) coronal MDCT reformatted image shows displaced crowded (swirl's sign) mesenteric vessels (white arrow).

of mesenteric vessels (Swirl's sign) ($p = 0.01$); however, other non-significant findings were as follows: small-bowel feces sign ($p = 0.6$), encapsulation ($p = 0.8$), lack of omental fat overlying clustered small-bowel segments ($p = 0.2$) (Table 2) (Cases 1 and 2).

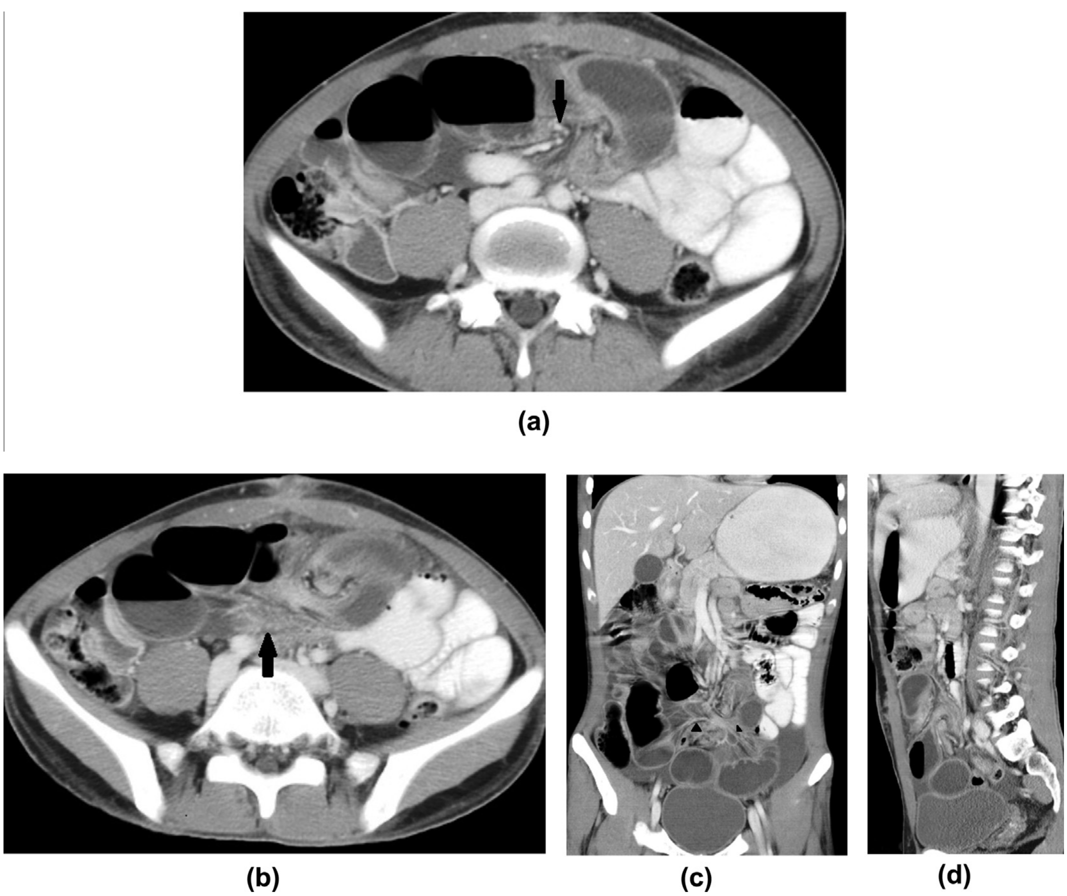
There was very good agreement between MDCT and intraoperative diagnosis of IH regarding cluster of small-bowel segments ($k = 0.886$), moderate agreement with mass effect on surrounding organs ($k = 0.575$), crowded mesenteric vessels (Swirl's sign) ($k = 0.502$) and poor agreement with small-bowel feces sign, encapsulation, and lack of omental fat overlying clustered small-bowel segments (Table 2).

According to the operative findings, intestinal strangulation was diagnosed in 6 patients (22%), four (67%) patients with internal hernia (three transmesenteric (37.5%) and one case paraduodenal hernia (7%)) and two (33%) patients with ASBO. MDCT diagnosed strangulation in 5 (83%) cases while one (17%) case with early ischemic changes was missed. Overall sensitivity, specificity, PPV, NPV and accuracy of MDCT in diagnosing small bowel strangulation measured 83%, 100%, 100%, 95%, and 96% respectively and it showed very good agreement with surgery ($k = 0.886$).

Calculation of the diagnostic Odds ratio (DOR) for different MDCT signs of strangulation showed that bowel-wall thickening (DOR = 100; 95% CI, 3.8–15655.5), abnormal bowel-wall enhancement, mesenteric infiltrates, mesenteric fluid (DOR = 40; 95% CI, 3.5–290), ascites (DOR 16; 95% CI, 1.2–466.8) and engorged mesenteric vessels (DOR 3.07; 95% CI, 0.247–83.3) were better tests to discriminate between patients with strangulation and those without as the DOR > 1 in all. The sensitivity, specificity, PPV, NPV, accuracy and DOR of different MDCT features predictive of intestinal strangulation are listed in Table 3.

All MDCT signs for detecting strangulation were statistically significant and varied from highly significant for bowel-wall thickening and mesenteric vessel engorgement ($p < 0.001$) to significant difference for abnormal bowel-wall enhancement, mesenteric infiltrate and mesenteric fluid, in all p value = 0.00 l and ascites $p = 0.01$ (Table 4) (Cases 3 and 4).

Measuring k value to assess agreement between signs of strangulation at MDCT and intraoperative diagnosis



Case 2. Post exploration and splenectomy transmesenteric internal hernia in 35 years old male patient presented with acute severe abdominal pain. Contrast enhanced MDCT examination (oral and intravenous) reveals (a and b): Axial CT images show cluster of dilated small bowel with proximal and distal bowel dilatation, crowded and engorged mesenteric vessels (black arrow). (c and d): Coronal and sagittal MDCT reformatted images show dilated bowel loops, the swirl sign (arrow head) and beak sign at hernia orifice with lack of omental fat overlying the herniated bowel.

Table 3
Diagnostic performance of different MDCT signs in diagnosis of strangulated internal hernia.

MDCT signs	SN% (95% CI)	SP% (95% CI)	PPV% (95% CI)	NPV% (95% CI)	Acc (95% CI)	+ve LR (95% CI)	−ve LR (95% CI)	DOR (95% CI)
Bowel-wall thickening	83% (42–98)	95% (84–99)	83% (42–99)	95% (84–99)	93% (66–98)	17.5 (2.6–232.8)	0.175 (0.02–0.68)	100 (3.8–15655.5)
Abnormal bowel-wall enhancement	80% (34–99)	90% (80–95)	76% (28–82)	95% (84–99)	89% (67–98)	8.8 (1.7–20.6)	0.2 (0.01–0.8)	40 (2.1–1786)
Mesenteric fluid	80% (34–99)	90% (80–95)	76% (28–82)	95% (84–99)	89% (67–98)	8.8 (1.7–20.6)	0.2 (0.01–0.8)	40 (2.1–1786)
Engorged mesenteric vessels	83% (42–98)	95% (84–99)	83% (42–99)	95% (84–99)	93% (66–98)	17.5 (2.6–232.8)	0.175 (0.02–0.68)	100 (3.8–15655.5)
Mesenteric infiltrate	80% (34–99)	90% (80–95)	76% (28–82)	95% (84–99)	89% (67–98)	8.8 (1.7–20.6)	0.2 (0.01–0.8)	40 (2.1–1786)
Ascites	83% (41–99)	76% (64–81)	50% (24–60)	94% (79–99)	78% (45–89)	3.5 (1.12–5.14)	0.219 (0.011–0.93)	16 (1.2–466.8)

SN: Sensitivity, SP: Specificity, PPV: Positive Predictive Value, NPV: Negative Predictive Value, Acc: Accuracy, +ve LR: Positive Likelihood Ratio, −ve LR: Negative Likelihood Ratio, DOR: Diagnostic Odds Ratio, 95% CI: 95% Confidence Interval.

showed good agreement between bowel wall thickening, engorged mesenteric vessels ($k = 0.786$), abnormal bowel-wall enhancement, mesenteric infiltrates and mesenteric fluid ($k = 0.658$); however, ascites showed moderate agreement ($k = 0.481$) (Table 4).

The false positive cases were four cases of adhesive intestinal obstruction and one case of sclerosing encapsulated peritonitis (Cocoon syndrome) (Case 5).

4. Discussion

Although internal hernias are infrequent, they are usually included in the differential diagnosis of acute intestinal obstruction, especially if it is not associated with a history of previous abdominal surgery or trauma. Computed tomography (CT) plays a significant role in the diagnosis of acute intestinal obstruction and organizing the surgical management [16].

To our knowledge this was the first prospective study that evaluated the value of MDCT in diagnosing IH and its complications. In this study, we assessed the role of MDCT by evaluating the diagnostic performance of the previously reported CT findings to allow more confident CT diagnosis.

There are many types of internal hernia that had been described in the literatures; paraduodenal hernia was considered to be the commonest type of internal hernia and accounts for more than 50% of internal hernias reported in the radiology and surgery literatures [17–19]. Other types of internal hernia include transmesenteric, supravesical, perivesical, intersigmoid, foramen of Winslow, and omental hernias are rare [20–23].

Recent studies showed that transmesenteric hernias became more common due to the increased incidence of surgical procedures as Roux-en-Y operation that predisposes the development of internal hernia [24–28].

In our study, we encountered only two types of IH: paraduodenal that was detected in 14 (64%) patients and transmesenteric in 8 (36%) patients, and also Blachar et al. [6,7] in their studies on internal hernia described only these two types of IH; however, they had higher incidence of transmesenteric hernia; this attributed to the higher incidence of liver transplantation surgery in the first study and Roux-en-Y operation in the second study.

MDCT showed excellent agreement with surgery in diagnosing paraduodenal hernia ($k = 1$), and good agreement in diagnosis of transmesenteric hernia ($k = 0.624$), and this was in accordance with Blachar et al. [7]. They stated that there was a good agreement between researchers in diagnosing paraduodenal hernias, that we supposed that it is easy to diagnose and there was poor agreement in diagnosing transmesenteric hernia, and also Martin et al. [1] in their study reported that transmesenteric hernias are more variable in appearance and location and hence they are difficult to be diagnosed on imaging examinations.

Small bowel dilatation was seen in all patients on MDCT involving only the herniated loops in 45%, proximal segment in 32% and both herniated and proximal segment in 23%, and also Yen et al. [8] in their study reported that patients with IH showed dilation of the herniated bowel

Table 4
The agreement between MDCT and intraoperative diagnosis as regarding detection of strangulated internal hernia.

MDCT signs	Inter-rater agreement		
	Kappa	95%CI‡	*p*-value*
Bowel-wall thickening	0.786	0.265–0.981	<0.001
Abnormal bowel-wall enhancement	0.658	0.133–0.874	0.001
Mesenteric fluid	0.658	0.133–0.874	0.001
Engorged mesenteric vessels	0.786	0.265–0.981	<0.001
Mesenteric infiltrate	0.658	0.133–0.874	0.001
Ascites	0.234	−0.167 to 0.624	0.3

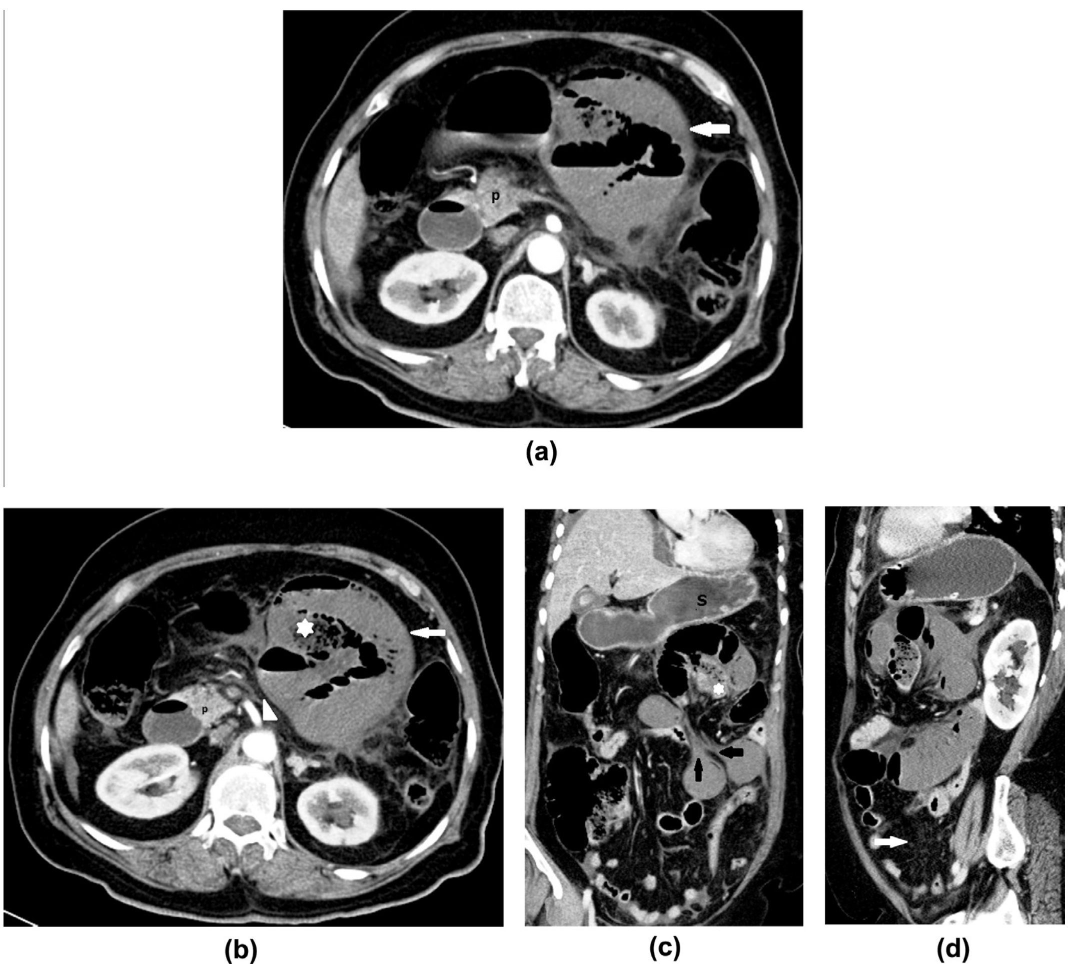
* p value of kappa statistics; $p < 0.05$ is significant.
‡ McNemar test; 95%CI: 95% confidence interval.

segments in 46% of patients and showed dilation of the proximal and herniated segment in 39% of the cases.

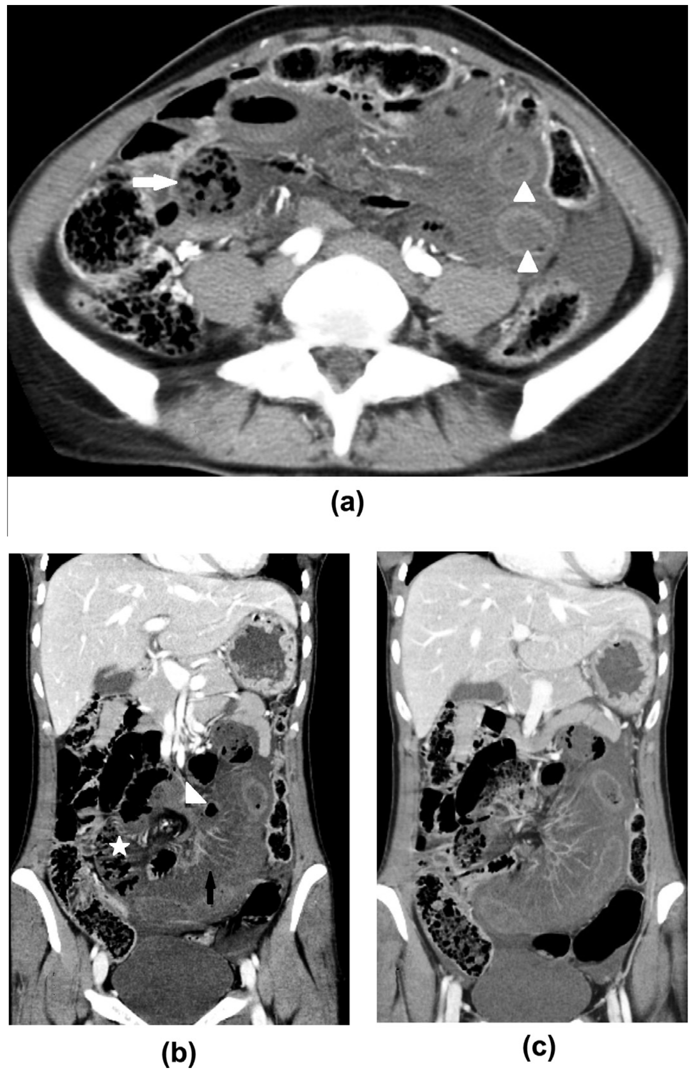
Correlation between MDCT findings and surgical diagnosis of IH showed that the presence of cluster of small bowel, mass effect on the surrounding organs, mesenteric vessels engorgement as well as crowding and convergence of mesenteric vessels (swirl's sign) on MDCT examination were statistically significant for the presence of IH with $p \leqslant 0.0001$, 0.009, 0.01, 0.013, respectively.

In accordance with our results Yen et al. [8] in their study compared CT finding of both IH and ASBO and stated that the statistically significant CT findings of IH include the following: the presence of a cluster of small-bowel segments ($p < 0.0001$); crowding and convergence of mesenteric vessels ($p < 0.0001$); engorged mesenteric vessel ($p = 0.0002$); and mass effect on the surrounding organs ($p = 0.002$).

Also Takeyama et al. [16] concluded that MDCT findings in internal hernias commonly include clusters of dilated small bowel loops in abnormal locations within the peritoneal cavity with mass effect and displacement of the neighboring organs. In addition, the mesenteric vessels can appear engorged, displaced, and stretched.



Case 3. Left PDH with strangulation in a 52 years old male patient presented with acute severe epigastric. Contrast enhanced MDCT of the abdomen (oral and intravenous contrast) reveals (a and b): Axial CT images show saclike mass of dilated jejunal loops (arrow) at the left epigastric region, pancreas (P), with mass effect on splenic flexure, and SMA (arrow heads), small bowel proximal to the sac shows dilatation, there are engorged and crowded mesenteric vessels, peritoneal stranding, mesenteric edema and infiltrates, bowel loop inside the sac shows small bowel feces sign (⁎). (c and d): Coronal and sagittal MDCT reformatted images show mild mass effect of the bowel mass on the stomach (s) with multiple beak signs of involved bowel at the hernial orifice (black arrow), small bowel feces sign) (⁎) and mesenteric infiltrates (white arrow).



Case 4. Transmesenteric hernia with strangulation in 28 years old male patient with mid-line abdominal pain for 48 H. Contrast enhanced MDCT examination (intravenous contrast) of the patient reveals (a): axial CT images show small bowel dilatation, with loss of wall enhancement and wall thickening (white arrow heads), small bowel fecal sign in one loop (white arrow) and free fluid. (b and c): Coronal MDCT reformatted image shows peaking sign (white arrow head), small bowel fecal sign (⁎), mesenteric vessels engorgement and radial direction (black arrow), abnormal bowel wall enhancement, mesenteric fluid and ascites.

However, in our study we found that other MDCT signs such as encapsulation, small-bowel feces sign and lack of omental fat overlying the clustered small-bowel segments were statistically nonsignificant with $p = 0.8$, 0.6, 0.2 respectively; these were in agreement with Yen et al. [8] and they reported that an associated small-bowel feces sign was more commonly associated with ASBO than IH; also encapsulation, lack of omental fat overlying clustered small-bowel, ascites, and abnormal bowel-wall enhancement, were more frequent in patients with IH but they were not statistically significant.

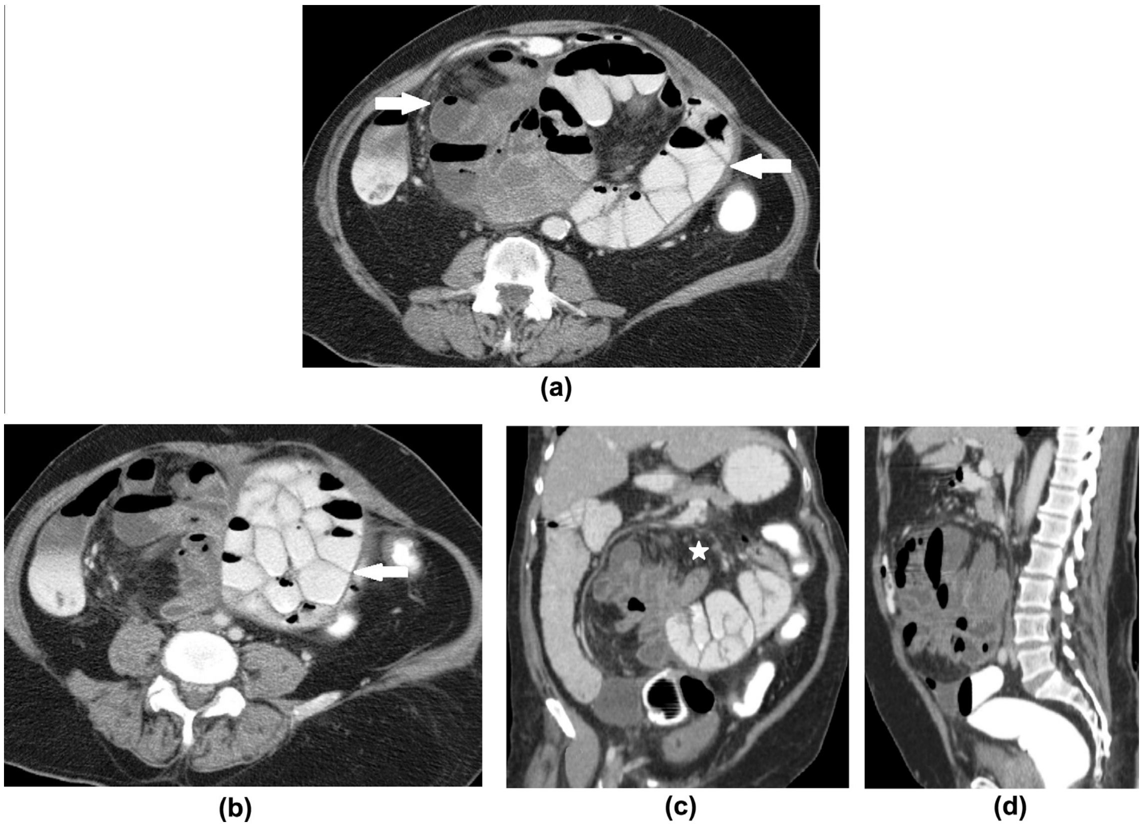
Strangulation occurred in 5–42% of small bowel obstruction and was associated with high rate of morbidity and mortality [5]. Incarcerated bowel loops in IH are particularly prone to strangulation because of vascular compromise by high pressure in the hernial neck and are further aggravated by volvulus of herniated bowel segments [29].

Our sensitivity, specificity, PPV, NPV and accuracy of MDCT in diagnosing small bowel strangulation measured 83%, 100%, 100%, 95%, and 96% respectively. This was going with the previously reported sensitivity, specificity, PPV, and NPV of MDCT in diagnosing bowel strangulation that ranged from 83% to 100%, 61% to 93%, 72% to 88%, and 93% to 100%, respectively [30–33].

Transmesenteric hernias are more liable to develop volvulus, ischemia or strangulation than other types of IH; the reported incidence was as high as 30–40%, with high mortality rates reaching about of 50% and 100% for the treated and non-treated cases respectively [1,12,34].

In agreement with previous report, in our study three out of four cases of IH had strangulation diagnosed as transmesenteric hernia.

Many previous studies had described MDCT findings in cases of small bowel ischemia and strangulation like



Case 5. Cocoon syndrome in 67 years old female patient presented with acute midline abdominal pain. Contrast enhanced MDCT (oral, intravenous and enema) reveals (a and b): axial ct image of lower abdomen shows encapsulated bowel mass of ileal loops (white arrows) with mild bowel dilatation and the absence of oral contrast enhancement, and there is mass effect on ascending colon, no mesenteric fat overlying the bowel mass. (c and d): Coronal and sagittal MDCT reformatted images show a membrane surrounding the bowel mass with engorged mesenteric vessels and mesenteric infiltrates (∗).

bowel-wall thickening and high attenuation of the bowel wall as the most important signs of bowel ischemia on non-contrast CT images, whereas abnormal bowel-wall enhancement and mesenteric fluid were corresponding with ischemia on contrast enhanced CT examinations [8,35–38].

In this study analysis of six (22%) patients with intestinal strangulation revealed similar CT findings as those described before including bowel-wall thickening, engorged mesenteric vessels, abnormal bowel-wall enhancement, the presence of mesenteric infiltrate, mesenteric fluid and ascites, and all of these signs showed good agreement and were statistically significant with surgery in diagnosing strangulation.

Furukawa et al. [30] concluded that Pneumatosis intestinalis and gas in the portal veins were seen in advanced cases of bowel infarction. On the other hand Balthazar et al. [39] reported that the most reliable CT findings were intestinal pneumatosis. None of our patients had Pneumatosis intestinalis and this may be due to the rapid surgical evaluation.

In our study we missed the evaluation of two important signs: the increased small bowel attenuation and delayed bowel wall enhancement. Owing to the general condition of the patients with ASBO, our MDCT protocol did not include either unenhanced or delayed enhanced CT examination and we considered this as a limitation in our work. Other limitation in this study was the small number of patients diagnosed with strangulation.

Summarily, internal hernia is a serious and under-diagnosed condition that carries bad prognosis as volvulus and strangulation of the herniated small bowel segment are commonly associated. MDCT findings that were evaluated in this study could preoperatively diagnose the presence of IH or strangulation, in most cases. MDCT had a high sensitivity and specificity in the detection of small bowel obstruction and accurately demonstrated the site, the cause of obstruction and the presence of ischemic changes at the involved bowel.

In conclusion MDCT examination is recommended for the evaluation of patients presented with acute bowel obstruction, particularly when clinical and initial plain film radiography indicates a higher grade obstruction or remains indeterminate and/or a strangulation is suspected.

Conflict of interest

The authors declare that there is no conflict of interest.

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