COMPARATIVE EVALUATION OF PLAIN FILMS, ULTRASOUND AND CT IN THE DIAGNOSIS OF INTESTINAL OBSTRUCTION

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Abstract

Background: There are limited studies in the literature comparing plain radiography, US and CT in the evaluation of intestinal obstruction. We carried out this prospective study to compare the relative efficacies of these three imaging techniques in patients with intestinal obstruction.

Material and Methods: Thirty-two patients presenting with clinical suspicion of intestinal obstruction were subjected to plain radiography, US and CT and the findings were compared with reference to the presence or absence of obstruction, the level of obstruction and the cause of obstruction. The final diagnosis was obtained by surgery (n=25), or by contrast studies and/or clinical follow-up in those who were treated conservatively (n=7).

Results: Out of 32 patients, 30 had mechanical intestinal obstruction (22 had small bowel obstruction and 8 had large bowel obstruction). Of the remaining 2 patients, 1 had adynamic ileus and the other had a mesenteric cyst. CT had high sensitivity (93%), specificity (100%) and accuracy (94%) in diagnosing the presence of obstruction. The comparable sensitivity, specificity and accuracy were, respectively, 83%, 100% and 84% for US and 77%, 50% and 75% for plain radiography. The level of obstruction was correctly predicted in 93% on CT, in 70% on US and in 60% on plain films. CT was superior (87%) to both US (23%) and plain radiography (7%) in determining the aetiology of obstruction.

Conclusion: CT is a highly accurate method in the evaluation of intestinal obstruction especially for determining the level and cause of obstruction and should be the technique of choice when clinical or plain radiographic findings are equivocal.

Key words: Intestines, obstruction; CT, ultrasonography.

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Accepted for publication 13 January 1999.

Intestinal obstruction is a common surgical emergency and, because of its serious nature, demands an early diagnosis (6, 21). Plain abdominal radiography remains the first step in the diagnostic imaging evaluation of a patient with suspected bowel obstruction. However, the diagnostic accuracy of plain radiographs alone is low, varying from 55% to 80%; in up to 20% of patients, there may not be any plain radiographic evidence of intestinal obstruction (13, 14, 20, 23). Recently, CT has been advocated as a procedure that has higher sensitivity than plain films and can be used to determine the precise site and cause of obstruction (9, 15–17). Although US has been infrequently used to evaluate patients with suspected intestinal obstruction, few studies have shown US to be useful in patients with clinical signs of obstruction and gasless plain radiography due to fluid-filled loops (13, 18). While the role of plain films, US, and CT individually in different clinical conditions has been the subject of many reports (1, 13, 16, 23), there are limited studies comparing the relative roles of these three imaging techniques in the evaluation of bowel obstruction. Accordingly, we carried out a prospective study to evaluate the diagnostic accuracy of plain abdominal radiography,
US and CT in patients with clinical suspicion of intestinal obstruction with reference to the presence or absence of obstruction, and the level and cause of obstruction.

Material and Methods

The study included 32 consecutive patients (21 male and 11 female; age range 13 to 75 years; mean age 35 years) presenting with clinical suspicion of bowel obstruction and referred for radiological evaluation between January 1990 and December 1993. Plain abdominal radiography, abdominal US and CT were done in all patients within a period of 6–36 h.

Supine and erect radiographs of the abdomen were done in all patients and evaluated for the presence of dilated bowel loops, the relative amount of air and fluid, and their distribution. Intestinal obstruction was diagnosed when plain films showed more than 2 air fluid levels in dilated bowel loops (>2.5 cm diameter in the case of small bowel and >6.0 cm in large bowel). An attempt was made to find the level of obstruction by noting the location of the dilated loops and the presence of valvulae, hastra and faecal matter in the dilated loops. Jejunal loops were identified by the presence of valvulae and their location in midabdomen or upper abdomen; ileal loops by the absence of valvulae (featureless) and their location in pelvis and lower abdomen; colon was identified by the presence of hastra, faecal matter and their location in the periphery of abdomen. An attempt was also made to find the possible cause of obstruction from these radiographs.

US was performed with a General Electric RT 3600 machine using 3.5 or 5 MHz sector and/or linear transducers. Intestinal obstruction was diagnosed when there were dilated bowel loops with or without peristaltic activity and a zone of transition beyond which dilatation was not appreciated. Adynamic ileus was diagnosed when dilatation involved both large and small bowel loops with sluggish or absent peristaltic activity. The study was considered inconclusive when proper evaluation was not possible because of gas-filled bowel loops. The level of obstruction was obtained by assessing specific mucosal structures like valvulae conniventes (≥4 folds per 2.5 cm denoting jejunal loop and ≤3 folds per 2.5 cm denoting ileal loop) (Fig. 1) and hastrations (denoting colon). The zone of transition was carefully evaluated to ascertain the cause of obstruction.

CT was performed (Somatom HiQ/Shimadzu SCT 2000) after giving oral (2% iodiinated, watersoluble) contrast medium; 500–800 ml was given orally starting at least 45 min before scanning and an additional 300 to 400 ml was given immediately before the actual commencement of scanning. About 500 ml of 2% iodiinated water soluble contrast was also administered rectally in patients with strong clinical suspicion of large bowel obstruction (n=8). In all patients, a bolus injection of 150 ml 60% iodiinated contrast medium was given i.v. at a rate of 2 ml/s. Ten-mm thick sections at 10-mm table increments were taken to cover the entire abdomen and pelvis. Additional 5-mm sections were obtained in suspected areas.

On CT, the diagnosis of obstruction was made based on the presence of dilated bowel loops (>2.5 cm in small bowel and >6.0 cm in large bowel) and change in the calibre of bowel loops from distended segments proximal to the point of obstruction to a collapsed segment distal to the obstruction with or without a definite transition zone. The transition zone was assessed for the presence or

Fig. 1. A 25-year-old man with postoperative adhesions. a) Plain radiography (supine film) shows multiple dilated air-filled small bowel loops. b) US shows distended fluid-filled jejunal segments characterized by closely spaced valvulae conniventes. c) CT shows dilated fluid-filled small bowel loops with collapsed loops on the right side of the abdomen.
absence of thickening, tumour, intussusception, inflammation, abscess, hernia etc. Failure to visualize an obstructive lesion was interpreted as obstruction caused by adhesions. The level of obstruction was determined by following the dilated loops starting from the rectum and proceeding proximally. The location of the dilated loops was also used in predicting the level of obstruction.

The plain films and CT images were interpreted independently by two radiologists each, who were blinded to the findings of other imaging modalities and the final diagnosis. Any differences of opinion regarding the imaging findings among the radiologists evaluating each modality were resolved through consensus. US was performed and interpreted by an experienced radiologist who was also blinded to the results of other imaging techniques. The findings were compared to the final diagnosis obtained by surgery (n=25), or by contrast studies and/or clinical follow-up in those patients who were managed conservatively (n=7).

Statistical analysis: Sensitivity, specificity and accuracy of the three imaging modalities were calculated for the diagnosis of obstruction and compared. The percentage of cases in which the level and cause of obstruction could be determined were also compared.

Results

Thirty out of 32 patients had intestinal obstruction, out of whom 22 (73%) had small bowel and 8 (27%) had large bowel obstruction. The specific aetiologies of small bowel obstruction included tubercular strictures in 5 patients, ovarian carcinoma causing distal small bowel obstruction (due to direct infiltration (n=2) or serosal metastasis (n=1)) in 3 patients, adhesions following surgery in 3 patients, small bowel volvulus in 2 patients, and jejuno-jejunal intussusception (in a patient with Peutz-Jeghers syndrome), small bowel lymphoma, appendicitis with adhesions, appendicular abscess, pelvic abscess, right paracolic abscess, ischaemic jejunal stricture, jejunal stricture secondary to non-specific jejunitis, and retained surgical sponge in 1 patient each. Large bowel obstructions were caused by carcinoma of the colon in 4 patients, and carcinoma of the gallbladder with infiltration into the hepatic flexure, sigmoid volvulus, ischaemic stricture involving the sigmoid colon, and colo-colic intussusception due to polyp in 1 patient each (Table 1). In 2 patients, no mechanical obstruction was found; 1 patient had adynamic ileus due to postpartal puerperal sepsis, and another had a mesenteric cyst.

Plain radiography was able to diagnose obstruction in 23 (77%) of the 30 patients. Level of obstruction was correctly predicted on plain films in

<table>
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<th>Table 1</th>
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<tr>
<td>Relative efficacy of the three imaging modalities for the diagnosis of obstruction</td>
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<tr>
<td>Plain radiography</td>
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<tr>
<td>Sensitivity, %</td>
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<td>Specificity, %</td>
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<td>Accuracy, %</td>
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<th>Table 2</th>
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<td>Relative efficacy of plain radiography, US and CT in diagnosing the level and cause of obstruction</td>
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<tr>
<td>Total number of patients</td>
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<td>Level of obstruction</td>
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<td>Cause of obstruction</td>
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Fig. 2. A 13-year-old girl with colo-colic intussusception. a) Plain radiography (erect film) shows dilated colon up to mid-descending colon. b) US (transverse section in left lumbar region) demonstrates a target lesion showing alternating hypo- and hyperechoic layers. c) CT at the same level also demonstrates a target lesion with alternating high and low attenuation layers.
Fig. 3. A 60-year-old man with small bowel volvulus. CT shows radial distribution of several distended and fluid-filled loops with mesenteric oedema and stretched mesenteric vascular structures converging to the point of torsion (\(*\) — "whirl sign"). Note presence of intramural air (\(\rightarrow\)) suggesting strangulation; this was confirmed at surgery.

18 of these 23 patients (Table 2). In the other 5 patients, the level was wrongly identified; in 1 patient with colon carcinoma at the hepatic flexure, the large bowel obstruction was misinterpreted as distal small bowel obstruction because of fluid-filled, gasless right colon; in 1 patient with adhesive small bowel obstruction, the hugely dilated small bowel loops were mistaken for large bowel; 3 cases of distal small bowel obstruction due to adhesions (n=2) or volvulus (n=1) were misinterpreted as proximal small bowel obstructions. The cause of obstruction could be correctly identified in 2 patients (7%) only; plain films showed the characteristic coffee-bean sign in the patient with sigmoid volvulus and a soft tissue mass in the dilated ascending colon in a case of colonic carcinoma. Of the 2 patients with no obstruction, plain films were wrongly interpreted (false-positive) as showing obstruction in 1 patient.

US could determine the presence of obstruction in 25 (83%) patients (Table 1). US assessment was inadequate in 2 patients because of predominantly gas-filled bowel loops. In 2 other patients with low-grade intermittent partial obstruction, bowel loops were not dilated at the time of the US examination. One patient was misdiagnosed as having ileus because of sparse peristaltic activity. US correctly identified the level of obstruction in 21 patients (Table 2). Level of obstruction was wrongly interpreted in 4 patients: 1 case of small bowel obstruction was interpreted as large bowel obstruction because the hugely dilated small bowel loops were mistaken as large bowel; 1 case of large bowel obstruction due to carcinoma of the colon at the hepatic flexure was misdiagnosed as distal small bowel obstruction as air-filled distended ascending colon could not be visualized on US; 2 cases of distal small bowel obstruction were misinterpreted as having proximal small bowel obstruction. US could correctly identify the cause of obstruction in 7 patients only viz. right ovarian mass (n=2), intussusception (n=2) (Fig. 2), appendicular abscess (n=1), pelvic abscess (n=1), and carcinoma of the ascending colon (n=1).

CT provided a correct diagnosis regarding the presence of obstruction in 28 (93%) of the 30 pa-

Fig. 4. A 24-year-old man with abdominal tuberculosis. a) Plain radiography (supine film) shows dilated small bowel loops. b) CT shows ileal stricture (\(\Rightarrow\)) with mural thickening affecting the ileo-caecal region (\(\bullet\)) and hypodense lymph node (\(\rightarrow\)).
Table 3

<table>
<thead>
<tr>
<th>Cause of obstruction</th>
<th>Patients, n</th>
<th>Plain radiography</th>
<th>US</th>
<th>CT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malignancy</td>
<td>9</td>
<td>1</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>Inflammation</td>
<td>9</td>
<td>0</td>
<td>2</td>
<td>8</td>
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<tr>
<td>Adhesion</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Volvulus</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Structure</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Intussusception</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Foreign body</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>30</td>
<td>2</td>
<td>7</td>
<td>26</td>
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</table>

Patients with obstruction (Table 1). CT also correctly diagnosed 2 patients who did not have obstruction as having adynamic ileus and a mesenteric cyst, respectively. Level of obstruction was correctly identified in all the 28 patients in whom CT diagnosed the presence of obstruction (Table 2). CT correctly identified the aetiology of obstruction in 24 (Figs. 3, 4) of these 28 patients. The aetiology in the other 4 patients included ischaemic stricture of jejunum, jejunal stricture secondary to non-specific jejunitis, appendicitis with adhesions and bowel wall metastasis from ovarian tumour in 1 patient each (Table 3). In the 2 patients in whom CT was false-negative for obstruction (because of absence of bowel dilatation at the time of imaging), the underlying disease process was correctly diagnosed as small bowel lymphoma in 1 patient and abdominal tuberculosis in the other. Hence, the overall efficacy of CT in the diagnosis of aetiology of obstruction was 87% (26/30).

Discussion

Conventionally, plain radiography of the abdomen is the first and primary imaging procedure in cases of bowel obstruction. The probability of making a correct diagnosis of presence of obstruction on plain films has varied from 55% to 80% in most previous studies; in the present study, plain films diagnosed obstruction in 77% (23/30) of cases. The problems encountered in correctly predicting the site of obstruction resulting either from fluid-filled bowel loops, or hugely dilated small bowel with effacement of folds mimicking large bowel or due to abnormal positioning of small bowel loops, are well described in literature (11, 24); we encountered these problems in 5 patients. Abdominal radiography is generally considered to be a poor modality for the detection of underlying aetiology of obstruction due to lack of specific features (12, 14). Ko et al. reported the efficacy of plain films in the diagnosis of the cause of obstruction to be 2% (13). In the present study also, the cause of obstruction could be correctly suggested in 2 patients only.

US has been infrequently employed to investigate intestinal obstruction (13, 18). MEISER & MEISSNER (18), in a prospective study of 48 patients, found that US was positive in 25% of the patients in whom plain films were normal, and the cause of obstruction could be detected in 13%. Ko et al. (13) found US to be 89% sensitive in diagnosing obstruction; the level and cause were correctly predicted in 76% and 28% of the cases, respectively. In the present study, US had a similar sensitivity (83%) in diagnosing obstruction. A major limitation is the presence of gas-filled bowel loops which prevent adequate US assessment (13); this was seen in 2 of our patients. Also, as seen in 2 other patients, sluggish peristaltic activity in the late stages of mechanical obstruction may lead to erroneous diagnosis of paralytic ileus. The very high sensitivities (98% and 96%) reported in 2 earlier series were probably related to the fact that in both studies cases of mechanical obstruction as well as adynamic ileus were included under the term of obstruction. Reasons for misinterpretation of the site of obstruction on US include hugely dilated small bowel loops mimicking large bowel loops and gas-filled bowel loops not being identified on US.

The efficacy of US in diagnosing the exact aetiology of obstruction is low, varying from 28% to 46% (13, 18). Like previous studies, our results also show that US is useful in diagnosing conditions like intussusception, extrinsic mass lesions, or intra-abdominal abscesses; however, it is of limited value in depicting bowel strictures of varying aetiologies or obstructions secondary to adhesions (Table 3).

Since the first report describing the role of CT in bowel obstruction by MEGIBOW et al. in 1991 (17), CT has been increasingly used in the evaluation of bowel obstruction. The high sensitivity (93%), specificity (100%), and accuracy (94%) of CT in the diagnosis of intestinal obstruction seen in our study are similar to those reported in the initial studies (9, 17), but much higher than those reported by MAGLINTE et al. (15, 16). This discrepancy is probably related to the fact that most of the patients in the present study had high-grade obstruction while the reports by MAGLINTE et al. (15, 16) included an equal number of patients with high- and low-grade bowel obstruction. MAGLINTE et al. (15) showed that CT had a sensitivity of 81% for high-grade and 48% for low-grade obstruction. In our study also, the 2 patients in whom CT was
false-negative for obstruction, had low-grade intermittent obstruction. High- and low-grade obstructions are generally diagnosed based on barium studies (15); in high-grade obstruction, only small amounts of barium pass beyond the obstruction while in low-grade obstruction there is sufficient flow across the obstruction. These features are reflected on CT as grossly dilated loops proximal to the obstruction with sudden change in the calibre in high-grade obstruction compared to mild to moderate dilatation and gradual change in the calibre of loops in low-grade obstruction; this affects the accuracy of CT in diagnosing the presence, the level and the cause of obstruction.

The speed and ability of CT to reveal the cause of obstruction makes it particularly valuable in the acute setting. In previous studies, CT has been shown to correctly reveal the cause of obstruction in 73–95% of cases (9, 15–17); in the present study, CT correctly identified the underlying aetiology in 26 (87%) patients. These percentages compare favourably with the sensitivity of plain films and US in determining the cause of obstruction. CT has been shown to be an excellent modality in the diagnosis of conditions like intussusception, volvulus (Fig. 3) and extraluminal lesions like abscesses and tumours (4, 10, 19, 22); all cases of intestinal obstruction due to these aetiologies were correctly diagnosed by CT in the present study.

Diagnosis of adhesions (Fig. 1) as a cause of intestinal obstruction is usually made when there is a history of previous surgery and CT fails to reveal any definite pathology at the site of transition (11, 15); using these criteria, all of our 3 cases of postoperative adhesions were correctly identified. Unlike cases reported in the Western literature, tuberculosis remains a common cause of intestinal obstruction in endemic countries like India (5) and CT has been shown to be an accurate method in the diagnosis of abdominal tuberculosis (8). In the present study also, CT correctly diagnosed all the 7 patients with abdominal tuberculosis. In these patients, apart from showing mural thickening of the obstructed segment, CT was useful in suggesting the correct diagnosis by demonstrating the characteristic extra-luminal findings which included multicompartment (predominantly mesenteric) lymphadenopathy, low-density areas within enlarged nodes, mural thickening of the ileocaecal region, and mesenteric and omental infiltration (Fig. 4) (3, 8).

CT is particularly useful in closed-loop obstruction and strangulation (2, 7). BALTHAZAR et al. reported a sensitivity of 78.9% in closed-loop obstruction and 62.5% in strangulation (4). The present study confirmed these results; CT detected 3 out of 4 cases of closed loop obstruction and also correctly diagnosed the only case of strangulation.

In conclusion, CT is a highly sensitive and accurate imaging technique for diagnosing bowel obstruction and for determining the level and cause of obstruction. In comparison, plain radiography and US are relatively insensitive modalities. US has a very limited role in the evaluation of intestinal obstruction and is only occasionally useful to distinguish dynamic and adynamic obstruction. CT should be the imaging modality of choice when the results of clinical and plain film evaluation are inconclusive.

REFERENCES