Efficacy of CT in Distinguishing Small-Bowel Obstruction from Other Causes of Small-Bowel Dilatation

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OBJECTIVE. Dilatation of the small bowel is a common finding on plain abdominal radiographs. In such cases, it is often difficult to determine if the cause of the dilatation is small-bowel obstruction, paralytic ileus, or another intraabdominal disorder. Accordingly, we studied the efficacy of CT in making this distinction.

MATERIALS AND METHODS. The medical records of 75 patients with small-bowel dilatation seen on CT scans (more than three segments > 2.5 cm in diameter) were reviewed. The patients were divided into three groups (obstruction [27 patients], other surgical diagnosis [16 patients], and no surgery [32 patients]) on the basis of clinical course, findings at surgery, or both. CT scans were retrospectively evaluated by two gastrointestinal radiologists who did not know the results of the chart review. They evaluated the images with regard to the following specific criteria for obstruction: presence/continuity of duodenal, small-bowel, and colonic dilatation; presence of air-fluid levels; amount of intestinal fluid; presence of prestenotic dilatation; presence of transition zone; and cause of obstruction. In addition, each radiologist gave an overall impression regarding the presence or absence of obstruction (criteria not specified to the observers) and its site, or other cause of bowel dilatation. The CT interpretations of each of the radiologists were compared with the patients' subsequent clinical course.

RESULTS. Observer A was correct in 89%, 88%, and 72% of cases in the obstruction, other surgical diagnosis, and no surgery groups, respectively. Observer B was correct in 78%, 81%, and 69% of cases in the obstruction, other surgical diagnosis, and no surgery groups, respectively. Observer agreement regarding the proposed criteria for obstruction ranged from 65% to 91%. For both observers, only the presence of continuous small-bowel dilatation, prestenotic dilatation, and a transition zone correlated significantly with the presence of small-bowel obstruction.

CONCLUSION. CT can be a useful test for evaluating small-bowel dilatation and can aid both the diagnosis of small-bowel obstruction and its differentiation from other conditions resulting in small-bowel dilatation.

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Small-bowel obstruction is a common clinical entity that is associated with signs and symptoms that can be similar to those seen in other conditions such as postsurgical ileus, intraabdominal abscess or malignant tumor, pancreatitis, peptic ulcer disease, and gastroenteritis. The radiologic workup of patients with suspected small-bowel obstruction usually begins with the plain abdominal radiograph. However, because of overlapping and often confusing findings, additional radiologic studies are often necessary to distinguish obstruction from ileus. Previous reports [1, 2] have suggested that CT may be useful; however, neither of these reports specifically addressed the accuracy of CT in the differentiation of small-bowel obstruction from other conditions known to cause small-bowel dilatation. We believe that a realistic control group for evaluating the accuracy of CT in small-bowel obstruction should include those patients, and we therefore undertook this study. Furthermore, we evaluated several specific CT criteria in an attempt to identify those that, either alone or in combination, might prove useful in diagnosing small-bowel obstruction.

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Materials and Methods

The study consisted of a retrospective, blinded review of the CT scans from 75 patients with small-bowel dilatation. The patients were 16–88 years old; 32 were male and 43 were female. Records were collected from a 2-year period, and patients were included in the study solely on the basis of the findings on the CT scans. Clinical history, indications for CT, and findings on plain abdominal radiographs were often not available and were not used as a basis for inclusion or exclusion. The single entrance criterion was the CT finding of dilated small-bowel loops, defined as the presence of at least three segments of small bowel measuring at least 2.5 cm in diameter. Although 3.0 cm is more commonly used to identify abnormal small-bowel dilatation on plain films, we chose to use 2.5 cm in order to take into account magnification inherent to projection radiographs. The use of this measurement is in agreement with the findings of Fukuya et al. [2].

The medical records of all patients were reviewed by an investigator who was not involved in the selection of patients or the interpretation of images. Patients' data, such as age, sex, medical history, and hospital course, were reviewed and recorded. In patients who underwent surgery, the surgical notes and any resulting pathologic reports were reviewed. In patients who did not undergo surgery, a minimum of 6 months' clinical follow-up was required for them to be included in the study.

On the basis of surgical findings and clinical outcome, the patients were divided into three groups (obstruction, other surgical diagnosis, no surgery). In addition, for the purpose of analysis, patients were also categorized solely on the basis of whether or not they had undergone surgery. Those who had undergone surgery (patients in the obstruction and other surgical diagnosis groups) were compared with those who had not.

Forty-three of the patients underwent surgery; thirty-two did not (no surgery group) and showed no evidence of bowel obstruction on follow-up (minimum, 6 months). Of the patients who underwent surgery, 27 were found to have small-bowel obstruction (obstruction group). Within this group, obstruction was due to adhesions in 12 (Figs. 1 and 2), peritoneal carcinomatosis in six, tumor involving a single bowel segment in six (Fig. 3), and hematoma, abscess, and intussusception in one each. Sixteen of the patients who underwent surgery were found to have conditions other than small-bowel obstruction (other surgical diagnosis group). Within this group, bowel dilatation was due to abscess in eight, peritoneal carcinomatosis in two, inflammatory bowel disease in two, and aortic aneurysm, small-bowel necrosis, and pancreatitis with pseudocyst in one each. One patient in this group had no findings at surgery to explain the bowel dilatation (negative laparotomy).

The CT examinations were performed according to standard departmental protocol, including the use of oral contrast medium when possible (Gastrografin diluted 1:40 in water), 5 × 8 mm slice profile, 2-sec scan time with minimum interscan delay (usually 4–6 sec), and variable use of IV contrast material.

All CT scans were retrospectively interpreted by two gastrointestinal radiologists who did not know the patients' clinical history, original CT interpretation, hospital course, or outcome. Several specific criteria that were thought to have potential utility in the CT evaluation of small-bowel obstruction were studied. These included the presence of duodenal and large-bowel dilatation, continuity of small- and large-bowel dilatation, character of intestinal contents, presence of air-fluid levels, prestenotic dilatation, transition zone, and cause of transition. Duodenal dilatation was considered to be present when the entire duodenum was seen and was distended with contrast material (Fig. 1A). No specific diameter was used for this determination, as it was thought that the appearance alone was both unusual and specific enough. Large-bowel dilatation was considered to be present when the diameter of the colon was greater than 6 cm. Bowel dilatation was considered to be continuous when all of the bowel proximal to the

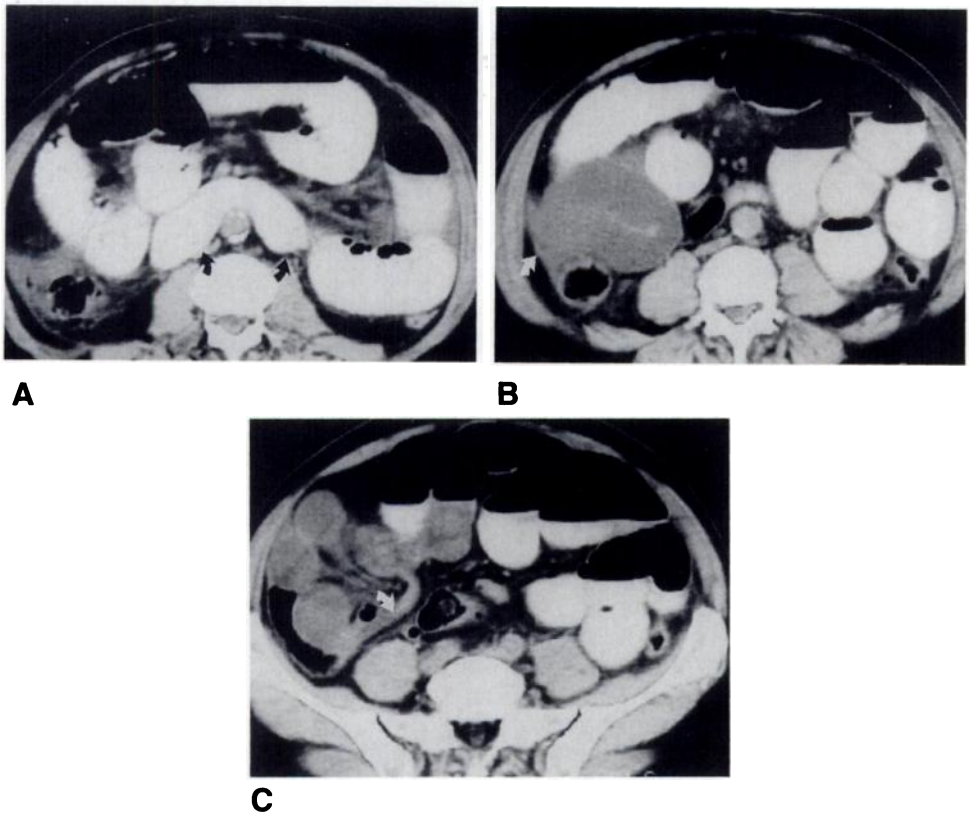

Fig. 1.—68-year-old man with closed-loop small-bowel obstruction.

***A,* CT scan shows dilated duodenum (*arrows*) filled with contrast material. Multiple dilated, contrast-filled small-bowel loops are also identified; in this instance, fluid fills more than 50% of total cross-sectional area of visualized small-bowel loops.**

***B,* CT scan shows fluid-filled, closed loop of small bowel (*arrow*) in right lower quadrant. Note multiple dilated, contrast-filled loops proximal to obstruction.**

***C,* CT scan of section 4 cm inferior to *B* shows an abrupt transition from dilated to narrowed small bowel (*arrow*) at base of twisted loop.**

zone of transition (or all of the bowel if no transition zone was identified) was dilated. Prestenotic dilatation was considered to be present if the loops of bowel immediately proximal to the transition zone were at least as dilated as (if not more than) any other bowel loops. Continuous dilatation and prestenotic dilatation, although similar, are therefore quite different from each other. For example, (1) the loops immediately proximal to the transition zone can be the most dilated without there being continuous dilatation (i.e., prestenotic dilatation without continuous dilatation), or (2) even if continuous dilatation is present, the diameter of the loops immediately proximal to the transition zone need not be equal to or greater than that of more proximal loops (i.e., continuous dilatation without prestenotic dilatation). Intestinal contents were evaluated with respect to the relative amounts of fluid and gas; the two observers were asked if they thought that fluid filled greater (Fig. 1A) or less (Fig. 4) than 50% of the total cross-sectional area of the visualized loops of small or large bowel. The observers were asked to grade each study with respect to each of the criteria. In addition, they were asked to give an overall impression regarding the presence or absence of small-bowel obstruction and its cause (in patients thought to have small-bowel obstruction). When obstruction was not thought to be present, the perceived cause of small-bowel dilatation was recorded. The observers were not specifically asked to categorize patients into one of the three diagnostic groups eventually created.

The observers' impressions and the findings at surgery or follow-up were reviewed in order to determine whether or not each interpretation had been *correct overall* and had been *appropriate* with regard to surgical vs nonsurgical categorization of patients. Interpretations were considered correct overall if the observer not only correctly interpreted the study with regard to the presence or absence of bowel obstruction, but also correctly identified either the cause of obstruction or other disease in patients with nonobstructive dilatation. Interpretations were considered appropriate with regard to surgical vs nonsurgical categorization if an impression was given that, in normal circumstances, would suggest an approach (i.e., surgical vs nonsurgical) that was consistent with the actual outcome. This determination was made in an attempt to assess the potential contribution of the studies to the clinical decision-making process. For example, if the observer identified intestinal perforation and bowel obstruction, and the patient was found to have perforation without obstruction, the interpretation was considered to have been appropriate with regard to placement into the surgical group but was not considered to have been correct overall. Categorization of patients as nonsurgical was considered to have been appropriate if the patient did not undergo surgery, no condition that would normally require surgery was mentioned by the observer, and on follow-up the patient had no evidence of intestinal obstruction. An interpretation most compatible with a conservative approach was also considered correct in the case of a negative laparotomy (one case in this study).

Statistical Analysis

The sign test for paired observations was used to compare the two observers' CT interpretations (in terms of both overall correctness and appropriate categorization). The relationship of the grouping (obstruction, other surgical diagnosis, and no surgery) to each of the individual CT criteria (present/absent, yes/no) was analyzed for each observer by means of the χ^2-test for 3×2 contingency tables (or by Fisher's exact test when indicated; see Table 1).

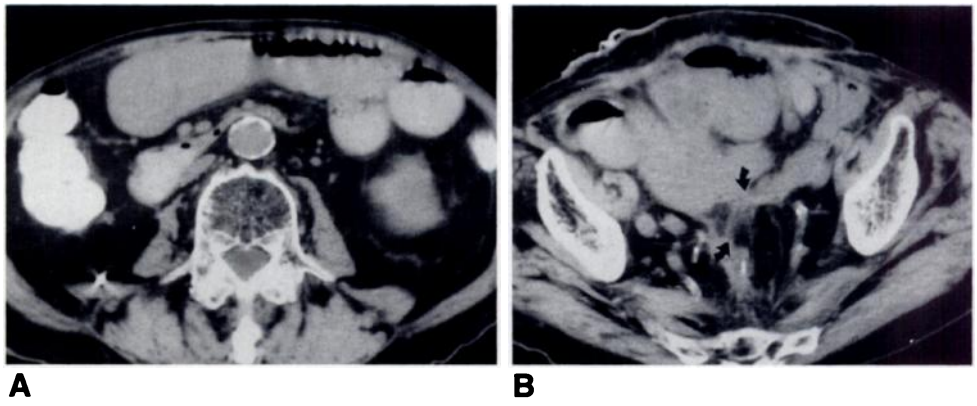

Fig. 2.—94-year-old man with small-bowel obstruction due to adhesions.

***A*, CT scan through upper part of abdomen shows multiple dilated, fluid-filled small-bowel loops.**

***B*, CT scan through pelvis shows transition site adjacent to strands and inflammatory change in fat (*arrows*). This appearance suggests adhesions as cause of obstruction.**

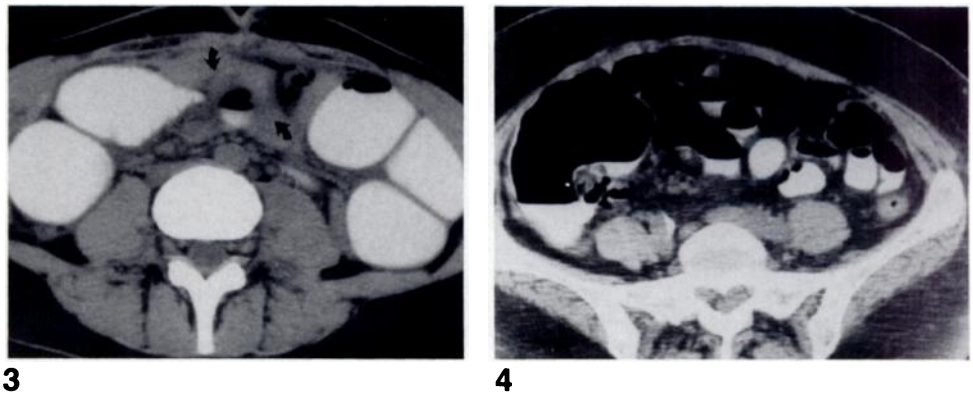

Fig. 3.—35-year-old woman with metastatic ovarian carcinoma. CT scan shows tumor metastasis (*arrows*) surrounding a narrowed small-bowel loop in mid abdomen. Also note massively dilated more proximal small-bowel loops, filled predominately with contrast material rather than gas.

Fig. 4.—68-year-old woman with postoperative ileus. CT scan shows multiple mildly dilated, mostly gas-filled, small-bowel loops throughout abdomen. No transition site was identified. Also note gas-filled and somewhat distended cecum.

Results

Observers A and B were correct overall in 61 (81%) and 56 (75%) of 75 cases, respectively. Within specific groups of patients, observer A was correct overall in 24 (89%) of 27, 14 (88%) of 16, and 23 (72%) of 32 cases in the obstruction, other surgical diagnosis, and no surgery groups, respectively. Observer B was correct overall in 21 (78%) of 27, 13 (81%) of 16, and 22 (69%) of 32 cases in the obstruction, other surgical diagnosis, and no surgery groups, respectively. The differences between observers were not statistically significant.

When only the surgical vs nonsurgical categorization is considered, the interpretations of observers A and B were considered to have been appropriate in 67 (89%) and 61 (81%) of 75 cases, respectively. Within specific patient groups, the interpretations of observer A were considered appropriate in 27 (100%) of 27, 15 (94%) of 16, and 23 (72%) of 32 cases in the obstruction, other surgical diagnosis, and no surgery groups, respectively. The interpretations of observer B were considered appropriate in 26 (96%) of 27, 13 (81%) of 16, and 22 (69%) of 32 cases in the obstruction, other surgical diagnosis, and no surgery groups, respectively. The differences between observers were not statistically significant.

Evaluation of the specific criteria is presented in Table 1, and it reveals that for both observers, only the presence of continuous small-bowel dilatation, prestenotic dilatation, and the identification of a transition zone were significantly ($p < .01$) related to the presence of small-bowel obstruction. Other findings were distributed relatively equally among the patients in all three diagnosis groups. Agreement between the observers with regard to the evaluation of the specific criteria for obstruction was seen 65–91% of the time (mean, 79%).

Discussion

The radiologic workup of patients with suspected small-bowel obstruction begins with the plain abdominal radiograph. When associated with the appropriate signs and symptoms, this study can lead to a definitive diagnosis and facilitate appropriate management of the case. However, the findings are often inconclusive, and additional radiologic studies are required. Megibow et al. [1] have suggested that CT may have a role in the evaluation of suspected small-bowel obstruction. They reviewed 84 CT examinations from patients with suspected intestinal obstruction (64 of whom ultimately were proved to have obstruction), as well as 83 CT examinations from patients without history or other indications of intestinal obstruction, and reported overall sensitivity of 94% and specificity of 96%. Subsequently, Fukuya et al. [2] reviewed the CT examinations of 30 patients who were found to have evidence of small-bowel obstruction at laparotomy and compared them with the CT examinations of 30 patients without obstruction. They were able to diagnose small-bowel obstruction correctly in 90% of the patients with obstruction and reported no false-positives. In addition, on the basis of receiver-operating-characteristic analysis, they suggested that "the optimum balance of sensitivity and specificity was achieved when 2.5 cm was used to indicate dilatation of the small bowel." These studies have led to heightened interest in the use of CT for the evaluation of suspected small-bowel obstruction. This study was designed to address the unanswered question of whether CT can be used to differentiate small-bowel obstruction from other conditions known to cause small-bowel dilatation, and if possible, to determine criteria useful for the differentiation.

The principal findings of the current study are a somewhat lower overall accuracy than reported in earlier studies, as

TABLE 1: Observer Evaluation of Individual CT Criteria

Criterion	Observer	Patient Group			*p* Value
		Obstruction	Other Surgical Diagnosis	No Surgery	
Duodenal dilatation	A	13 (48)	5 (31)	12 (38)	.512
	B	5 (19)	1 (6)	7 (22)	.395
Continuous dilatation of small bowel[a]	A	23 (85)	7 (44)	16 (50)	.006
	B	21 (78)	7 (44)	14 (44)	.017
Small-bowel fluid > 50%	A	22 (81)	12 (75)	23 (74)	.786
	B	22 (81)	11 (69)	25 (81)	.570
Air-fluid levels	A	23 (85)	11 (69)	25 (78)	.443
	B	22 (81)	11 (69)	27 (84)	.431
Large-bowel dilatation	A	7 (26)	5 (31)	10 (31)	.889
	B	6 (22)	4 (25)	12 (38)	.400
Continuous dilatation of large bowel	A	6 (22)	3 (19)	3 (9)	.361
	B	4 (15)	3 (19)	4 (13)	.846
Large-bowel fluid > 50%	A	13 (57)	8 (53)	12 (43)	.598
	B	12 (46)	8 (50)	7 (25)	.158
Presence of transition[a]	A	27 (100)	7 (44)	14 (44)	.000
	B	26 (96)	7 (44)	20 (63)	.001
Prestenotic dilatation[a]	A	21 (78)	4 (25)	8 (25)	.000
	B	25 (93)	7 (44)	17 (53)	.001

Note.—Numbers in table are numbers of patients followed by percentages in parentheses.

[a] For these criteria, the distribution of responses among patient groups differed significantly.

well as the identification of three specific findings that correlated significantly with the diagnosis of small-bowel obstruction. Our unconventional analytic methods (i.e., three groups, choice of gold standard, analysis for correctness overall and appropriate categorization) prevent our results from being directly compared with those of either Megibow et al. or Fukuya et al. However, the lower overall accuracy probably reflects the more challenging control group used (i.e., patients with bowel dilatation). Furthermore, the study group more closely approximates the "real-life" challenges that face the radiologist interpreting these examinations and trying to distinguish patients with obstructive dilatation from those with dilatation due to other conditions. Our results confirm the utility of CT in the evaluation of patients who may have small-bowel obstruction and suggest that it can also help to differentiate among patients with nonobstructive bowel dilatation. Given the challenging control group used, the accuracy was remarkably high.

Limitations of the study include the choice of surgery as the gold standard for the diagnosis of small-bowel obstruction and the difficulty in establishing a diagnosis in patients who did not undergo surgery. The obstruction group included only those patients who were found at laparotomy to have definite evidence of small-bowel obstruction; patients with what some might consider "partial" or "self-resolving" small-bowel obstruction were therefore invariably excluded. Our rationale for grouping together all patients managed nonsurgically was that it is impossible to differentiate "paralytic ileus" from "partial small-bowel obstruction" accurately on clinical grounds alone and, further, that these conditions may represent different points along a single disease spectrum. In addition, we thought that small-bowel obstruction could be accurately and reliably confirmed only at laparotomy.

The other surgical diagnosis group was used to assess the contribution of CT to the identification of patients with bowel dilatation due to conditions other than mechanical small-bowel obstruction. The success in making correct diagnoses in this group of patients attests to the utility of CT and confirms the results of previous studies that have evaluated the role of CT in patients with acute abdominal disorders [3–5]. In fact, Megibow et al. [1] argued that the improved ability of CT in this regard justifies its use over traditional barium small-bowel studies.

Not surprisingly, the group in which the observers had the lowest accuracy was the no-surgery group. This probably reflects the difficulty in establishing a correct diagnosis in these patients, radiologically and clinically. From a practical standpoint, however, it may not matter what diagnosis is rendered (i.e., ileus vs partial obstruction) as long as proper therapy is not withheld from those who require it. The critical issue is the identification of patients with small-bowel obstruction or other conditions who require surgery.

It is also important to identify patients who require definitive therapy (e.g., surgery, abscess drainage) as a group separate from those who do not. This is particularly important in the care of patients with suspected small-bowel obstruction, as delays in instituting therapy may have dire consequences. In order to address this issue, we looked at the accuracy of the CT interpretations with regard to appropriate categorization of the patients as either surgical (obstruction and other surgical diagnosis groups) or nonsurgical. Patients who were appropriately categorized, even if the correct cause of their bowel dilatation had not been identified, were thought to have benefited from the use of CT in their diagnostic workup. The observers were considered to have been appropriate with regard to surgical vs nonsurgical categorization more often than they were correct overall.

Neither of the previously published studies [1, 2] specifically evaluated criteria for the diagnosis of small-bowel obstruction with CT. In an attempt to do so, we evaluated several findings that we had thought might be useful, before we undertook the study. The results of this evaluation are presented in Table 1. It is clear that most of the criteria were not significantly discriminatory and were in fact relatively equally distributed among the three patient groups. However, the distribution of three findings was significantly different among the different groups of patients. These findings were (1) the presence of continuous small-bowel dilatation, (2) the presence of prestenotic bowel dilatation, and (3) the identification of a distinct transition zone between normal and abnormally dilated bowel. All three were seen significantly more often in the obstruction group than in either of the other two groups. Their identification is therefore important in the evaluation of abdominal CT scans of patients who may have small-bowel obstruction and should lead one to consider that diagnosis. One limitation of our evaluation of these criteria is that the observers were not in complete agreement regarding their interpretation. Nevertheless, agreement ranged from 65% to 91%. Perhaps in the future, the usefulness of these criteria can be further assessed in a prospective study.

A final point that should be considered in the evaluation of CT as a diagnostic test for patients who may have small-bowel obstruction is the difficulty in interpreting the studies. We found the cases to be extremely challenging and the interpretation quite time-consuming. Perhaps this reflects a learning curve associated with the use of CT in newer tasks such as the evaluation of small-bowel obstruction. However, it more likely relates to the difficulty in carefully following multiple bowel loops in and out of axial images, correctly identifying transition zones and their causes, and accurately identifying or excluding the presence of adhesions. Given the latter explanation, it is unlikely that increased experience will make the interpretation significantly easier or faster. Despite these reservations, the overall positive results attest to the fact that, with proper attention to detail, CT can lead to the correct diagnosis and help to facilitate correct management decisions in patients with suspected intestinal obstruction.

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