Detected peritoneal fluid in small bowel obstruction is associated with the need for surgical intervention

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Background: Predicting the clinical course in adhesional small bowel obstruction is difficult. There are no validated clinical or radiologic features that allow early identification of patients likely to require surgical intervention.

Methods: We conducted a retrospective review of 100 patients consecutively admitted to a tertiary level teaching hospital over a 3-year period (2002–2004) who had acute adhesional small bowel obstruction and underwent computed tomography (CT). The primary outcomes that we assessed were conservative management or the need for surgical intervention. We investigated time to physiologic gastrointestinal function recovery as a secondary outcome. We examined independent predictors of surgical intervention in a bivariate analysis using a stepwise logistic regression analysis.

Results: Of the 100 patients investigated, we excluded 12. Of the 88 remaining patients, 58 (66%) were managed conservatively and 30 (34%) underwent surgery. Peritoneal fluid detected on a CT scan (n = 37) was associated more frequently with surgery than conservative management (46% v. 29%, p = 0.046, χ^2). Logistical regression identified peritoneal fluid detected on a CT scan as an independent predictor of surgical intervention (odds ratio 3.0, 95% confidence interval 1.15–7.84).

Conclusion: The presence of peritoneal fluid on a CT scan in patients with adhesional small bowel obstruction is an independent predictor of surgical intervention and should alert the clinician that the patient is 3 times more likely to require surgery.

Contexte : Il est difficile de prédire l'évolution clinique de l'occlusion de l'intestin grêle causée par des adhérences. On ne dispose d'aucun paramètre clinique ou radiologique validé pour le dépistage précoce chez les patients susceptibles d'avoir besoin d'une intervention chirurgicale.

Méthodes : Nous avons procédé à une revue rétrospective de 100 patients consécutifs admis dans un hôpital universitaire de soins tertiaires sur une période de 3 ans (2002 à 2004); ces patients souffraient d'une occlusion aiguë de l'intestin grêle causée par des adhérences et ont subi une tomographie assistée par ordinateur. Les paramètres mesurés ont été le traitement conservateur ou le recours à la chirurgie. À titre de paramètre secondaire, nous avons évalué le temps requis pour que les patients recouvrent une fonction gastro-intestinale physiologique. Nous avons effectué une analyse bivariée des prédicteurs indépendants selon le principe de l'analyse de régression logistique multiple.

Résultats : Nous avons exclu 12 patients sur les 100 étudiés. Parmi les 88 patients restants, 58 (66 %) ont reçu un traitement conservateur et 30 (34 %) ont subi une chirurgie. La présence de liquide péritonéal à la tomographie assistée par ordinateur (n = 37) a été associée plus souvent à la chirurgie qu'au traitement conservateur (46 % c. 29 %, p = 0,046, χ^2). L'analyse de régression logistique a permis de déterminer que la détection de liquide péritonéal à la tomographie assistée par ordinateur constituait un prédicteur indépendant du recours à la chirurgie (rapport des cotes 3,0 ; intervalle de confiance à 95 %, 1,15–7,84).

Conclusion : Chez des patients atteints d'une occlusion de l'intestin grêle causée par des adhérences, la présence de liquide péritonéal à la tomographie assistée par ordinateur constitue un prédicteur indépendant du recours à la chirurgie et signale d'emblée au médecin que son patient est 3 fois plus susceptible d'avoir besoin d'une intervention chirurgicale.

In the United States, hospital admissions for adhesive small bowel obstruction are responsible for nearly 1 million inpatient days and cost more than $1 billion annually.[1] Predicting the clinical course and timing of surgical intervention remains difficult. Clinical assessment, laboratory indices and plain abdominal radiographs have not proven reliable in the early identification of patients likely to require surgical intervention.[2] A recent Cochrane review and meta-analysis of oral water-soluble gastrografin contrast agent in the management of adhesive small bowel obstruction reported that the appearance of contrast agent in the colon on an abdominal radiograph within 24 hours of administration was a predictor of nonoperative resolution of the condition. Administration of gastrografin was also shown to reduce the duration of hospital stay among patients not requiring surgical intervention. However, the administration of gastrografin itself did not reduce the need for surgical intervention.[3,4]

Computed tomography (CT) is a robust method of diagnosing small bowel obstruction.[5,6] Even before multidetector CT techniques, sensitivity and specificity for detection of adhesional small bowel obstruction were high.[6] Knowledge of anatomic level[7] and delayed wall enhancement detected on a CT scan[8] have been shown to contribute to decision-making in the management of small bowel obstruction. In the absence of definitive indications for surgical intervention, including perforation or bowel wall ischemia, the need for surgical decompression is identified based on a combination of multiple CT criteria, none of which has been validated. However, no single prognostic CT finding has been shown to predict the need for surgical intervention.

The etiology of peritoneal fluid in patients with small bowel obstruction is not clear. Vascular compromise due to encasement and twisting of affected intestines in patients with closed loop and strangulating obstructions is believed to result in the accumulation of free fluid in the peritoneal cavity.[9] A high red blood cell count (> 20 000) on diagnostic paracentesis has been shown in one observational study to predict surgical intervention.[10] However, this does not explain the presence of peritoneal fluid in patients with simple mechanical obstruction and other non-necrotic intestinal conditions.[11] Good interobserver correlation between radiologists for the presence of peritoneal fluid has been demonstrated.[8] Abdominal ultrasonography, which is not routinely used in patients with small bowel obstruction, has been previously reported to have a sensitivity of 90% for detecting peritoneal fluid associated with small bowel obstructions requiring surgical intervention; however, the method is neither predictive (27%) nor specific (51%).[12] The only other report associating peritoneal fluid detected on an ultrasound with the need for surgery[13] was a series of 150 patients managed surgically. The presence of peritoneal fluid detected on a CT scan as an independent predictor of the need for surgical intervention in patients with clinical small bowel obstruction has not been studied previously.

The primary aim of our study was to determine whether the presence of radiologically detected peritoneal fluid on a CT scan in patients with clinical small bowel obstruction was associated with an increased need for surgical intervention. We performed subgroup analysis to determine whether demographic or presentation features impacted on clinical and surgical outcomes.

Methods

We identified all patients consecutively admitted to a tertiary level teaching hospital between January 2002 and December 2004 using the Hospital-In-Patient-Enquiry system database (HIPE). We retrospectively investigated all patients who received a diagnosis of small bowel obstruction during the study period, and we included in our study all those with clinical and radiological suspicion for small bowel obstruction who underwent CT scanning during the study period. Exclusion criteria were factors other than adhesional small bowel obstruction that may have accounted for the presence of peritoneal fluid on the CT scans. In all patients, CT was performed immediately after clinical and plain radiological evaluation.

We determined our sample size based on 80% statistical power to detect a significant difference at $\alpha = 0.05$. We calculated the sample size based on pilot data estimating surgical intervention rates of 50% in the presence and 20% in the absence of peritoneal fluid on CT scans; we used the Lehr formula, assuming equal allocation.[14] After adjusting for unequal allocation, we determined that the minimum sample size required to detect a significant difference was 84 patients.[15] Owing to data capture being performed in blocks of 20 and the potential for missing data, we selected 100 consecutive patients for study.

All CT scans were conducted on a Siemens Somotom Plus unit (Siemens) according to a standard protocol. All patients received 1000 mL of 2% iodinated water-soluble contrast medium orally unless contraindicated. Patients received 100 mL of intravenous iodinated contrast medium (35 mg/100 mL), injected at a rate of 2 mL/s. The delay between the start of injection and imaging varied from 70 to 90 seconds. The slice thickness was 8 mm, pitch was 1.0 and the reconstruction interval was 5 mm or 8 mm. A radiologist-in-training and a senior abdominal radiologist interpreted all CT scans with consensus obtained during consultation. We considered small bowel obstruction to be present when continuous distended bowel loops (> 2.5 cm) were visualized proximal to collapsed bowel loops. If transition zones could not be defined, we considered obstruction to be indeterminate or absent. When a point of transition from dilated bowel to normal calibre without apparent cause was identified, we classified etiology as adhesional. We defined peritoneal fluid as the presence of fluid in the

peritoneal cavity, and we noted whether it was present or absent in all patients. We recorded the amount of fluid (mild, moderate or severe) when it was reported. The attenuation value of peritoneal fluid was not routinely documented. We considered scans to be positive when peritoneal fluid in the abdomen was visible; when no peritoneal fluid was detected, we considered the scan to be negative.

We correlated all CT examinations with patient clinical data. Final diagnosis was established at the time of operation or clinical follow-up. We retrieved data from the case notes and entered them into a confidential Excel (Microsoft Corp.) database. All patients who had surgical intervention underwent adhesiolysis and/or bowel resection. Conservative management consisted of intravenous fluid therapy and placement of a nasogastric tube connected to free drainage. We managed patients with no food or drink orally. Among patients managed conservatively, follow-up consisted of a clinical examination every 12 hours, daily laboratory data and daily plain abdominal radiographs until resolution of all symptoms and signs of adhesional small bowel obstruction, as assessed by a senior surgeon (A.H., D.E., N.O., E.M).

The primary outcomes we assessed were conservative management or surgical intervention; the secondary outcomes were bowel resection, physiologic gastrointestinal function recovery and recurrence of small bowel obstruction within 1 year.

Statistical analysis

We tested normality using the Shapiro–Wilk test. We compared qualitative variables using the χ^2 test. We used the Mann–Whitney *U* and Kruskal–Wallis tests to compare quantitative variables, reported as medians and interquartile ranges. To identify independent predictors of surgical intervention, we examined variables with a significance of $p \leq 0.1$ in the bivariate analysis using a stepwise logistic regression analysis. We assessed the identified variables for collineraity and interaction. Odds ratios (OR) of predictors of surgical intervention identified in the logistic regression model are reported with 95% confidence intervals (CIs). We performed statistical analyses using SPSS, version 11 (SPSS Inc.).

RESULTS

We reviewed the cases of 100 consecutive patients with small bowel obstruction over the 3-year study period (Fig. 1). We excluded 12 patients owing to malignant ascites ($n = 6$), cirrhosis ($n = 5$) and congestive heart failure ($n = 1$). A total of 58 patients (66%) were managed conservatively, and 30 (34%) patients underwent surgical intervention. Patient demographics were similar in both groups (Table 1).

Of the 88 patients included, 37 had peritoneal fluid detected on CT scans. Of these, 17 required surgical intervention (Table 2). The absence of peritoneal fluid ($n = 51$) was associated with surgical intervention in 13 patients, whereas the other 38 patients were treated successfully with conservative management ($p = 0.046$, χ^2). Arbitrary measurements of fluid quantity (minimal, moderate or large) were reported for 28 of the 37 (76%) patients in whom fluid was detected. There were no statistical

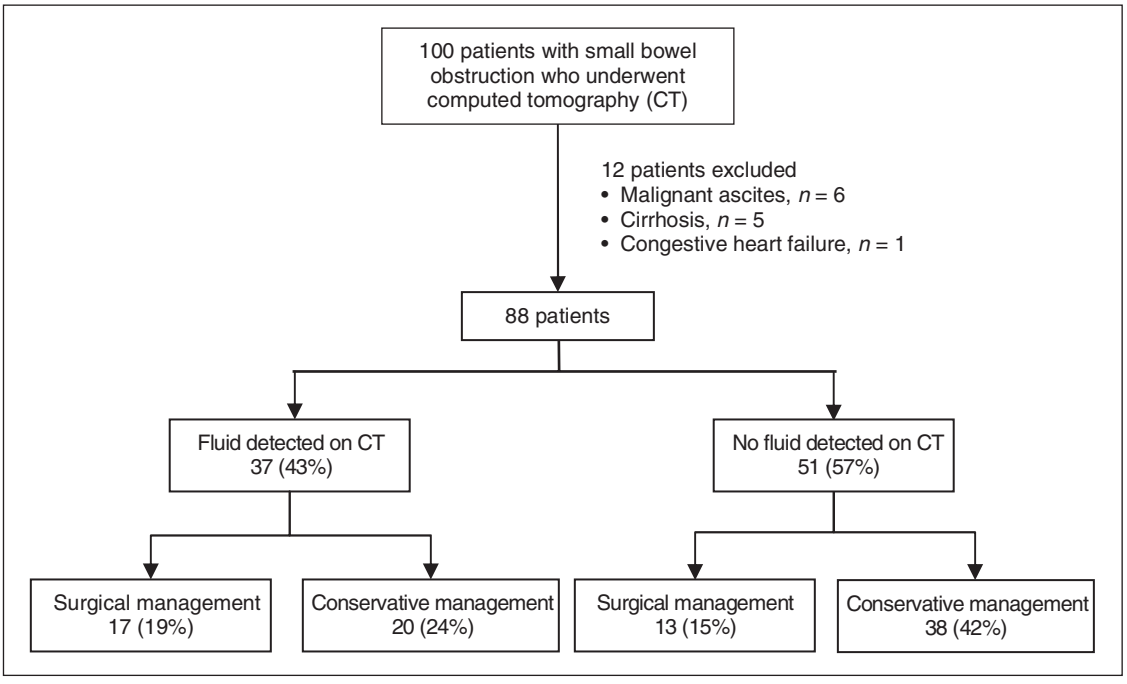

Fig. 1. Distribution of patients with small bowel obstruction whose conditions were managed surgically or conservatively.

differences between the surgical and conservative management groups (Table 1).

The median interval between the clinical diagnosis and CT examination was 1.0 (interquartile range 0–2.0) day in both groups. Patients undergoing surgical intervention tended to have a higher incidence of previous small bowel obstruction than those managed conservatively (n = 9, 30% in the surgical group v. n = 8, 14% in the conservative management group; p = 0.07, χ^2 test). The median duration of prodromal symptoms did not differ significantly between patients with or without peritoneal fluid detected on CT scans (median 3.0 [interquartile range 1.0–4.5] d in the fluid group v. 3.0 [1.0–4.0] d in the no fluid group; p = 0.48, Mann–Whitney U test). In patients undergoing surgical intervention, the presence of peritoneal fluid on a CT scan at diagnosis did not predict early surgical intervention (median 1.0 [interquartile range 0–2.0] d in the fluid group v. 1.0 [1.0–2.0] d in the no fluid group; p = 0.66, Mann–Whitney U test.

In the surgical group, 9 patients underwent bowel resection, and the presence of necrosis was confirmed at pathology in all patients. Interestingly, patients in whom peritoneal fluid was detected on a CT scan did not have a greater incidence of bowel resection at the time of surgery than patients in whom no fluid was detected (n = 5, 27.8% in the fluid group v. n = 4, 33% in the no fluid group; p = 0.75, χ^2 test).

Patients in whom peritoneal fluid was detected on a CT scan at diagnosis recovered physiologic gastrointestinal function at a median of 5.0 (interquartile range 3.0–7.5) days compared with a median of 4.5 (interquartile range 3.0–5.0) days among patients in whom no fluid was detected. This difference was not statistically significant (p = 0.20, Mann–Whitney U test).

Peritoneal fluid detected on a CT scan at diagnosis did not predict the recurrence of small bowel obstruction within 1 year, regardless of how the bowel obstruction was managed (n = 2, 5% in the fluid group v. n = 2, 3.9% in the no fluid group; p = 0.74, χ^2 test).

We entered the variables in the bivariate analysis that had a significance level of $p \leq 0.1$, fluid detected on a CT scan and previous small bowel obstruction into the logistic regression model. Our logistic regression analysis identified only the presence of peritoneal fluid preoperatively on a CT scan (OR 3.0, 95% CI 1.15–7.84) as an independent predictor of surgical intervention (Table 3).

Table 1. Bivariate analysis for prognostic factors in 88 patients with adhesional small bowel obstruction

Characteristic	Conservative management n = 58	Surgical management n = 30	p value
Male sex, no. (%)	20 (35)	9 (30)	0.67†
Age, median (range) yr	68 (48–80)	55 (50–78)	0.50*
Previous abdominal surgery, no. (%)	45 (77)	20 (67)	0.27†
Previous SBO	8 (14)	9 (30)	0.07†
Prodromal symptoms, median (IQR) d	3 (1–4)	3 (1–4)	0.56*
Time to CT, d	1 (0–2)	1 (0–2)	0.77*
Fluid on CT, no. (%)	20 (34)	17 (57)	0.046†
Fluid quantity			
Minimal	13 (23)	8 (27)	0.29†
Moderate	2 (3)	2 (7)	0.29†
Large volume	1 (2)	2 (7)	0.12†
Not specified	4 (7)	5 (17)	
Transition zone	26 (45)	16 (53)	0.45†

CT = computed tomography; IQR = interquartile range; SBO = small bowel obstruction.
*Mann–Whitney U test.
†Pearson χ^2 test.

Discussion

Computed tomography is the standard imaging modality for evaluating patients with small bowel obstruction and permits accurate diagnosis in the emergency setting.[16,17] Surprisingly, no single CT finding has been validated as an independent predictor of surgical intervention. In the absence of clear clinical indications, the decision to operate is based not on science but on surgeons' clinical judgement and preferences regarding timing of surgical intervention.[18,19] Conflicting management practices result from the inability to differentiate patients who will require surgical intervention from patients whose conditions will resolve with conservative management. Conventional clinical criteria, plain radiology or laboratory data are insufficient to determine management.[7] In our study, 34% of

Table 2. Primary outcomes of 88 patients with small bowel obstructions, by subgroup

Outcome	Fluid detected on CT scan, n = 37		No fluid detected on CT scan, n = 51	
	Surgical management n = 17	Conservative management n = 20	Surgical management n = 13	Conservative management n = 38
Duration of prodroma symptoms, median (IQR) d	2.0 (1.0–4.0)	3.0 (1.0–4.8)	3.0 (1.5–4.5)	3.0 (1.0–4.25)
Bowel resection, no. (%)	5 (14)	NA	4 (8)	NA
Time to diet, median (IQR) d	5.0 (4.0–8.0)	4.5 (3.0–7.0)	5.0 (4.0–6.5)	4.0 (2.75–5.0)
Recurrence within 1 year, no. (%)	0 (0)	2 (5)	1 (2)	1 (2)

CT = computed tomography; IQR = interquartile range; NA = not applicable.

patients underwent surgical intervention. This is comparable to rates reported in other studies in which the decision to operate was made on clinical and radiological grounds of nonresolution of the obstruction or the onset of signs of strangulation.[3,20]

Many causes for peritoneal fluid on the CT scans of patients with small bowel obstruction have been identified.[21,22] These include malignant ascites, cirrhosis and congestive cardiac failure. Usually clinical history and examination will identify the patients with congestive cardiac failures and advanced cirrhosis. Multidetector CT will usually identify advanced neoplastic disease, thus reducing the potential for neoplastic disease to be treated in a similar fashion to simple adhesional obstruction.

The finding of peritoneal fluid on a CT scan has not been previously shown to be of prognostic value as an adjunct to management of small bowel obstruction. Our study demonstrates that the presence of peritoneal fluid on a CT scan is an independent predictor of surgical intervention in patients with adhesional small bowel obstruction. Donckier and colleagues[7] have proven a role for CT in predicting the need for early surgery among patients with complicated small bowel obstruction. They reported that signs of strangulation or volvulus on CT scans led to the diagnosis of complicated obstruction with an overall sensitivity of 100% and a specificity superior to 90%. However, diagnosis was based on a combination of multiple CT criteria and clinical signs. Furthermore, CT criteria lacked specificity when signs of severity were discrete or isolated. In particular, CT criteria were not useful in determining whether patients with simple distal obstruction would require surgical intervention. In contrast, we found that the presence or absence of peritoneal fluid on a CT scan can be used in all patients to objectively predict a greater need for surgical intervention. Makita and colleagues[9] have shown that peritoneal fluid may differentiate between intestinal necrosis and non-necrosis in patients with closed loop and strangulating obstruction of the small bowel. However, all 25 patients in their study were managed surgically, in contrast to our study. We did not detect a difference in rates of bowel resection between patients with or without peritoneal fluid detected on a CT scan. Other studies have shown peritoneal fluid to be nondiscriminatory in differentiating uncomplicated small bowel obstructions from those complicated by necrosis or strangulation.[8] Peritoneal fluid detected on a CT scan has also been shown not to be a discriminatory sign of ischemia of bowel wall in patients with small bowel obstruction.[21,23] The efficacy of CT varies widely in the literature; sensitivities of 29%–75% and specificities of 76%–98% have been reported.[21,23,24] There is no discernable consensus from these studies, and the presence or absence of peritoneal fluid has not been associated with the need for surgical intervention.

Table 3. Logistic regression analysis* (backward stepwise: likelihood ratio) of factors predicting the need for surgical intervention for patients with adhesional small bowel obstruction

Variable	B (SE)	OR (95% CI)
Constant	–1.42† (0.38)	0.2 NA
Fluid detected on CT scan	1.10‡ (0.49)	3.0 (1.15–7.84)

B = regression coefficient; CI = confidence interval; CT = computed tomography; NA = not applicable; OR = odds ratio; SE = standard error.
*R^2 = 0.30 (Hosner & Lemeshow), 0.09 (Cox & Snell), 0.13 (Nagelkerke)
Model $\chi^2(2) = 8.5$, $p < 0.05$.
†$p < 0.001$.
‡$p < 0.5$.

In our study, secondary analyses showed that demographic and presentation features did not impact on clinical outcome. The incidence of bowel resection, physiologic gastrointestinal function recovery and recurrence of small bowel obstruction within 1 year did not differ significantly between patients with or without peritoneal fluid detected on a CT scan.

Our study demonstrates that arbitrary measures of the quantity of fluid detected on CT scans are not a significant predictor of the need for surgical intervention. A limitation of our study is that quantity of fluid was only recorded in 76% of CT scans, which made it difficult to draw robust conclusions on this point. Other studies have commented on the quantity of peritoneal fluid to distinguish between low- and high-grade bowel ischemia.[12,25] Radiologists will likely differ in opinion on the amount of fluid present, thus the interpretation of CT findings is subject to intraobserver variability. In our opinion the presence or absence of peritoneal fluid, regardless of the amount, is a simple, objective and intuitive CT criterion that can be universally applied as an adjunct to the management of patients with small bowel obstruction.

As our study was retrospective, it was the surgeons' clinical judgement and preference that determined whether patients received surgery or conservative management; peritoneal fluid detected on a CT scan was not used as an adjunct to decision-making. As a result, 20 patients in whom peritoneal fluid was detected on a CT scan were managed conservatively based on surgeon-specific clinical criteria alone. Knowledge of the value of peritoneal fluid as an independent predictor of surgical intervention should increase surgeon vigilance for cases of adhesional small bowel obstruction that may not resolve with conservative management.

The presence of peritoneal fluid on CT scans of patients with small bowel obstruction should alert the clinicians that these patients are 3 times more likely to require surgical intervention than those in whom no fluid is detected. We advocate the use of presence or absence of peritoneal fluid to support decision-making regarding surgical intervention in patients with small bowel obstruction.

Competing interests: None declared.

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References

1. Miller G, Boman J, Shrier I, et al. Etiology of small bowel obstruction. *Am J Surg* 2000;180:33-6.
2. Gough IR. Strangulating adhesive small bowel obstruction with normal radiographs. *Br J Surg* 1978;65:431-4.
3. Abbas SM, Bissett IP, Parry BR. Meta-analysis of oral water-soluble contrast agent in the management of adhesive small bowel obstruction. *Br J Surg* 2007;94:404-11.
4. Abbas S, Bissett IP, Parry BR. Oral water soluble contrast for the management of adhesive small bowel obstruction. *Cochrane Database Syst Rev* 2007;(3):CD004651.
5. Maglinte DD, Gage SN, Harmon BH, et al. Obstruction of the small intestine: accuracy and role of CT in diagnosis. *Radiology* 1993;188:61-4.
6. Frager D, Medwid SW, Baer JW, et al. CT of small-bowel obstruction: value in establishing the diagnosis and determining the degree and cause. *AJR Am J Roentgenol* 1994;162:37-41.
7. Donckier V, Closset J, Van Gansbeke D, et al. Contribution of computed tomography to decision making in the management of adhesive small bowel obstruction. *Br J Surg* 1998;85:1071-4.
8. Catel L, Lefevre F, Lauren V, et al. [Small bowel obstruction from adhesions: Which CT severity criteria to research?] [article in French]. *J Radiol* 2003;84:27-31.
9. Makita O, Ikushima I, Matsumoto N, et al. CT differentiation between necrotic and nonnecrotic small bowel in closed loop and strangulating obstruction. *Abdom Imaging* 1999;24:120-4.
10. Kobayashi S, Matsuura K, Matsushima K, et al. Effectiveness of diagnostic paracentesis and ascites analysis for suspected strangulation obstruction. *J Gastrointest Surg* 2007;11:240-6.
11. Balthazar EJ, Birnbaum BA, Megibow AJ, et al. Closed-loop and strangulating intestinal obstruction: CT signs. *Radiology* 1992;185:769-75.
12. Ogata M, Imai S, Hosotani R, et al. Abdominal ultrasonography for the diagnosis of strangulation in small bowel obstruction. *Br J Surg* 1994;81:421-4.
13. Grassi R, Romano S, D'Amario F, et al. The relevance of free fluid between intestinal loops detected by sonography in the clinical assessment of small bowel obstruction in adults. *Eur J Radiol* 2004; 50:5-14.
14. Lehr R. Sixteen s squared over d squared: a relation for crude sample size estimates. *Stat Med* 1992;11:1099-102.
15. Campbell MJ, Julious SA, Altman DG. Estimating sample sizes for binary, ordered catagorical, and continuous outcomes in two group comparisons. *BMJ* 1995;311:1145-8.
16. Suri S, Gupta S, Sudhakar PJ, et al. Comparative evaluation of plain films, ultrasound and CT in the diagnosis of intestinal obstruction. *Acta Radiol* 1999;40:422-8.
17. Daneshmand S, Hedley CG, Stain SC. The utility and reliability of computed tomography scan in the diagnosis of small bowel obstruction. *Am Surg* 1999;65:922-6.
18. Suter M, Zermatten P, Halkic N, et al. Laparoscopic management of mechanical small bowel obstruction: Are there predictors of success or failure? *Surg Endosc* 2000;14:478-83.
19. Chosidow D, Johanet H, Montariol T, et al. Laparoscopy for acute small-bowel obstruction secondary to adhesions. *J Laparoendosc Adv Surg Tech A* 2000;10:155-9.
20. Miller G, Boman J, Shrier I, et al. Natural history of patients with adhesive small bowel obstruction. *Br J Surg* 2000;87:1240-7.
21. Ha HK, Kim JS, Lee MS, et al. Differentiation of simple and strangulated small-bowel obstructions: usefulness of known CT criteria. *Radiology* 1997;204:507-12.
22. Ha HK, Shin BS, Lee SI, et al. Usefulness of CT in patients with intestinal obstruction who have undergone abdominal surgery for malignancy. *AJR Am J Roentgenol* 1998;171:1587-93.
23. Kim JH, Ha HK, Kim JK, et al. Usefulness of known computed tomography and clinical criteria for diagnosing strangulation in small-bowel obstruction: analysis of true and false interpretation groups in computed tomography. *World J Surg* 2004;28:63-8.
24. Zalcman M, Sy M, Donckier V, et al. Helical CT signs in the diagnosis of intestinal ischemia in small-bowel obstruction. *AJR Am J Roentgenol* 2000;175:1601-7.
25. Delabrousse E, Destrumelle N, Brunelle S, et al. CT of small bowel obstruction in adults. *Abdom Imaging* 2003;28:257-66.