

Small Bowel Obstruction: Conservative vs. Surgical Management

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PURPOSE: The aim of this study was to assess incidence, risk factors, and recurrence rates for conservative and surgical management of small bowel obstruction. **METHODS:** Retrospective chart review was conducted of 329 patients accounting for 487 admissions with small bowel obstruction. Data were obtained from the institutional database and patient charts. Patients with early recurrent small bowel obstruction had prior operations or hospitalization with conservative therapy for small bowel obstruction, then had a hospital stay >10 days following abdominal surgery because of obstruction or required readmission for small bowel obstruction within 30 days. Patients treated for prior small bowel obstruction and then readmitted after 30 days for a recurrent small bowel obstruction were classified as having late recurrent small bowel obstruction. **RESULTS:** A total of 329 patients with a diagnosis of small bowel obstruction were identified. At index admission, 43 percent (142) were successfully treated conservatively, whereas 57 percent (187) failed conservative treatment and underwent surgery. Overall, there were eight early deaths, four in each group (2.8 percent conservative vs. 2.1 percent surgical; no significant difference). The frequency of recurrence for those treated nonoperatively was 40.5 percent compared with 26.8 percent for patients treated operatively ($P < 0.009$). Patients treated without operation had a significantly shorter time to recurrence (mean, 153 vs. 411 days; $P < 0.004$) and had fewer hospital days for their index small bowel obstruction (4.9 vs. 12.0 days; $P < 0.0001$). Two hundred one (63 percent) patients had abdominal sur-

gery and 119 (37 percent) patients had no prior abdominal surgery before developing a small bowel obstruction. Previous abdominal operations by procedure type were colorectal surgery (34 percent), gynecologic surgery (28 percent), exploratory laparotomy (20 percent), appendectomy (14 percent), cholecystectomy (12 percent), herniorrhaphy (8 percent), and gastric bypass (5 percent). The mean time interval between initial procedure and index small bowel obstruction was 1.3 years for gastric bypass, 6.1 years for herniorrhaphy, 7.8 years for exploratory laparotomy, 8 years for cholecystectomy, 8.4 years for colorectal surgery, 11.8 years for gynecologic surgery, and 22.5 years for appendectomy. There was no significant difference between early and late recurrent small bowel obstruction in patients treated nonoperatively or operatively, regardless of prior history of abdominal surgery. Logistic regression analysis failed to identify any specific risk factors that were predictors of the success of conservative or surgical management. **CONCLUSIONS:** Operatively treated patients had a lower frequency of recurrence and a longer time interval to recurrence; however, they also had a longer hospital stay than that of patients treated nonoperatively. There was no significant difference in treatment type or in incidence or type of prior surgery among patients with early and late small bowel obstruction. None of the variables analyzed in this study were significant predictors of the success of a particular treatment. [Key words: Small bowel obstruction; Intestinal obstruction; Adhesions]

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Small bowel obstruction (SBO) is a major cause of morbidity and financial expenditure worldwide. The high incidence and recurrent nature of the problem place a significant burden on our health care system. Adhesions have been well documented as the leading cause of SBO in the Western world.¹⁻¹⁰ One study analyzing factors predisposing to adhesive SBO found that long-term prognosis and recurrence rates were affected by prior procedure type, time interval to recurrence, and adhesion formation.¹ Several products, including anti-adhesive membranes (Seprafilm)

and spray gels (SprayGel), have been developed to reduce the extent of postoperative adhesions and, theoretically, subsequent SBOs.¹¹⁻¹³ There are few studies, however, addressing the outcome after conservative *vs.* surgically managed SBO patients. Miller *et al.* provided some insight by looking at predisposing etiologies for SBO. They again determined that prior adhesions were the most common, followed by Crohn's disease and neoplasia.¹⁴ Our goal was to evaluate the long-term outcome of patients after operative and nonoperative treatment of SBO and to identify risk factors predisposing to recurrence.

PATIENTS AND METHODS

All patients admitted to the George Washington University Hospital between April 1990 and October 2002 with the diagnosis of small bowel obstruction and/or postoperative adhesions with intestinal obstruction were candidates for inclusion in this study. A database query was performed at the George Washington University Medical Center to identify patients who may have had SBO. Preliminary review identified 426 patients with SBO; those with postoperative ileus or other possible diagnoses were excluded. Only complete medical records were used in the study to ensure that all necessary information was available and accurate. Complete medical records were defined as containing information from index SBO to either recurrent SBO or last documented follow-up visit. We identified 329 patients with a total of 487 admissions for SBO that formed the cohort of the study. There were eight postoperative deaths, and these patients were excluded from the study because our goal was to evaluate long-term outcome. This project was approved by the Institutional Review Board at the George Washington University Medical Center.

The diagnosis of SBO was based on medical history, physical examination, and abdominal radiographic findings and, when possible, was confirmed intraoperatively. The index SBO was defined as the first experienced and documented SBO. Subsequent SBOs were considered recurrences. Demographic data were collected for age, race, and gender. Data obtained from the index SBO included date first seen, date last seen, follow-up, and related symptoms such as nausea, vomiting, abdominal pain, distention, and bowel sounds. Information on method of treatment, resolving treatment, length of hospital stay, and, if

surgically treated, laparotomy was defined by specific procedure type. Past surgical history was documented by number of prior operations, type, and time interval between last operation to index SBO. The number of recurrences, treatment, and time interval to recurrence were documented. Follow-up was based on representation of patients at the George Washington University Medical Center for any medical condition and ascertainment of the presence or absence of a subsequent SBO. Patients who did not return were not documented as a recurrence. Conservatively *vs.* surgically managed patients were then evaluated in terms of risk factors such as HIV status, hysterectomy, Crohn's disease, ulcerative colitis, and colon cancer, including location, diverticular disease, colonic surgery based on procedure type, and radiation. Early recurrent SBO was defined as SBO in patients with prior operations or hospitalization with conservative therapy for SBO, the patients then having a hospital stay >10 days following abdominal surgery because of obstruction or required readmission for SBO within 30 days. Patients treated for prior SBO and then readmitted after 30 days for a recurrent SBO were classified as having late recurrent SBO. Early and late recurrent SBO patients were also compared in terms of method of treatment and whether they had a history of prior abdominal surgery. Patients with shorter lengths of hospital stay (<10 days) and no readmission for SBO were not evaluated on the basis of early *vs.* late SBO.

The data were entered into a computerized database and analyzed with SAS software (SAS Institute, Inc., Cary, NC). Differences in continuous variables between nonoperative and operative patients were compared by means of the Student's *t*-test. A chi-squared test was used for assessing differences in proportions between these groups of patients. Survival curves for the two groups were modeled after the Kaplan-Meier method. Those patients who had no recurrence noted on their charts at the time of review were censored at that time point. Differences in survival across the groups were assessed with the generalized form of the Wilcoxon rank-sum test. The time in days to recurrence for nonoperative and operative patients was evaluated through survival analysis. All factors were considered simultaneously. No model selection algorithm was used. Variables entered into the model were chosen *a priori* by the investigators as being of possible importance as risk factors and/or confounders on the basis of previous research and literature review. The outcomes of conservatively *vs.*

Table 1.
Demographics of Patients with Small Bowel Obstruction
by Treatment Group (N = 321)

Factor	Conservative Treatment Group	Surgical Group	P Value
Patients (N)	138	183	
Male:female (%)	37:63	35:65	NSD
Mean age (years)	54.7	55.8	NSD
African-American	48%	41%	NSD
Caucasian	42%	49%	NSD
Hispanic	3%	3%	NSD
Asian	2%	1%	NSD
Other	6%	6%	NSD

NSD = no significant difference.

surgically managed patients were then tested against the above risk factors by means of logistic regression analysis.

RESULTS

A total of 329 patients with a diagnosis of SBO and/or postoperative adhesions with obstruction were identified. Of these patients, 142 (43 percent) were managed conservatively and 187 (57 percent) were managed surgically after failed conservative treatment. Additionally, there were patients who went immediately to the operating room without a trial of conservative management and were evaluated as surgically managed patients. Conservatively managed patients were hospitalized for a mean of 4.9 days and surgically treated patients were hospitalized for a mean of 4.5 days before surgery. This was the average duration of conservative treatment before taking patients to the operating room. Conservative treatment consisted of intravenous fluids, nasogastric intubation, and bowel rest in most patients. Eight perioperative deaths were excluded from the study, four in each group, yielding mortality rates of 2.8 percent and 2.1 percent for the conservatively and surgically treated patients, respectively. The final groups analyzed included 138 conservatively managed patients and 183 surgically managed patients. There were no significant differences in age, gender, and race between groups (Table 1).

Ninety-eight percent of the 183 patients managed surgically underwent laparotomy. In 120 patients (67 percent) treatment with laparotomy and lysis of adhesions (LOA) was all that was necessary. Another 22 (12 percent) also required small bowel resection. The rest of operatively managed patients underwent either

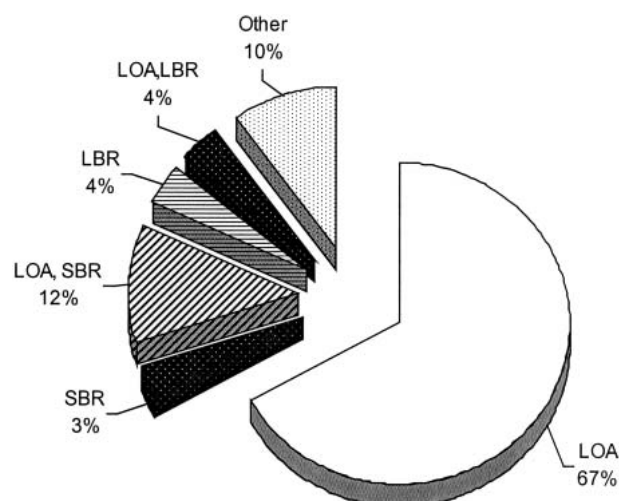


Figure 1. Surgical procedures performed for patient with small bowel obstruction (N = 183). LBR = large bowel resection; LOA = lysis of adhesions; SBR = small bowel resection.

a combination of laparotomy and large bowel resection (4 percent), small bowel resection (3 percent), or laparotomy and LOA with large bowel resection (4 percent). The categories of large bowel resection (4 percent) included hemicolectomy and ileocectomy, with or without ileostomy. Eight patients (10 percent) underwent exploratory laparotomy without any other additional procedures (Fig. 1).

The incidence of recurrent SBO was significantly higher in the conservatively managed group of patients—40.5 percent *vs.* 26.8 percent ($P < 0.009$) (Table 2). Survival analysis demonstrated that the patients managed nonoperatively had a significantly shorter time to recurrence—153 *vs.* 411 days ($P < 0.004$). As expected, the nonoperative patients had a shorter hospital stay than that of the operatively managed patients (4.9 *vs.* 12.0 days; $P < 0.0001$). Caution must be exercised when considering the length of hospital stay because most patients who underwent surgery had an initial trial of conservative treatment. As a consequence, operatively managed patients would be expected to have an extended hospital stay compared with that of the nonoperative patients.

Two hundred and one (63 percent) patients had had prior abdominal surgery before developing an SBO. The etiology of SBO in those 119 (37 percent) patients without prior surgery included HIV-positive status, Crohn's disease, ulcerative colitis, colon cancer, other cancer, diverticular disease, Meckel's diverticulum, Ogilvie's syndrome, hernia (abdominal wall, incisional, inguinal, internal), congenital adhesions,

Table 2.
Outcome of Patients With Small Bowel Obstruction by Treatment Group (N = 321)

	Conservative Treatment Group	Surgical Group	P Value
Patients (N)	138	183	
SBO recurrence rate	56 (40.5%)	49 (26.8%)	<0.009
Mean time to recurrence (days)	153	411	<0.04
Mean hospital stay (days)	4.9	12	<0.0001

SBO = small bowel obstruction.

volvulus, stricture, endometriosis, chemotherapy, and radiation. These etiologies represent the diagnoses and possible but not absolute contributing factors to developing obstruction, such as adhesions secondary to disease processes causing SBO.

Of those patients with a previous abdominal operation before developing an SBO, 81 (40 percent) were managed conservatively and 120 (60 percent) surgically. The previous abdominal operations by type were colorectal surgery (34 percent), gynecologic surgery (28 percent), exploratory laparotomy (20 percent), appendectomy (14 percent), cholecystectomy (12 percent), herniorrhaphy (8 percent), and gastric bypass (5 percent).

Colorectal surgery was the most common procedure preceding development of an SBO, comprising 26 percent (36) of the conservatively managed SBO patients and 38 percent (69) of the surgically managed SBO patients. In the conservatively managed SBO patients, the antecedent procedure was partial colectomy in 17 percent and total colectomy in 9 percent. In surgically managed patients 13 percent of the colorectal procedures were total colectomies. Interestingly, the time interval between colorectal surgery to index SBO was 9.6 years in the nonoperative patients *vs.* 7.8 years for those managed operatively.

The mean time intervals between initial operative procedures and index SBO were 22.5 years for appendectomy, 11.8 years for gynecologic surgery, 8.4 years for colorectal surgery, 8 years for cholecystectomy, 7.8 years for exploratory laparotomy, 6.1 years for herniorrhaphy, and 1.3 years for gastric bypass. Although patients with a prior history of gastric bypass surgery had the shortest time interval to index SBO, they accounted for only 5 percent (17) of the 321 patients enrolled in the study.

Among those patients with recurrent SBO following their index SBO, there was no significant difference between early and late recurrent SBO in patients treated nonoperatively or operatively, regardless of a prior history of abdominal surgery. Of the 81 patients with previous abdominal surgery who were managed

conservatively, 10 (12 percent) had early recurrent SBO and 8 (10 percent) had late recurrent SBO. One hundred twenty patients were identified as having prior abdominal surgery and operatively managed SBO. Of these patients, 32 (37 percent) had early recurrent SBO and 6 (5 percent) had late recurrent SBO following operation for an SBO. Of patients without a prior abdominal operation and who were conservatively treated (*n* = 57), 8 (14 percent) developed an early recurrent SBO and 5 (9 percent) a late recurrent SBO. Of the 62 patients without prior abdominal surgery and surgically managed SBO, 20 (32 percent) had early recurrent SBO and 2 (3 percent) had late recurrent SBO.

A variety of risk factors were analyzed and compared for both the nonoperative and operative patients. These included underlying disease type (colon cancer, other intestinal cancers, Crohn's disease, ulcerative colitis, diverticular disease, acute diverticulitis), prior surgeries such as hysterectomy, HIV status, and prior radiation treatment (Table 3). Logistic regression analysis failed to identify any specific risk factors that were predictors of success of conservative or surgical management.

DISCUSSION

Small bowel obstruction is one of the most common long-term complications of virtually all abdominal surgeries. Adhesions remain the leading cause of SBO.¹⁴ Postoperative adhesions have been documented to occur in 68 percent to 100 percent of patients undergoing one or more laparotomies.^{15–17} All surgeons operating in the abdomen expect to find adhesions during secondary laparotomies. Aside from prior laparotomy findings of extensive adhesions and, perhaps, a history of peritonitis, it is very difficult to predict which patients will have extensive adhesions or “friendly” ones or even none at all. Interestingly, our study demonstrated additional large bowel resections for SBO from extensive adhesions encountered

Table 3.
Risk Factors for Patients With Small Bowel Obstruction (N = 321)

Risk Factor	Conservative Group n (%)	Surgical Group n (%)	P value
Patients (N)	138	183	
Colon cancer	15 (11)	31 (17)	NSD
Other intestinal cancer	27 (20)	26 (14)	NSD
Crohn's disease	11 (8)	12 (7)	NSD
Ulcerative colitis	3 (2)	12 (7)	NSD
Diverticular disease	13 (9)	10 (6)	NSD
Diverticulitis	11 (8)	8 (4)	NSD
HIV positive	5 (4)	0 (0)	NSD
H/o hysterectomy	28 (20)	39 (21)	NSD
Radiation	8 (6)	10 (6)	NSD

H/o = history of; NSD = no significant difference.

during operation that resulted not only in SBO but sometimes extensive large bowel compromise without evident large bowel obstruction. However, we encountered other secondary disease pathology (*i.e.*, diverticulitis, ulcerative colitis) that was also contributory to these associated large bowel resections in the presence of SBO.

Various authors have debated the proper course of treatment for SBO. The focus has been on the natural history and length of treatment at the time of obstruction. Seror *et al.* reported a 73 percent success rate with conservative management of SBO, one of the highest in the literature.¹⁸ However, other studies range widely, from 20 percent to 62 percent resolution, without surgery.¹⁸ Our successful conservative therapy rate of 43 percent compares well with these reports.

In the past, the dictum "The sun should never rise or set on a small bowel obstruction" was the gold standard among surgeons.¹ That approach has changed considerably, however, over the last 10 to 20 years. Current practice is to assess the completeness of the obstruction and try to identify patients with impending bowel compromise for early intervention. Although computed tomography scanning appears to be playing an increasingly larger role, most clinicians still rely on examination and plain abdominal films. As always, it is a fine balance between waiting for the obstruction to resolve with conservative therapy and rushing the patient off to the operating room. Any patient with clear evidence of bowel compromise, hernia incarceration, peritonitis, or sepsis must be operated on expeditiously. Unfortunately, the situation is not always so clear.

A major concern of surgeons is that patients who are operated on will tend to develop more adhesions and consequently more SBOs than those that are

managed conservatively. This study addresses this concern directly. One of the more interesting findings is that there was a significantly higher recurrence rate and shorter time to recurrence for the conservatively managed patients whereas patients undergoing surgery enjoyed a lower recurrence rate and a longer interval to recurrence (40.5 percent *vs.* 26.8 percent and 153 *vs.* 411 days, respectively). An inherent weakness in the present study was the lack of solidly documented follow-up. Therefore, these results have to be evaluated accordingly. Our results are nonetheless similar to those of Barkan *et al.*, who found five-year recurrence rates for conservatively managed patients to be 40 percent, in contrast to 20 percent for those managed surgically.¹⁹ However, Miller *et al.* arrived at different conclusions when they found similar recurrence rates in both groups with adhesive SBO (32 percent *vs.* 34 percent).¹ A significant limitation of these studies is that they did not take into account the differences in follow-up times and time to recurrence for each group of patients. Use of methods measuring time to event can lead to more valid assessments of recurrence when not all patients have recurred, as in the present study. Interestingly, both Miller *et al.* and Barkan *et al.* reported similar times to recurrence.^{1,19}

Our patients treated with operation experienced an extended hospital stay with a median of 4.9 days for successful conservative treatment *vs.* 12 days for those patients who failed nonoperative treatment and underwent surgery. Miller *et al.* reported virtually the same numbers, whereas Landercasper *et al.* found an even greater difference in hospital stay (8 *vs.* 20 days).²⁰ This is not surprising because many of the patients undergoing surgery had an initial median of 4.9 days of attempted conservative treatment.

Prior surgery is the most significant risk factor for the development of SBO, primarily because of adhe-

sion development. This factor was examined in this study by comparing SBO patients with and without past abdominal surgery. Aside from postoperative adhesions, nonoperative causes of SBO include Crohn's disease, ulcerative colitis, colon cancer, other cancer, diverticular disease, Meckel's diverticulum, hernia (abdominal wall, incisional, inguinal, internal), congenital adhesions, volvulus, stricture, endometriosis, chemotherapy, and radiation. Aside from adhesions, Miller *et al.* found Crohn's disease (7 percent) to be the most common etiology of SBO, followed by miscellaneous (7 percent), which ranged from volvulus to Meckel's diverticulum, then neoplasm (5 percent), hernia (2 percent), and radiation injury (1 percent).¹⁴ In the present study, none of these nonoperative factors were indicators of the success of a particular treatment but did provide insight into the nonoperative causes of SBO.

Of those patients who had abdominal surgery, colorectal surgery was the most common prior procedure (34 percent), followed by gynecologic surgery (28 percent). Our report was more substantial than prior studies but similar to Miller *et al.*, who reported a history of prior colorectal surgery of 24 percent and of gynecologic surgery of 22 percent.^{1,4,17,21-23} We documented a wide variety of procedures, including exploratory laparotomy (20 percent), appendectomy (14 percent), cholecystectomy (12 percent), herniorrhaphy (8 percent), and gastric bypass surgery (5 percent). These findings alone do not implicate one procedure more than another because we did not look at the frequency of SBO in all patients undergoing a specific procedure. Yet it appears that more common procedures will be associated more frequently with SBO and more extensive procedures with greater bowel manipulation and denuded surface area within the peritoneal cavity are likely to result in more adhesions. It is well known that patients with inflammatory bowel disease have a higher rate of SBO than patients with cancer as their indication for surgery. It is probable that intrinsic patient factors such as the inflammatory and immunologic milieu play a significant role.

The time intervals between procedure type and index SBO ranged from gastric bypass at 1.3 years to appendectomy at 22.5 years. Interestingly, the time interval to postoperative SBO resulting from gastric bypass was quite similar to that in another study, which reported an average time interval to presentation of 104 (range, 4-305) days.²⁴ For colorectal procedures, the interval to obstruction for patients requir-

ing surgical correction was shorter than that for those successfully treated conservatively. A possible reason for this could be that the surgically treated patients had a greater percentage of total colectomies (13 percent *vs.* 9 percent), resulting in more raw retroperitoneal surfaces and greater consequent adhesion formation.

The significance of the management of early *vs.* late SBO patients has been explored in the literature but has not been clearly defined. One prospective cohort study concluded that early postoperative SBO patients who did not respond to conservative treatment within six days should be reexplored.²⁵ In contrast, a retrospective study of early postoperative SBO patients suggested that nonoperative management may be continued for up to two weeks unless signs of ischemia are present.²⁶ MacLean *et al.* found that after ileal pouch-anal anastomosis procedures, surgical intervention was more commonly required for late rather than early SBO.²⁶ The differences in these reports continue to confound the issue. In our analysis of the management of early and late SBO patients, we found no significant differences and so we cannot shed any further light on this problem.

We found that some of the surgically managed patients underwent an operation for SBO that was not caused by adhesions alone but secondarily by other disease processes such as tumor and perforated diverticulitis. Taking this into account, many of the conservatively managed patients with some of these same etiologies would be expected to suffer the same process over again whereas some of the surgically treated patients had their etiologic factor eliminated at the time of operation. These observations must be considered when evaluating recurrence rates for surgically or conservatively managed patients.

We attempted to evaluate a series of risk factors to see if any could predict which patients would respond to conservative therapy and which should go to surgery promptly. Prior abdominal hysterectomy was the most common risk factor identified in both groups. These patients were distinguished from those having vaginal hysterectomy, which accounted for very few patients. Noncolorectal forms of intestinal cancer outnumbered colon cancer in the conservatively managed patients whereas the opposite was true for the surgically treated patients. However, according to logistic regression analysis, we were not able to identify any risk factors that predicted the success of a particular treatment.

CONCLUSION

Surgically treated patients had a lower frequency of recurrence and a longer time interval to recurrence; however, they also had a longer hospital stay compared with those patients treated nonoperatively. Adhesions remain the leading cause of SBO. We were unable to accurately identify clear criteria for the success of nonoperative *vs.* operative treatment of SBO. None of the variables analyzed in this study were significant predictors of success of a particular treatment. We found no significant difference in treatment type or incidence or type of prior surgery between early and late recurrent SBO patients. The management of SBO and timing of surgical intervention continue to be governed by clinical decisions honed by training and experience. Further study of methods for control and treatment of SBO is important because of its frequency, morbidity, and cost in health care dollars and patient disability.

REFERENCES

1. Miller G, Boman J, Shrier I, Gordon PH. Natural history of patients with adhesive small bowel obstruction. *Br J Surg* 2000;87:1240–7.
2. Tanphiphat C, Chittmitrarp S, Prasopsunti K. Adhesive small bowel obstruction. A review of 321 cases in a Thai hospital. *Am J Surg* 1987;154:283–7.
3. McEntee G, Pender D, Mulvin D, *et al.* Current spectrum of intestinal obstruction. *Br J Surg* 1987;74:976–80.
4. Mucha P. Small bowel obstruction. *Surg Clin North Am* 1987;67:597–620.
5. Asbun HJ, Pempinello C, Halasz NA. Small bowel obstruction and its management. *Int Surg* 1989;74:23–7.
6. Bender JS, Busuito MJ, Graham C, Allaben RD. Small bowel obstruction in the elderly. *Am Surg* 1989;55:385–8.
7. Canady J, Jamil Z, Wilson J, Bernard LJ. Intestinal obstruction: still a lethal clinical entity. *J Natl Med Assoc* 1987;79:1281–4.
8. Holder WD. Intestinal obstruction. *Gastroenterol Clin North Am* 1988;17:317–40.
9. Richards WO, Williams LF. Obstruction of the large and small intestine. *Surg Clin North Am* 1988;68:355–76.
10. Zadeh BJ, Davis JM, Canizaro PC. Small bowel obstruction in the elderly. *Am Surg* 1985;51:470–3.
11. Vrijland W, Tseng LN, Eijkman HJ, *et al.* Fewer intra-peritoneal adhesions with use of hyaluronic acid-carboxymethylcellulose membrane. *Ann Surg* 2000;235:193–7.
12. Ferland R, Mulani D, Campbell PK. Evaluation of a sprayable polyethylene glycol adhesion barrier in a porcine efficacy model. *Hum Reprod* 2001;16:2718–23.
13. Becker JM, Dayton MT, Fazio VW, *et al.* Prevention of postoperative adhesions by a sodium hyaluronate-based bioresorbable membrane: a prospective, randomized, double-blind multicenter study. *J Am Coll Surg* 1996;183:297–306.
14. Miller G, Boman J, Shrier I, Gordon PH. Etiology of small bowel obstruction. *Am J Surg* 2000;180:33–6.
15. Ellis H. The clinical significance of adhesions: focus on intestinal obstruction. *Eur J Surg* 1997;557:5–9.
16. Luijendijk RW, de Lange DC, Wauters CC, *et al.* Foreign material in postoperative adhesions. *Ann Surg* 1996;223:242–8.
17. Menzies D, Ellis H. Intestinal obstruction from adhesions: how big is the problem? *Ann R Coll Surg Engl* 1990;72:60–3.
18. Seror D, Feigin E, Szold A, *et al.* Scientific papers: how conservatively can postoperative small bowel obstruction be treated? *Am J Surg* 1993;165:121–6.
19. Barkan H, Webster S, Ozeran S. Factors predicting the recurrence of adhesive small bowel obstruction. *Am J Surg* 1995;170:361–5.
20. Landercasper J, Cogbill TH, Merry WH, Stolee RT, Strutt PJ. Long term outcome after hospitalization for small bowel obstruction. *Arch Surg* 1993;128:765–71.
21. Cox MR, Gunn IF, Eastman MC, Hunt RF, Heinz AW. The operative etiology and types of adhesions causing small bowel obstruction. *ANZ J Surg* 1993;63:848–52.
22. Matter I, Khalemsky L, Abrahson J, Nash E, Sabo E, Eldar S. Does the index operation influence the course and outcome of adhesive intestinal obstruction? *Eur J Surg* 1997;163:767–72.
23. Montz FJ, Holschneider CH, Solh S, Schuricht LC, Monk BJ. Small bowel obstruction following radical hysterectomy: risk factors, incidence, and operative findings. *Gynecol Oncol* 1994;53:114–20.
24. Filip JE, Mattar SG, Bowers SP, Smith CD. Internal hernia formation after laparoscopic Roux-en-Y gastric bypass for morbid obesity. *Am Surg* 2002;68:640–3.
25. Ellozy S, Harris M, Bauer J, Gorfine S, Kree I. Early postoperative small bowel obstruction: a prospective evaluation in 242 consecutive abdominal operations. *Dis Colon Rectum* 2002;45:1214–7.
26. MacLean AR, Cohen A, MacRae HM, *et al.* Risk of small bowel obstruction after the ileal pouch-anal anastomosis. *Ann Surg* 2002;235:200–6.