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SURGICAL ENDOSCOPY
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Laparoscopic vs. open surgery for acute adhesive small-bowel obstruction: patients' outcome and cost-effectiveness

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Abstract
Background: Numerous studies have demonstrated the feasibility of laparoscopy in the management of acute adhesive small-bowel obstruction (AASBO). However, comparative data with laparotomy are lacking. The aim of this study was to compare laparoscopy and laparotomy for the treatment of AASBO in terms of patient outcome and cost-effectiveness.
Methods: A retrospective chart review of all patients who underwent surgery for AASBO from 1999 to 2005 was conducted. Data recorded included operative and postoperative course, among others. Operative and total hospital charges were estimated from the Patient Accounting System.
Results: Thirty-one patients who underwent laparoscopy were matched to a similar group of patients who underwent laparotomy. In the laparoscopy group, four patients (13%) had a laparoscopy-assisted procedure and ten patients (32%) were converted. The laparoscopy group was subdivided into laparoscopy, laparoscopy-assisted, converted, and assisted-converted subgroups. In the majority of the patients, AASBO was secondary to a single band. Overall morbidity was significantly higher in the laparotomy group ($p = 0.007$). Morbidity rates were statistically significant between the laparoscopy and assisted-converted subgroups ($p = 0.0001$) but not between the laparotomy group and assisted-converted subgroup ($p = 0.19$). Median hospital stay and median time to first bowel movement were significantly shorter in the laparoscopy group. Charge data were available for only the last three years of the study. Operative charges and total hospital charges were similar between the laparoscopy and the laparotomy groups ($p = 0.14$ and $p = 0.10$, respectively). There was a significant difference in total hospital charges between the laparoscopy subgroup and laparotomy group ($p = 0.03$).
Conclusions: Laparoscopy for AASBO is associated with reduced hospital stay, early recovery, and decreased morbidity. Laparoscopy-assisted and converted surgeries do not differ significantly from laparotomy in regard to patient outcome. Operative and total hospital charges are similar for both laparoscopy and laparotomy.

Key words: Laparoscopy — Adhesions — Small bowel — Obstruction — Cost-effectiveness

Postoperative adhesions account for 74% of surgical admissions for acute small-bowel obstruction (SBO) [9]. Patients with SBO secondary to adhesions are usually conservatively treated; however, up to 57% require surgery [16]. Conventional laparotomy was traditionally considered the standard of care for these patients, requiring a major operation that may be associated with substantial morbidity and occasional mortality.

Since the 1990s, laparoscopic surgery has rapidly expanded with clear advantages of low morbidity, shorter hospital stay, and faster return to full activity. For many years, acute adhesive small-bowel obstruction (AASBO) after previous surgery has been regarded as a contraindication to laparoscopy. However, some studies have reported the feasibility and safety of laparoscopy in the management of adhesive SBO and showed that laparoscopy for bowel surgery reduces the incidence of incisional hernia and SBO rates compared with those of laparotomy and, therefore, the need for readmission and additional surgery [2, 3, 11, 14]. Total expenditures and

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length of stay associated with bowel obstruction caused by postoperative adhesions are substantial [6].

A shift of surgical practice from laparotomy to laparoscopic surgery with shorter hospital stay, lower morbidity, and recurrent SBO rates has changed total hospitalization expenditures. However, comparative studies on the effectiveness and cost of laparoscopy versus laparotomy for AASBO are lacking. Therefore, this study aimed to compare laparoscopy to laparotomy in the management of AASBO to assess potential advantages, patient outcome, and hospital charges.

Patients and methods

After Institutional Review Board approval, a retrospective chart review of all patients who had undergone laparoscopy or laparotomy for AASBO from January 1999 to January 2005 was performed. Data regarding age, gender, American Society of Anesthesiologists (ASA) risk score, body mass index (BMI), comorbidities, previous surgical history and the number of SBO episodes, duration of symptoms, operative time, surgical and operative details, reasons for conversion, complications, postoperative bowel movements, and length of stay were reviewed. Operative and total hospital charges were estimated from the Patient Accounting System (Invision Power Services, Forest, VA). Data from the laparoscopy group were analyzed and compared with those from the laparotomy group. Charge data were available only for the last 3 years of the study.

All patients were diagnosed with SBO before surgery based on clinical symptoms and radiologic studies (X-ray and CT scan). Perioperative broad-spectrum parenteral antibiotics and subcutaneous heparin with external sequential pneumatic compression stockings were routinely used. The surgical approach was selected depending on the patient's condition and the surgeon's preference. The open Hasson technique was used for the first port insertion in the lateral abdomen away from any previous incisions.

Patients who underwent laparoscopy were divided into subgroups of laparoscopy, laparoscopy-assisted (when an incision of 5 cm or less was necessary to resect necrotic bowel), converted (any incision longer than 5 cm to facilitate a resection or any incision at all in patients in whom a resection was not required), and laparoscopy-assisted combined with converted. Both groups and all subgroups were evaluated and compared with respect to the number of previous operations and episodes of SBO and duration of symptoms before admission. All data were evaluated on an intention-to-treat analysis as a laparoscopic procedure.

Statistical analysis was performed using Student's t test, chi-squared test, and Fisher's exact test to evaluate variables and compare them among the groups. A p value of less than 0.05 was considered significant.

Results

There were a total of 62 patients in this study: 31 in the laparoscopy group included 13 males and 18 females of a mean age 54.6 (range = 33–82) years, and 31 in the laparotomy group included 9 males and 22 females of a mean age 63 (range = 22–88) years. Clinical characteristics of the groups and subgroups are shown in Tables 1 and 2.

Laparoscopy was successfully completed in 17 of 31 patients (55%), whereas in 4 patients (13%) an assisted procedure was performed to facilitate segmental resection, and in 10 patients (32%) the operation was converted to a laparotomy. Conversion was required for necrotic bowel in four patients, extensive dense adhesions in five patients, and the inability to verify small-bowel viability in one patient. Neither the number of previous operations and episodes of SBO nor the duration of symptoms before admission was associated with the need for conversion.

Eight patients in the laparoscopy group (4 in the laparoscopy-assisted and 4 in the converted) and ten patients in the laparotomy group had segmental small-bowel resection for necrotic bowel ($p = 0.58$). In most patients the obstruction was caused by a single band (58% and 61% in the laparoscopy and open groups, respectively), which was found more frequently after appendectomy, after gynecologic surgery, and after multiple previous operations than after single surgery (Table 3).

Table 1. Clinical data: laparoscopy vs. laparotomy

Group	Laparoscopy ($n = 31$)	Laparotomy ($n = 31$)
BMI (kg/m^2)	23	24
ASA score (1–5)	2	2
Duration of symptoms (days)	2.3	2.3
Previous surgery (n)	1.1	1.7
Previous episodes of SBO (n)	1.3	0.6

BMI = body mass index; ASA score = American Society of Anesthesiologists risk score; SBO = small-bowel obstruction

Table 2. Clinical data: laparoscopy subgroups

	Laparoscopy ($n = 31$)	Laparoscopy-assisted ($n = 4$)	Converted ($n = 10$)
BMI (kg/m^2)	23	22	24
ASA score (1–5)	2	2.5	2
Duration of symptoms (days)	2.7	2.5	1.8
Previous surgery (n)	1.2	1.0	1.2
Previous episodes of SBO (n)	1.6	1.2	1.0

BMI = body mass index; ASA score = American Society of Anesthesiologists risk score; SBO = small-bowel obstruction

Table 3. Etiology of adhesions ($n = 62$ patients)

Prior procedures	Multiple adhesions	Single band
Appendectomy	—	3
Gynecologic	4	6
Colon	6	5
Small bowel	3	2
Multiple operations	9	15
Others	—	9
Total	22	40

Table 4. Outcome: laparoscopy vs. laparotomy

Group	Laparoscopy ($n = 31$)	Laparotomy ($n = 31$)
Operative time (min)	78	70
Hospital stay* (total/postop) (days)	7/5	13/9
First bowel movement* (days)	3	6
Morbidity* (%)	$n = 5$ (16)	$n = 14$ (45)

*$p < 0.05$

Table 5. Outcome: laparoscopy subgroups

Subgroup	Laparoscopy ($n = 17$)	Laparoscopy-assisted ($n = 4$)	Converted ($n = 10$)	Assisted + converted (combined) ($n = 14$)
Operative time (min)	75	98	84	90
Hospital stay (total/postop) (days)	4/4*	8/6.5*	9/6.5	9/6.5
First bowel movement (days)	3*	4*	4.5	4.5
Morbidity (%)	6*	25*	30	29

*$p < 0.05$

There were no statistically significant differences in the operative time among the primary groups or subgroups; similarly, no differences were noted in the length of hospitalization and the time to first bowel movement between the laparoscopy-assisted and the converted subgroups ($p = 0.6$ and $p = 0.53$, respectively) and between the laparoscopy-assisted combined with converted subgroup and the laparotomy group ($p = 0.15$ and $p = 0.46$, respectively) (Tables 4 and 5). However, there were significant differences in both the length of hospitalization and the time to first bowel movement between the laparoscopy and combined laparoscopy-assisted-converted subgroups ($p = 0.01$ and $p = 0.02$, respectively); these differences were also noted when comparing the laparoscopy and laparotomy groups ($p = 0.0007$ and $p = 0.0001$, respectively) (Tables 4 and 5). The overall morbidity rate was significantly lower in the laparoscopy group compared with the laparotomy group ($p = 0.007$), and patients whose surgery was successfully completed laparoscopically had an easier postoperative recovery with fewer complications than patients in the laparoscopy-assisted or converted groups. However, the difference between laparoscopy and laparoscopy-assisted subgroups was not statistically significant ($p = 0.49$). There were considerably less complications and no mortality in the laparoscopy group compared to one mortality and various complications in the laparotomy group (Table 6).

The mean operative charges were similar between the laparoscopy and the laparotomy groups at $ 11,819.92 and 9,972.07, respectively ($p = 0.14$). Likewise, when intention to treat was factored in, there was no statistically significant difference between the two groups in total hospital charges: $ 39,866.87 and 61,855.68, respectively ($p = 0.10$). The only significant difference was found in total hospital charges between the laparoscopy subgroup and the laparotomy group at $ 29,904.24 and 61,855.68, respectively ($p = 0.03$).

Table 6. Morbidity and mortality

Morbidity type	Laparotomy	Laparoscopy
Pulmonary	3	—
Cardiac	2	—
Wound infection	1	2
Line sepsis	1	—
Deep vein thrombosis	1	—
Enterocutaneous fistula	1	—
Intra-abdominal abscess	2	—
Prolonged ileus	3	3
Total*	14 (45%)	5 (16%)

*$p < 0.05$

Discussion

Peritoneal adhesions following open surgery account for 74% of all bowel obstructions [9]. Patients requiring surgery for AASBO have traditionally undergone laparotomy with substantial morbidity associated with a long incision, prolonged postoperative pain, prolonged ileus, and reduced postoperative pulmonary function. Moreover, laparotomy results in incisional hernia formation and further adhesion formation, with a readmission rate of at least 32% [3, 10].

Laparoscopic surgery, with reduced surgical trauma, may offer advantages to patients undergoing surgery for AASBO, such as reduced postoperative pain, ileus, hospitalization with fewer postoperative complications, and lower subsequent incidence of adhesions and incisional hernias. Thus, laparoscopic treatment of AASBO may ultimately be associated with financial savings.

Since 1991 multiple retrospective reports have shown the feasibility of laparoscopy in the management of acute SBO [1, 5, 7, 11, 14, 15]. The conversion rate ranged from 20% to 48%, usually because of abdominopelvic postoperative adhesions, which were the main cause of obstruction [1, 5]. The largest retrospective multicenter study reported successful laparoscopic treatment of SBO in 168 of 308 patients (54.6%) with a significantly shorter period of postoperative ileus and hospital stay compared to a converted group of patients, but with no statistically significant difference in the total number of immediate or delayed complications, mortality, or recurrent obstructions [7].

The success of the laparoscopic approach depends on several factors. Duration of surgery and a bowel diameter exceeding 4 cm were predictors of conversion ($p < 0.001$ and $p = 0.02$, respectively) in a study by Suter et al. [15]. However, in the current study neither the extent nor the number of previous operations correlated with the need for conversion. Levard et al. [7] showed that the rate of success was significantly higher ($p < 0.001$) in patients operated on early (< 24 h after hospitalization versus ≥ 48 h), and who had only one or two prior operations, or who had single band obstruction rather than diffuse adhesions.

Reports in the literature comparing laparoscopy and laparotomy for AASBO are sparse; similarly, there are few cost analysis data comparing the laparoscopic technique to laparotomy.

Chopra et al. [2] retrospectively compared the results of laparoscopy for AASBO with those of laparotomy. They found that the complication rate was significantly lower in the laparoscopy group ($p < 0.01$), but there was no difference in morbidity between the converted and laparotomy groups. Statistically significant differences were also found in operative time, hospital stay, and the duration of postoperative ileus. Wullstein et al. [17] reported a retrospective comparison between the two techniques, noting that duration of symptoms had no influence on the complication rate; however, the number of previous operations was a risk factor for intraoperative complications. In the current study the laparoscopy group had a significantly faster recovery of bowel function, a shorter hospital stay, and fewer postoperative complications than did the laparotomy group.

Operative and total hospital charges are increasingly important factors; however, there are no standardized methods for charge analysis. Several studies have been performed to compare cost-effectiveness of the laparoscopic approach to open colorectal surgery in elective cases [8, 12, 13]. Some studies have shown lower charges for laparoscopic procedures than for laparotomy [8, 12, 13], while others have found no cost benefit [12], mainly because of significantly longer operative time and a greater cost of disposable instruments associated with laparoscopy. However, comparative data on charges associated with emergent laparoscopic colorectal surgery versus laparotomy are lacking.

Neither the number of previous operations, small-bowel obstruction episodes, duration of symptoms before admission, ASA score, nor BMI influenced the need for conversion. In the current series 55% of patients were successfully treated laparoscopically; the cases which were converted to laparotomy were due to extensive adhesions, which were less frequently noted than a single band.

The risk of small-bowel perforation during laparoscopy for AASBO may be higher than in laparotomy. Wullstein et al. [17] reported a 26.9% rate of bowel injury in the laparoscopy group versus 13.5% in the laparotomy group. In our experience there were no intraoperative bowel perforations, perhaps because of early conversion and a meticulous atraumatic technique in the handling of dilated and edematous bowel and when performing adhesiolysis. We routinely use the open Hasson technique, placing the first port away from any previous incision, gently using atraumatic intestinal bowel clamps, and dividing adhesions with scissors or Harmonic Scalpel® (Ethicon Endosurgery, Cincinnati, OH) rather than with monopolar electrocautery, as recommended by Suter et al. [15] and Strickland et al. [14]. Moreover, we perform bowel exploration from the cecum and collapsed small bowel proximally toward the transition zone and dilated loops, and lyse only relevant bands or adhesions to release obstruction and create working space, as advocated by Nagle et al. [11] and Kirshtein et al. [5].

In the current study, there were statistically significant differences in hospital stay, time to the first bowel movement, and complication rate between the laparoscopy and assisted-converted subgroups and between the laparoscopy and laparotomy groups, even when laparoscopy-assisted and converted cases were included in the intention-to-treat analysis of the laparoscopy group. However, there was no difference between laparoscopy-assisted and converted subgroups or between assisted-converted and laparotomy groups. These data support prior findings [2, 17].

Because of its retrospective nature, a clear problem in this design is that study selection bias cannot be completely eliminated. Another deficiency is that this study included only patients with AASBO and only analyzed short-term outcome and charges. Posthospital discharge, disability expense, lost wages, quality of life, long-term recurrent obstruction, or incisional hernia formation rates were not evaluated. However, review of the literature demonstrates that laparoscopic surgery reduces adhesion formation [4] and the incidence of ventral hernia and SBO rate compared with laparotomy [3]. Decreased recurrence of adhesive SBO and incisional hernia formation after laparoscopy may be associated with further financial savings to the health-care system.

The current study analyzes operative and total hospital charges only during the hospitalization period and does not include indirect costs of sick leave (during the hospitalization and after the discharge) or costs associated with long-term complications. Several previous studies have conducted economic analyses of elective laparoscopy versus laparotomy for colorectal surgery and have shown higher operative charges for the laparoscopic approach; however, total charges were reduced due to faster recovery compared with open surgery [8, 12, 13]. The duration of hospitalization and the incidence and type of postoperative complications rather than operative charges mainly contribute to total cost. Therefore, the higher operative charges incurred with laparoscopy is offset by lower hospitalization charges and potential lower long-term morbidity of adhesions and incisional hernias. Therefore, it seems intuitive that the laparoscopic technique is more financially advantageous.

In addition, this study included only emergency surgery, which may affect operative and total hospital charges. We did not find any significant differences between the two groups relative to operative and total hospital charges. The total hospital charge was significantly less only in the group of the patients whose surgery was successfully laparoscopically completed.

Conclusion

The laparoscopic management of AASBO was successful in 55% of patients and was associated with a shorter hospital stay, faster postoperative recovery of bowel function, and lower morbidity than was laparotomy. The need for laparoscopy-assisted or converted surgery was associated with an increased risk of postoperative complications and did not differ from laparotomy in patient short-term outcome. ASA score, BMI, duration

of symptoms before admission, number of previous operations, and number of episodes of SBO were not predictors for conversion.

A meticulous atraumatic surgical technique and a low threshold for conversion are important factors in preventing intraoperative complications, although conversion itself increases postoperative morbidity. Further studies are needed to evaluate additional potential short-term advantages and long-term morbidity of recurrent AASBO and incisional hernias.

References

1. Borzellino G, Tasselli S, Zerman G, Pedrazzani C, Manzoni G (2004) Laparoscopic approach to postoperative adhesive obstruction. Surg Endosc 18(4): 686–690
2. Chopra R, McVay C, Phillips E, Khalili TM (2003) Laparoscopic lysis of adhesions. Am Surg 69(11): 966–968
3. Duepree HJ, Senagore AJ, Delaney CP, Fazio VW (2003) Does means of access affect the incidence of small bowel obstruction and ventral hernia after bowel resection? Laparoscopy versus laparotomy. J Am Coll Surg 197(2): 177–181
4. Garrard CL, Clements RH, Nanney L, Davidson JM, Richards WO (1999) Adhesion formation is reduced after laparoscopic surgery. Surg Endosc 13(1): 10–13
5. Kirshtein B, Roy-Shapira A, Lantsberg L, Avinoach E, Mizrahi S (2005) Laparoscopic management of acute small bowel obstruction. Surg Endosc 19(4): 464–467
6. Kossi J, Salminen P, Rantala A, Laato M (2003) Population-based study of the surgical workload and economic impact of bowel obstruction caused by postoperative adhesions. Br J Surg 90(11): 1441–1444
7. Levard H, Boudet MJ, Msika S, Molkhou JM, Hay JM, Laborde Y, Gillet M, Fingerhut A (2001) French Association for Surgical Research. Laparoscopic treatment of acute small bowel obstruction: a multicentre retrospective study. ANZ J Surg 71(11): 641–646
8. Liberman MA, Phillips EH, Carroll BJ, Fallas M, Rosenthal R (1996) Laparoscopic colectomy vs traditional colectomy for diverticulitis. Outcome and costs. Surg Endosc 10(1): 15–18
9. Miller G, Boman J, Shrier I, Gordon PH (2000) Etiology of small bowel obstruction. Am J Surg 180(1): 33–36
10. Miller G, Boman J, Shrier I, Gordon PH (2000) Natural history of patients with adhesive small bowel obstruction. Br J Surg 87(9): 1240–1247
11. Nagle A, Ujiki M, Denham W, Murayama K (2004) Laparoscopic adhesiolysis for small bowel obstruction. Am J Surg 187(4): 464–470
12. Philipson BM, Bokey EL, Moore JW, Chapuis PH, Bagge E (1997) Cost of open versus laparoscopically assisted right hemicolectomy for cancer. World J Surg 21(2): 214–217
13. Senagore AJ, Duepree HJ, Delaney CP, Dissanaike S, Brady KM, Fazio VW (2002) Cost structure of laparoscopic and open sigmoid colectomy for diverticular disease: similarities and differences. Dis Colon Rectum 45(4): 485–490
14. Strickland P, Lourie DJ, Suddleson EA, Blitz JB, Stain SC (1999) Is laparoscopy safe and effective for treatment of acute small-bowel obstruction? Surg Endosc 13(7): 695–698
15. Suter M, Zermatten P, Halkic N, Martinet O, Bettschart V (2000) Laparoscopic management of mechanical small bowel obstruction: are there predictors of success or failure? Surg Endosc 14(5): 478–483
16. Williams SB, Greenspon J, Young HA, Orkin BA (2005) Small bowel obstruction: conservative vs. surgical management. Dis Colon Rectum 48(6): 1140–1146
17. Wullstein C, Gross E (2003) Laparoscopic compared with conventional treatment of acute adhesive small bowel obstruction. Br J Surg 90(9): 1147–1151