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Early laparoscopic adhesiolysis for small bowel obstruction: retrospective study of main advantages

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Abstract

Background The problem of managing adhesional small bowel obstruction (ASBO) is still unsolved. A conservative medical attitude is privileged even if it is associated to a high rate of recurrences, while surgery is applied to cases showing no improvement after 48–72 h. Adhesiolysis via laparotomy has been the standard surgical management, but it causes other adhesions in a vicious circle. The aim of the study is to evaluate the advantages of early laparoscopic adhesiolysis as an alternative approach.

Methods From January 2010 to April 2017, 107 patients were admitted with a diagnosis of ASBO. Patients underwent medical treatment, early surgery, emergency surgery or delayed surgery after failure of medical treatment. A retrospective review and explorative statistical analysis were performed using graphical diagnostic plots, Mann–Whitney (MW) test, Kolmogorov–Smirnov (KS) test, exact binomial test, and χ^2 test.

Results Medical treatment led to resolution in the 77.3% of cases, but patients exhibit much more recurrences than those in the surgical group (χ^2 $p<.001$). They also show a longer fasting time (MW $p=.027$; KS $p=.102$), a doubled number of radiological exams (MW $p<.001$; KS $p<.001$), and more major complications than those in the early surgery group. Early surgery group is associated to shorter fasting time (MW $p<.001$; KS $p<.001$), much shorter hospital stay (MW $p<.001$; KS $p=.002$) and a smaller number of radiological exams (MW $p=.005$; KS $p=.002$) compared with delayed surgery group. The laparoscopic group shows significantly earlier regain of intestinal transit (MW $p<.001$; KS $p=.002$), shorter fasting time (MW $p=.002$; KS $p=.008$), reduced number of radiological exams (MW $p=.003$; KS $p=.014$), reduced hospital stay (MW $p<.001$; KS $p=.005$), and no more complications than the open surgery group.

Conclusions Early laparoscopic surgery can be proposed as an effective alternative treatment for ASBO.

Keywords Small bowel obstruction · Laparoscopic adhesiolysis · Postoperative adherence formation · Management of small bowel adherences · Early adhesiolysis · Obstruction recurrences

Adherences formation

Adherences are defined as band of fibrotic tissue (scars) connecting surfaces that usually are not in contact. Their development is a major complication of surgery and it affects about the 93% of patients who underwent pelvic-abdominal surgery. Although the majority of these adherences remains silent and does not provoke any clinical symptoms, some of them can be responsible of "adhesive disease," a symptomatic state ranging from chronic abdominal pain (or infertility) to complete intestinal obstruction.

Adhesiogenesis starts early during the surgery, as every insult on peritoneal sheet causes phlogosis that evolves in fibrosis. In the damaged area, mast cells release histamine, which increases vascular permeability and attracts inflammatory cells. A fibrin gel matrix deposits and macrophages direct mesothelial cells on the hurt area to reconstruct the lining. Re-epithelialization takes about 5–7 days. If the interrupted surfaces stay in contact they develop an adherence. This can happen between two or more intra-abdominal organs and/or the inner abdominal wall [1–3].

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Causes of adherences

Common causes of peritoneal insult can be classified in three general categories:

- Post surgical; more of the 90% resulting from prior abdominal and pelvic surgery, primarily laparotomy.
- Infections or inflammatory disease (appendicitis, diverticulitis, endometriosis, pelvic inflammatory disease, bowel intestinal disease, abdominal tuberculosis), chemical peritonitis (contact with bile, opening of dermoid cysts), and irritation from foreign body.
- Post radiation; radiation therapy used for treatment of multiples malignant disease, such as colorectal, prostatic, gynecologic cancer or lymphoproliferative neoplasia, can cause early or late adhesions as a consequence of chronic ischemia of peritoneum. The severity is directly correlated to extent of the area treated, the dose of fractionation, and the total dose of radiation [4].

Small bowel obstruction due to adherences

Given the fibrotic nature of adhesive bands, they interfere with the regular intestinal motility producing, in the best case, abdominal discomfort, chronic bloating, cramping, alteration of bowel habits and constipation, nausea or early sensation of satiety. When extrinsic compression becomes complete, patients develop acute small bowel obstruction, whose pathognomonic signs are incoercible vomiting associate to cessation of gas and stools. Adhesional small bowel obstruction (ASBO) occurs in the 3% of all laparotomies, with the 1% occurring in the first postoperative year [5].

History of physiopathology of obstruction

The understanding of the physiopathology of small bowel obstructions is mainly due to Owen Wangensteen, Chairman of the Department of Surgery at the University of Minnesota from 1930 to 1968. His experiments on dogs established the cause of signs and symptoms and their treatment. The experiments consisted of tying the mid-ileum, and then dividing the esophagus and bringing out the upper end to the skin as a mucous fistula in half of the animals. In the other half, the gastrointestinal tract was maintained intact. The first group did not become distended with either gas or fluid and survived for prolonged periods. The second one experienced the classical consequences of small bowel obstruction, until death. In this way, Wangensteen proved that (i) swallowed air causes distention; (ii) the excess fluid accumulation above the obstruction is due to the pressure of the swallowed air on the bowel wall impeding venous outflow but not arteriolar inflow; and (iii) removing the air by means of gastric tubes (named Wangensteen Suction after him) improved clinical condition of both experimental animals and patients. Nasogastric suction allowed a safer surgery or even resolution without intervention in many cases.

Wangensteen established five main criteria that still apply today in order to consider the obstruction resolved, thus allowing the withdrawal of the suction: (i) cessation of "gas pains"; (ii) decrease of abdominal distention; (iii) visualization of gas in the colon on the radiograph; (iv) less fluid aspirated through the tube; and (v) toleration of temporary discontinuation of suction without recurrence of pain [6, 7].

Management of small bowel obstruction

Any treatment for small bowel obstruction starts with medical management involving intravenous hydration, correction of electrolyte abnormalities, intravenous antibiotics, nil per os, and nasoenteral suction.

Laboratory tests measuring white blood cell count, C-reactive protein (CRP), blood urea nitrogen, and creatinine can assess the level of systemic illness. However, these clinical tests are not specific, whereas Lactate dehydrogenase (LDH) is an abundant enzyme in intestinal mucosa that is considered a sensitive marker of bowel ischemia. In fact, when blood supply to bowel is compromised, mucosa suffers and serum levels of LDH increase. A recent study found that LDH > 1000 IU/l indicates gangrenous changes [8]. Erect plain radiography frequently shows multiple air fluid levels and distention of small bowel associated to the absence of gas in the colon. The best radiological exams remain the abdominal CT scan, especially with administration of oral or intravenous contrast. It shows the transition point, identifying the cause of obstruction and possible complications such as perforation, ischemia, or necrosis [9, 10].

The use of Gastrografin, the most common contrast medium, has been investigated as a method to stimulate the recovery of intestinal transit. In fact, its hyperosmolar power (2150 mOsm/l) activates movement of water into the small bowel lumen, decreases edema of the intestinal wall, and enhances smooth muscle contractile activity that can generate effective peristalsis. The presence of contrast in the colon is predictive of resolution.

A medical treatment can be successful in the 41–80% of cases [11, 12]. There is no consensus about when a conservative treatment should be considered unsuccessful and the patient should undergo surgical adhesiolisis, but the World Society of Emergency Surgery 2013 established that non-operative management can be prolonged up to 72 h if patients remain stable and there is no strangulation or peritonitis. After 72 h, surgery is recommended [13–17].

The problem is to identify which patients will respond to conservative treatment and those who will need surgery, bearing in mind that a necessary but delayed surgery exposes the patient to a higher risk of intestinal resection. In fact, the overall mortality is 10% but it increases to 30% with bowel necrosis/perforation. Predicting factors for emergency surgery are the presence of free intraperitoneal fluid, mesenteric edema, small bowel feces sign at CT scan, involuntary abdominal guarding, and severe abdominal pain [14, 18].

Surgical treatment

Open laparotomy has been considered for a long time the only possible surgical approach. However, laparotomy creates new adhesions and becomes itself the cause of recurrence. Laparoscopic adhesiolysis is emerging as an alternative to open surgery. In the past, it was informally banned in case of intestinal obstruction because of the complexity of surgery. In fact, coelioscopy can be challenging for the surgeon as the bowel distention reduces the visual field, makes the movements within the peritoneal cavity more difficult, and the intestinal wall more fragile and at greater risk of iatrogenic perforation. The first laparoscopic adhesiolysis in small bowel obstruction was performed by Mouret in 1972 [19]. Then, it was suggested for selected group of patients in case of first episode of obstruction or for patients with isolated bands. Today, a majority of surgeons accepts laparoscopy as initial step of exploration of the abdomen in case of bowel obstruction. A recent consensus conference established that the only absolute contraindications to laparoscopy for adhesiolysis are those related to pneumoperitoneum (hemodynamic instability or cardiopulmonary impairment) [20].

The surgery involves the use of Hasson's technique for open laparoscopy and placement of the first trocar in order to avoid accidental perforation of distended intestine that can be adherent to the anterior abdominal wall. Normally two 5-mm trocars are sufficient to explore peritoneal cavity and they are placed under direct vision, respecting triangulation. The possibility of moving the operating table in different positions is very helpful to perform adhesiolisis since gravity removes the intestinal limbs from the visual field. Reported causes of laparotomic conversion are as follows: (i) extended fibrous adhesions, especially in patients who have undergone more than two laparotomies; (ii) huge small bowel dilatation with a diameter of more than 4 cm; (iii) the presence of intestinal necrosis and consequent need for intestinal resection; and (iv) inadvertent enterotomy caused by inexperienced surgeon [21–25].

When laparoscopic adhesiolysis is successfully accomplished, it seems to have clinically proven advantage over open approach as it results in less postoperative pain, faster regain of intestinal function and faster postoperative first meal, shorter hospital stay, decreased complications, lower healthcare costs, and decreased postoperative adhesions formation [26–31].

The current study resumes the experience of a peripheral surgical center. The aim is to investigate the outcome of the laparoscopic approach for small bowel obstructions and to compare conservative treatment versus surgical treatment in terms of short-term and long-term results.

Materials and methods

From January 2010 to April 2017, 187 patients were admitted from Emergency Room to our department with a diagnosis of small bowel obstruction. Among these, 107 with adhesive causes were included after excluding other etiologies. Some patients were readmitted in different periods with the same diagnosis, resulting in 125 hospitalizations. Causes of exclusion were pregnancy, age (< 16 years), peritoneal carcinomatosis, Crohn disease, other causes of mechanical obstruction (e.g., neoplasia, bezoars, foreign body, strangulated hernia), or causes of functional obstruction (e.g., Olgive syndrome and paralytic ileus). Data regarding demography, previous medical treatments, and follow-up were collected with a standardized data collection form.

Critically ill patients, as those who presented signs of gravity at Ct scan (abundant free peritoneal fluid, small bowel feces sign, and mesenteric edema) or signs of peritoneal irritation (involuntary abdominal guarding), were addressed directly to emergency laparotomy (ES). All the others underwent medical treatment (MT) or surgical treatment in the first 24 h (S24) based on their clinical conditions, patient's will, surgeon's experience and preference, and complexity of the procedure. Our department routinely use Gastrografin for diagnostic and therapeutic purposes. When MT failed (no transit regain between 24 and 72 h or no contrast progression in the colon after 24 h from the administration) patients were addressed to delayed surgery (DS).

We retrospectively analyzed the following parameters: demographic features (age, gender, and BMI); number and type of previous surgical interventions; time between the last surgery and the present episode of obstruction; number of previous occlusion episodes; number of operated occlusions in the past; CRP and LDH values at the admission; type of treatment (medical and surgical); time of surgical treatment (ES, S24, and DS); type of surgical treatment (open adhesiolysis (OA) and laparoscopic adhesiolysis (LA)); number of intestinal resection cases; duration of hospital stay; time to regain intestinal function; total fasting time; number of radiological examinations; and number of recurrences after treatment and minor/major complications.

The regain of intestinal function is identified by the presence of stools or gas associated to contrast in the colon and/or removal of nasogastric tube without vomiting. The fasting time is defined as the interval between the admission date to hospital and that of the first meal (even liquid) by mouth.

The categorical data were compared using the χ^2 test and the exact binomial test. Continuous variables were compared using the Mann–Whitney (MW) test and the two-sample Kolmogorov–Smirnov (KS) test along with graphical diagnostic plots of the empirical cumulative distribution functions (ECDFs). The statistical analyses were performed using R software [32]. *P* values, *p*, smaller than 0.05 were considered as indication of statistical significance, bearing in mind the limits of null hypothesis statistical testing in ex post nonrandomized studies [33–35].

Surgical treatment

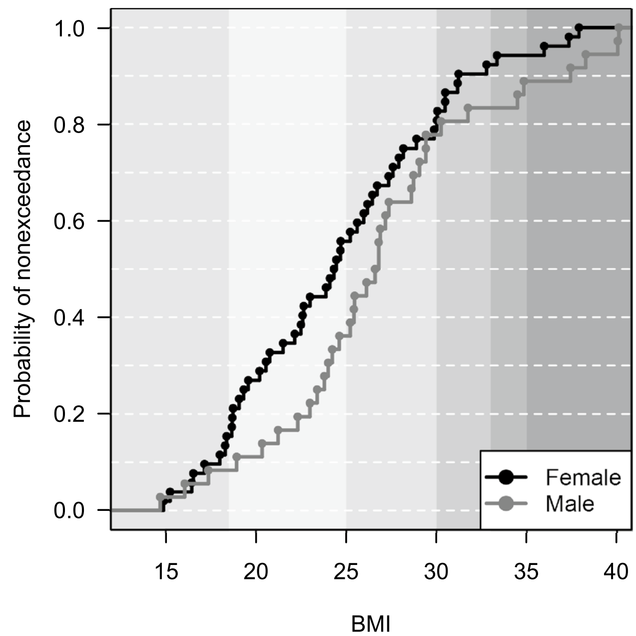

Fig. 1 ECDFs of BMI for female and male population

Results

The sample comprises 125 consecutive ASBO patients. Seventy-five patients (60%) underwent MT, 20 (6%) were treated by S24, 8 (6.4%) needed ES, and 22 (17.6%) underwent DS after MT failure. There were no cases of death. Mean follow-up is 46.75 months, ranging within (2, 88) months. The age ranges in (23, 95) years with median value of 50.5 years. The population comprises 107 (distinct) patients: 62 (57.9%) females, 44 (41.1%) males, and 1 (0.9%) transgender. Excluding the transgender patient, an exact binomial test yields $p = .098$, while the 95% confidence intervals (CIs) around the percentage of females in the 106 entries (58.4%) is (48.5, 68.0). These results indicate that the adherences affect similar proportions of females and males.

BMI values range within (14.87, 37.89) for females, and (14.69, 40.04) for males, with median values of 24.38 and 26.59 for females and males, respectively. Empirical cumulative distribution functions (ECDFs) in Fig. 1 show that the BMI distribution of females tends to be shifted on the right compared to that of males, thus denoting systematic higher values for the latter group. Furthermore, only about 40% of females and 28% of males show an ideal weight, less than the 16 and 8% are, respectively, underweight, and the majority (44% of females and 63% of males) are overweight, reflecting the known increase of BMI in the western population.

Figure 2A shows that the most frequent previous surgical interventions were appendicectomy (28 patients, 27%), laparotomy for different causes (predominantly abdominal wall surgery; 26 patients, 26%), colectomy (24 patients, 23%), and hysterectomy (24 patients, 22%). Stratifying by gender (Fig. 2B), there is a high prevalence of hysterectomy in females (24 patients, 54.5%). These data are in agreement with the current literature identifying multiple laparotomy, colorectal, and pelvic surgery as risk factors in adherence formation [12, 31].

The 91.5% of patients had previous abdominal surgery. One or two previous surgeries account for the 73.6% of cases, while the probability to have patients with more than 2 previous surgeries is 17.9%. Only 9 patients (8.5%) did not undergo previous surgical procedures. Stratifying by gender, males generally comes with less previous surgeries (77.3% with one or no surgeries against the 48.4% of females, and no cases with more than four previous operations). The highest frequencies of obstruction cases occur within the first year and between 1 and 4 years from the most recent surgery. It seems that females have a higher risk to suffer an occlusion between 1 and 4 years from the most recent surgery. For males, the risk is more spread across the time line, excluding the peak at time intervals less than 1 year.

Focusing on the S24 group (i.e., patients in which surgery was accomplished in the first 24 h, excluding the cases of ES), and MT + DS group (i.e., all the patients initially addressed to conservative treatment, including patients who needed a delayed surgery at a second stage), their statistics are compared in Table 1. We report median values and ranges in parentheses for continuous variables, and number of cases and corresponding percentages for categorical variables. The MT + DS group shows twice the number of radiological exams (MW $p < .001$; KS $p < .001$), and a prolonged fasting time (MW $p = .027$; KS $p = .102$) with respect of the S24 group. In the 85% of cases, there were

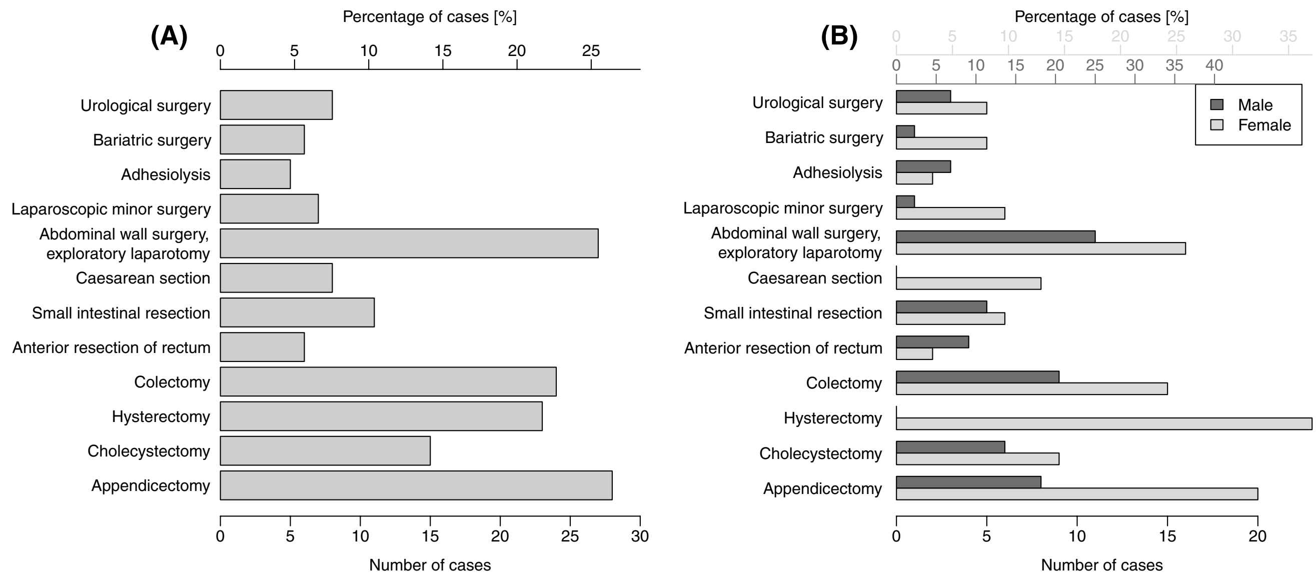

Fig. 2 Frequency of previous surgical treatments stratified by typology (**A**), and typology and gender (**B**)

Table 1 Comparison between S24 (early surgery) group and MT + DS group

	Treatment		Tests		
	S24	MT + DS	MW *p*	KS *p*	χ^2 *p*
Fasting time	3 (1,7)	3.5 (1,20)	.027	.102	
Intestinal transit regain (days)	2.5 (1,6)	2 (0,15)	.431	.606	
Number of radiological exams	2 (1,9)	4 (1,53)	< .001	< .001	
Complications					
Major	0 (0%)	9 (9.3%)			.122
Minor	3 (15%)	5 (5.2%)			
No	17 (85%)	83 (85.5%)			
Hospital stay	7 (4,16)	7 (3,45)	.464	.596	
Intestinal resection (yes%)	3 (15%)	4 (4.1%)			.177
Recurrences (yes%)	1 (5%) [2 NAs]	21 (21.6%) [17 NAs]			.112

no complications in both groups, but when complications happen, they tend to be major in the MT + DS group (9.3 vs. 0%). ECDFs in Fig. 3A–D provide a visual picture for the behavior of numeric variables. The two groups (S24 and MT + DS) behave similarly in the body of the distribution, while some discrepancies emerge in the upper part of the ECDFs. This behavior denotes that the two groups are similar on average, but the MT + DS group shows a higher probability to have unusually long fasting time, hospital stay, and regain of intestinal function.

We performed the same comparison between the S24 group and MT group, excluding patients of the DS group. Results are summarized in Table 2. The MT group requires twice the number of radiological exams of that of the S24 group (MW $p = .002$; KS $p < .001$), higher number of major complications (χ^2 $p = .050$) , and higher recurrence rate (χ^2 $p = .039$). Of course, intestinal resection can only occur in the S24 group. ECDFs in Fig. 3E–H confirm the results of the MW and KS tests. The S24 and MT groups show similar fasting time, hospital stay, and intestinal function regain. However, discrepancies in the upper part of ECDFs indicate that the medical treatment implies a higher probability to have unusually long hospital stay. In other words, the two treatments result in the same hospital stay on average; however, in some cases, the MT can require hospital stay much longer than that needed for S24. On the other hand, MT systematically needs a higher number of radiological exams, which can be very high in the most "complicated" cases.

MT was the initial approach to treat 97 patients. It led to resolution in 75 cases (77.3%) and it failed in 22 patients (22.6%), who then underwent DS.

Fifty patients out of 125 underwent surgical treatment. Of these 50 cases, 13 (26%; 10 females and 3 males) were treated by laparoscopic adhesiolysis (LA), 3 (6%; 1 female

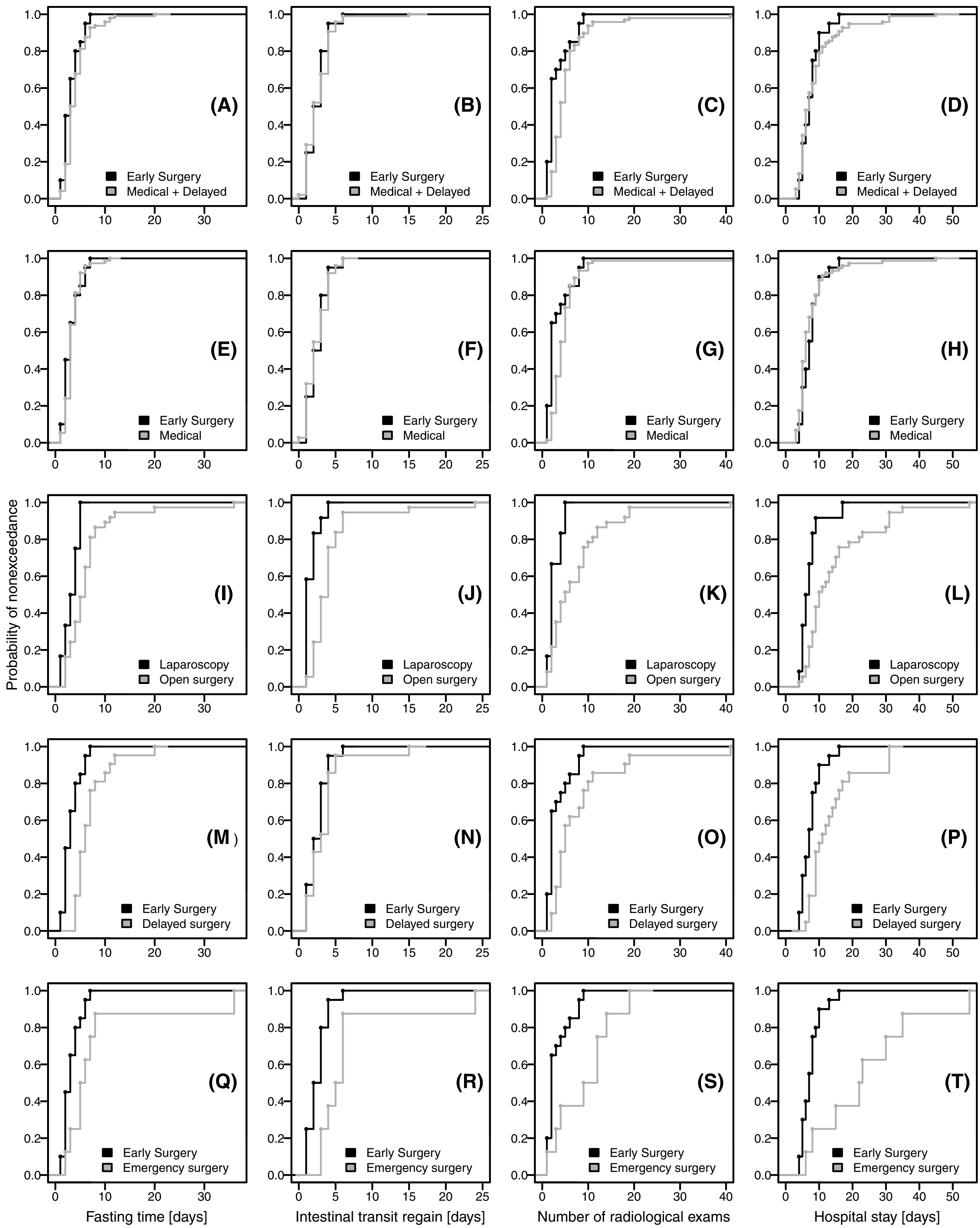

Fig. 3 Comparison of ECDFs of fasting time, time of intestinal function regain, number of radiological exams, and hospital stay for pairs of treatments: **A**–**D** Early surgery (S24) versus Medical + Delayed (MT + DS), **E**–**H** Early surgery (S24) versus Medical (MT + DS), **I**–**L** Laparoscopy (LA) versus Open surgery (OA), **M**–**P** Early surgery (S24) versus Delayed surgery (DS), and **Q**–**T** Early surgery (S24) versus Emergency surgery (ES)

Table 2 Comparison between S24 group and MT group

	Treatment		Tests		
	S24	MT	MW p	KS p	χ^2 p
Fasting time	3 (1,7)	3 (1,11)	.187	.248	
Intestinal transit regain (days)	2.5 (1,6)	2 (0,6)	.578	.817	
Number of radiological exams	2 (1,9)	4 (1,53)	.002	< .001	
Complications					
Major	0 (0%)	5 (6.7%)			.050
Minor	3 (15%)	2 (3.7%)			
No	17 (85%)	68 (90.6%)			
Hospital stay	7 (4,16)	6 (3,45)	.866	.914	
Intestinal resection (yes%)	3 (15%)	0 (0%) [expected]			.007
Recurrences (yes%)	1 (5%) [2 NAs]	20 (26.7%) [16 NAs]			.039

and 2 males) by LA subsequently converted in open adhesiolysis (OA) during the surgery when intestinal resection was required (2 cases) or the adhesion was too much extensive (1 case), and 34 (68%; 23 females and 10 males) by OA. Focusing on the type of surgery, the comparison between the LA group (13 cases) and the OA group (34 + 3 conversions) is summarized in Table 3. The LA group shows statistically significant reduction of fasting time (MW $p = .002$; KS $p = .008$), shorter regain of intestinal function (KS $p = .002$) smaller number of radiological exams (MW $p = .003$; KS $p = .014$), shorter hospital stay (MW $p < .001$; KS $p = .005$) than those of the OA group. ECDFs in Fig. 4I–L provide a visual display for the numeric variables and show a clear shift on the right (i.e., higher values) of the OA group with respect to the LA group for the considered parameters.

The comparison between the S24 group (20 patients) and DS group (22 patients) is summarized in Table 4. The former implies a median fasting time of 3 days with range (1, 7) while the latter 6 days ranging in (4, 20) (MW $p < .001$; KS $p < .001$). The difference between the times of regain of intestinal function is less evident, but the highest value for the DS group is more than twice the highest value of the S24 group. The DS group systematically requires more radiological exams (MW $p = .005$; KS $p = .002$). There is no evident difference of type and frequency of complication, while the hospital stay is sensitively reduced for the S24 group (MW $p < .001$; KS $p = .002$). ECDFs in Fig. 4M–P confirm a systematic shift on the right (i.e., higher values are systematically more probable) of the DS group compared to the S24 group. For regain of intestinal function, the ECDFs of the two groups are similar, with discrepancies emerging in the extreme values. In other words, unlike the other parameters, the times to regain of intestinal function are generally similar, but the DS group can require very long times in some rare cases.

Finally, we compared the S24 group with ES group (Table 5). As one patient was operated twice in emergency, there are 8 cases of ES and 7 distinct patients. All the cases were treated by OA. The comparison between the ES group and S24 group highlights that the former obviously shows a very prolonged fasting time (MW $p = .008$; KS $p = .032$), with the highest value (36 days) being five times greater than the highest value for the S24 group. The ES group has a higher time to regain normal intestinal function (MW $p < .001$; KS $p = .022$), higher number of radiological exams (MW $p = .005$; KS $p = .022$), and a higher risk of

Table 3 Comparison between LA group and OA group

	Treatment		Tests		
	LA	OA	MW p	KS p	χ^2 p
Fasting time	3.5 (1,5)	6 (2,36)	.002	.008	
Intestinal transit regain (days)	1 (1,4)	4 (1,24)	< .001	.002	
Number of radiological exams	2 (1,5)	5 (1,41)	.003	.014	
Complications					
Major	1 (7.7%)	8 (21.6%)			.081
Minor	0(0%)	7 (18.9%)			
No	12 (92.3%)	22 (59.5%)			
Hospital stay	6.5 (4,17)	10 (4,55)	< .001	.005	
Intestinal resection (yes%)	1 (7.7%)	10 (27%)			.290
Recurrences (yes%)	0 of 11 (0%) [2 NAs]	3 of 34 (8.8%) [3 NAs]			.746

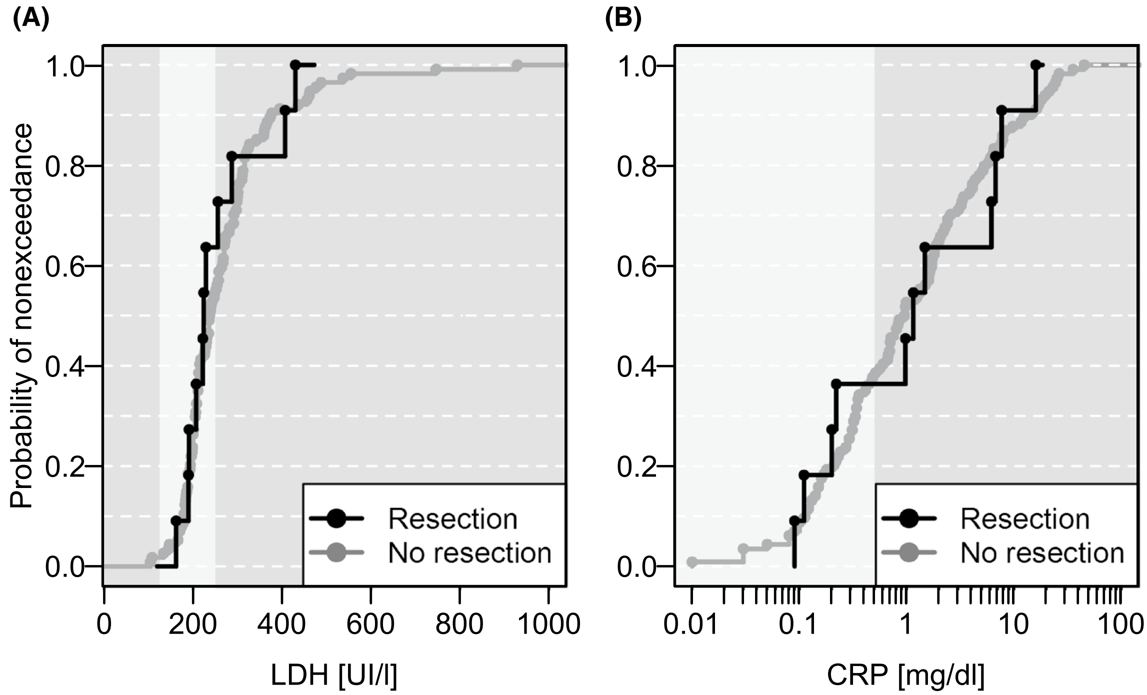

Fig. 4 ECDFs of LDH (**A**) and CRP values (**B**). Each panel compares ECDFs for cases with and without intestinal resection

Table 4 Comparison between S24 group and DS group

	Treatment		Tests		
	S24	DS	MW *p*	KS *p*	χ^2 *p*
Fasting time	3 (1,7)	6 (4,20)	< .001	< .001	
Intestinal transit regain (days)	2.5 (1,6)	3 (1,15)	.123	.210	
Number of radiological exams	2 (1,9)	5 (2,41)	< .001	.002	
Complications					
Major	0 (0%)	4 (18.2%)			.133
Minor	3 (15%)	3 (13.6%)			
No	17 (85%)	15 (68.2%)			
Hospital stay	7 (4,16)	11 (6,31)	< .001	.002	
Intestinal resection (yes%)	3 (15%)	4 (18.2%)			~ 1
Recurrences (yes%)	1 (5%) [2 NAs]	1 (4.5%) [1 NA]			~ 1

Table 5 Comparison between S24 group and ES group

	Treatment		Tests		
	S24	ES	MW *p*	KS *p*	χ^2 *p*
Fasting time	3 (1,7)	5.5 (2,36)	0.008	0.032	
Intestinal transit regain (days)	2.5 (1,6)	5.5 (3,24)	< 0.001	0.022	
Number of radiological exams	2 (1,9)	10.5 (1,19)	0.005	0.022	
Complications					
Major	0 (0%)	5 (62.5%)			< 0.001
Minor	3 (15%)	1 (12.5%)			
No	17 (85%)	2 (25.0%)			
Hospital stay	7 (4,16)	22 (6,55)	0.001	0.004	
Intestinal resection (yes%)	3 (15%)	4 (50%)			0.140
Recurrences (yes%)	1 (5%) [2 NAs]	1 (12.5%) [2 NAs]			~1

complications (75% vs. 15% corresponding to S24 Group; χ^2 $p < .001$), whereby the 62.5% of such complications are major. ECDFs in Fig. 3Q–T confirm the differences between the characteristics of these two groups.

Median operative time was 57 min (range 30–125 min) for LA group, 64 min (range 32–155 min) for OA group, and 96 min (range 63–126 min) for conversions, which was obviously influenced by necessity of intestinal resection. All operators included in this study were experienced general surgeons, accustomed to major advanced laparoscopic interventions (bariatric surgery and colo-rectal surgery). Skilled surgeons always supervised trainees.

LDH values range within (104, 929) UI/l for cases without resection, and (162, 430) UI/l for those with resection, with median values of 238 and 224 UI/l, respectively. ECDFs in Fig. 4A show that the LDH distributions are similar in the two cases (light-shaded areas denote the range (125, 250) UI/l of normal values of LDH). The MW and KS tests yield $p = .650$ and 0.828, respectively (i.e., no evident difference).

CRP values span the range (0.01, 45) mg/dl for cases without resection, and (0.09, 15.9) mg/dl for cases with resection, with median values of 0.96 and 1.15 mg/dl, respectively. ECDFs show that the CRP distributions are similar in the two cases (Fig. 4B; light-shaded areas denote the range (0, 0.5) mg/dl of normal values of CRP). MW and KS tests yield $p = .972$ and 0.903, respectively (i.e., no evident difference).

By counting the relapses of hospitalizations in our department, recurrence rate was 1 out of 20 cases (5%) for the S24 group (with 2 missing values), 1 out of 22 (4.5%) for the DS group (with 1 missing values), 20 out of 75 (26.6%) for the MT group (with 16 missing values), and 1 out of 8 (12.5%) for the ES group (with 2 missing values). In order to investigate the actual number of relapses, we have included in our research also surgical or medical relapses affecting patients in previous hospitalizations. For each patient, we counted the number of occlusion episodes preceding the first admission (in our department), which were not treated by surgery. These cases are considered as failures of MT in as much admissions in other hospitals. Then, we counted the number of failures occurred in our admissions. Altogether, we have 29 MTs that failed in 29 previous hospitalizations and 20 failures in 75 MTs in our hospital. Therefore, there are 104 MTs: 49 (47.1%) show relapses, 39 (37.5%) do not, while information is not available for the remaining 16 (15.4%) cases. In two cases, the readmission implied an ES with OA and intestinal resection.

Similar analysis was performed for surgical recurrences. For each patient, we counted the number of operations for occlusion preceding the first admission (in our department). These cases are considered as failures of surgical treatment in as much admissions in other hospitals. Then, we counted the number of failures of S24, DS, and ES occurred in the admissions in our department. Altogether, we have 4 surgical treatments that failed in 4 previous hospitalizations and 3 failures in 50 present surgical treatments. Therefore, there are 54 surgical treatments: 7 (13%) show relapses, 42 (77.8%) do not, while information is not available for the remaining 5 (9.2%) cases.

Under the hypothesis that the surgical treatment yields less relapses than the medical one, missing values were treated in a conservative way favoring the falsification of such an assumption. Namely, all missing values were assumed to be "no relapses" in the case of MT, and "relapses" in the case of surgical treatment. This criterion yields 49 relapses out of 104 (47.1%) for MT, and 12 out of 54 (22.2%) for surgical treatment (see Table 6). The χ^2 test yields $p = .002$ in favor of surgical treatment.

The lack of significant relationship between patients' ASA score and management or type of treatment (Table 7) indicates that no selection bias has occurred in our study. ASA 2 score is predominant for all groups, followed by ASA 3. Only one patient scored as ASA 4 was treated in the first 24 h by open surgery.

Discussion

Formation of adherences, mainly due to abdominal surgery, is the first cause of small bowel obstruction. The problem of managing a first episode or even recurring episodes of

Table 6 Comparison between MT and surgical relapses

	Treatment				Test
	MT (current)	MT (previous)	Surgical (current)	Surgical (previous)	χ^2 p
Number of hospitalizations	75	29	50	4	
Overall hospitalizations	104		54		
Recurrences	20 (26.6%)	29	3 (6%)	4	< .001
Overall recurrences	49 (47.1%)		7 (13%)		
N/A against our thesis	16		5		
Overall recurrences w/ NAs	49 (47.1%)		12 (22.2%)		.002

Table 7 Contingency tables of ASA score versus management and type of treatment

		ASA score				Test
		1	2	3	4	χ^2 p
Management	Open surgery	1 (2.7%)	24 (64.9%)	11 (29.7%)	1 (2.7%)	.055
	Medical	3 (4.0%)	52 (69.3%)	20 (26.7%)	0 (0.0%)	
	Laparoscopy	3 (23.1%)	9 (69.2%)	1 (7.7%)	0 (0.0%)	
Treatment	Medical	3 (4.0%)	52 (69.3%)	20 (26.7%)	0 (0.0%)	.106
	Delayed surgery	1 (4.5%)	13 (59.1%)	8 (36.4%)	0 (0.0%)	
	Emergency surgery	0 (0.0%)	5 (62.5%)	3 (36.5%)	0 (0.0%)	
	Early surgery	3 (15%)	15 (75%)	1 (5.0%)	1 (5.0%)	

intestinal occlusion is still unsolved. Currently, a conservative attitude, involving decompression of the intrabowel lumen by insertion of a suction tube and stimulation by administration of Gastrografin, is often privileged, whereas surgical intervention is applied only to cases that do not show improvements after 48–72 h. Even when MT is successful, it is associated with a high rate of recurrence and subsequent hospital admissions. Traditionally, laparotomy and adhesiolysis have been the standard surgical management, but OA often causes further adhesions in a vicious circle. Initially, laparoscopy for ASBO was informally banned because of greater difficulty, especially for untrained surgeons, and for suspected higher risk of iatrogenic injury compared with conventional laparotomy. Later, laparoscopy was limited to selected cases, while now it is more and more widespread as it is more frequently used for complex surgeries. Moreover, many studies have concluded that it is feasible and associated with early regain of intestinal transit, early refeeding, minor complications, and lower hospital stay.

This retrospective study reviews the cohort of ASBO patients admitted to our department and compare the features and outcomes of patients treated by medical versus surgical treatment. The aim is to understand whether early laparoscopic surgery can be considered a better option to manage ASBO in terms of short-term results (hospital stay, fasting time and consequently time to refeeding, time to regain intestinal function, number of radiological exams during recovery), and mild-term results (minor and major complications, and rate of recurrence).

Results show that the patients initially addressed to medical treatment (MT and DS) have a reasonable probability of resolution (77.3% of our cohort), but they show a prolonged fasting time, a doubled number of radiological exams, and more major complications in comparison with patients who underwent S24. If we exclude the DS group from the group initially treated by MT, we find that the difference in fasting time is no longer significant, as the fasting time of the DS group is obviously the sum of the time required by MT and the fasting time corresponding to peri- and post-operative phases. The time required for trying a conservative approach can obviously vary according to the protocol decided by operators to determine if the occlusion is resolved or not. Many centers adopted up to 72 h, but early administration of Gastrografin and a deadline of 24 h could reduce this time. However, in our case, even when patients received oral contrast quite early and the contrast transited through the colon by 24 h, clinical resolution sometimes required more time, even 48 h, because of other factors such as hydro-aerial levels, recurrent vomiting, and persistence of abdominal distention.

On the other hand, when we exclude the DS group from the initial MT, we observe an increase of the rate of recurrence, thus making the difference between surgical and medical treatments significant in support of the better effectiveness of surgery in the long term.

The comparison between OA and LA highlights that the LA group systematically shows significantly earlier regain of intestinal transit (1 day on average with a maximum of 4 days versus 4 days on average with a maximum of 24 days), shorter fasting time (only 3.5 days on average with a maximum of 5 days versus 6 days on average with a highest value of 36), reduced number of radiological exams, reduced hospital stay, and no more complications than those of the OA group. Therefore, LA for ASBO is not only less invasive and equally feasible than OA, but it has also positive implications in terms of costs and comfort for the patient.

Comparing the S24 and DS groups, the former is obviously associated to decreased fasting time. The differences in terms of regain of intestinal function are not significant, but S24 group shows shorter times of regain. The DS group systematically requires more radiological exams than the S24 group as the examinations to verify the effectiveness of the medical treatment must be added to the examinations for the surgical follow-up. Hospital stay is remarkably reduced in S24. To summarize, a surgery undertaken within the first 24 h seems to have more positive effects than a DS.

Finally, we analyzed the outcome of patients who underwent ES, since it comprises two patients who were treated several times only by MT. It should be highlighted that ES group is associated to a high risk of major complications and intestinal resection.

High LDH values and intestinal resection do not show any relationship. The highest values have been reported for patients who did not exhibit bowel necrosis and did not require resection. The same considerations hold true for CRP values. Since some patients were urgently taken out and suffered intestinal resection, in order to have comparable values of LDH and CRP (independently of the type of treatment), we used the values resulting from the clinical analysis performed at the time of admission. However, we believe that these parameters are not reliable enough and representative of the severity of the clinical situation. More likely, an analysis of the evolution of LDH and CRP values during the stay would provide a better picture, leading to other considerations and conclusions. Nonetheless, the low LDH values of the patients who underwent urgent resection for intestinal necrosis remain unexplained and deserve further research.

The Analysis of ASA score shows that the patient initial conditions do not influence the choice of the treatment, even though it should be noted that the majority of patients show mild systemic disease (ASA 2). However, we stress again that this study aims to review the standard treatment for the most patients rather than evaluating the best treatment for critical patients.

The present study has some limitations: small sample, retrospective nature, selection bias due to non-randomization, and short follow-up time. If all patients underwent early laparoscopic surgery, we cannot declare what the advantages or risk would be. Therefore, purposely designed perspective studies involving larger randomized samples and long follow-up period are required.

Despite these shortcomings, this study highlights the advantages of early laparoscopic surgical approach to the ASBO problem. When experienced surgeons perform laparoscopy, this is not more dangerous than open surgery, and when laparoscopy is feasible, it shows better results, including comparable or better operative time. When conversion is necessary, operative time is not too much incremented, with minimal risks for the patient. We therefore suggest laparoscopy as the option to be preferred for surgical treatment of ASBO.

Conclusions

Early laparoscopic surgery can be proposed as an alternative of management for SBO due to adherences. Early surgery is associated with reduced number of radiological exams, minor complications and lower recurrence rate compared to medical treatment, while laparoscopic surgery is associated with earlier regain of intestinal function, decreased fasting time, shorter hospital stay, reduced number of radiological exams, minor complications compared to open surgery. Medical treatment can be successful in the majority of the cases but it is associated to high recurrence rate, which may end in surgery, even urgent. All possibilities should be discussed with the patients accounting for their comorbidities, histories of complex laparotomies (e.g., Bricker), and will. Further studies should be undertaken to demonstrate risk factors and to identify which patients may benefit from medical treatment and who will need later surgery in any case.

Compliance with ethical standards

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