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# Laparoscopic versus open surgical management of small bowel obstruction: an analysis of clinical outcomes

**Ann Nordin**[1] · **Jacob Freedman**[2,3]

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**Abstract**
*Background* Laparotomy is the standard surgical approach for treatment of small bowel obstruction (SBO). Laparoscopic management could be beneficial in terms of less complications and shorter hospital stay. As the minimal invasive approach is gaining more acceptances in the treatment of SBO, there is an increased need of studies to analyze outcomes. The aim of the present study was to compare the short-term clinical outcomes of laparoscopy versus laparotomy in the surgical management of non-bariatric, non-malignant SBO.
*Methods* A retrospective analysis of patients treated for SBO during 2010–2015 was made by a comprehensive search of medical records. A matched-pair review was performed on patients managed surgically for non-bariatric, non-malignant SBO at Danderyd University Hospital, Stockholm, Sweden. Completed laparoscopic surgeries were matched against patients treated with open surgery.
*Results* Laparoscopy for SBO was initiated in 71 patients. Conversion to open surgery was performed in 42 %. Results from the matched-pair analysis showed that post-operative length of stay was reduced by 60 % ($P < 0.001$) in the laparoscopic cohort. Additionally, less major complications were reported and duration of surgery was reduced by 50 % ($P < 0.001$).
*Conclusions* Laparoscopic management is a safe and feasible alternative to laparotomy. Hospital length of stay was significantly shorter and morbidity rate acceptable.

**Keywords** Small bowel obstruction · Laparotomy · Laparoscopic surgery · Adhesiolysis · Outcomes

✉ Jacob Freedman
jacob.freedman@ki.se

[1] Karolinska Institutet, Stockholm, Sweden

[2] Department of Clinical Sciences, Karolinska Institutet at Danderyd Hospital, Stockholm, Sweden

[3] Department of Surgery, Danderyd Hospital, 18288 Stockholm, Sweden

## Small bowel obstruction

Small bowel obstruction (SBO) is a common cause of hospital admission and surgical intervention worldwide [1, 2]. In the USA, SBO accounts for 16 % of all surgical admissions and more than 300,000 surgeries annually [3]. These numbers reflect a notable burden on the healthcare system. The estimated yearly cost in the USA exceeded $2.3 billion in 2005, and the number is increasing [4]. The costs are not only a result of the emergent surgical intervention but also a result of the following hospitalization and potential post-operative complications [4–6]. An improvement in care efficiency of SBO patients could dramatically save both money and resources [5].

In industrialized countries, the small bowel is the site of obstruction in three quarters of all intestinal obstructions [7]. Previous abdominal surgery is the most important predictive factor of adhesion formation. The majority of patients presenting with adhesive SBO have undergone one or more abdominal or pelvic operations [6, 8]. This includes both laparoscopies and open procedures like appendectomies, bariatric operations, gynecological procedures, cholecystectomies and colorectal resections [6].

The traditional choice for lysis of intraabdominal adhesions is laparotomy. Laparotomy does, however, carry a risk of post-operative infections, incisional hernias, and may add to the process of adhesion formation [9, 10],

complications that could be minimized with a laparoscopic approach. Laparoscopic treatment of SBO is associated with less post-operative pain, quicker return of intestinal function, shorter hospital stay, reduced recovery time and fewer complications [2, 5, 6]. Findings also suggest that less post-operative adhesions are developed after laparoscopic surgery compared to the traditional open approach [1, 10].

However, since no randomized, controlled or prospective clinical trials have been made between the two methods. More evidence to confirm the feasibility and safety of laparoscopic approach in SBO is needed [2, 5, 6].

The aim of the present study was to compare the short-term clinical outcomes of laparoscopy versus laparotomy in the surgical management of small bowel obstruction.

## Materials and methods

### Study design

This is a retrospective matched case–control study that includes patients with small bowel obstruction admitted at Danderyd University Hospital, Stockholm, Sweden, between November 2010 and January 2015. The hospital is a teaching hospital with a primary uptake of half a million inhabitants and has a long tradition in laparoscopic surgeries where bariatric procedures, cholecystectomies, gastrectomies, many groin hernias and most colectomies are done laparoscopically.

The hospital database was queried for patients with a diagnosis of SBO, using ICD-10 codes for diagnosis or surgery for intestinal obstruction (K56X, JAH01, JFK01, JAP01) as a consequence of intestinal or peritoneal adhesions. The ICD-10 code for laparoscopic to open surgery (ZXK00) was used to find possible remaining patients that initially had undergone laparoscopy but not been registered with any of above ICD-10 codes.

Patients who underwent complete laparoscopic surgery were matched, based on age (±5 years) gender and previous surgery, with patients who had open surgery during the same time period. The patients in the matched open surgical group were found using ICD-10 codes for open approaches (JAH00, JFK00, JAP00). Data from these groups were collected and compared. Surgeries converted from laparoscopic to open approach were analyzed and included in the total laparoscopic group as intention-to-treat but were not included in the comparative analyze between laparoscopic and open surgical approach, Fig. 1.

Patients diagnosed with internal hernias as a complication after gastric by-pass surgery, inguinal hernias, obstruction due to tumors and major gastrointestinal resections (gastrectomies, colectomies, pancreatectomies, and hepatectomies) were excluded from the study.

Data drawn from the patient medical records included demographics and baseline characteristics such as age, sex, height and weight. Preoperative functional status was related to the patient's ability to perform activities of daily living (ADL) in the 30 days before surgery, defined as either dependent or independent. The patient's preoperative physical status was defined through American Society of Anesthesiologists (ASA) class [11] which was noted from the anesthesiologist's pre-surgery evaluation. For patients with previous abdominal surgery, etiology, operative characteristics such as type of surgical method and the presence or absence of a small bowel resection was noted.

Patient's comorbidities were grouped according to organ system: cardiac, pulmonary, renal, hepatic and neurological. Factors considered were hypertension, diabetes mellitus, body mass index (BMI) and smoking within the past year.

Operative and total anesthesia duration was recorded in minutes. Total length of stay (LOS) in hospital was recorded as continuous days from admission to a surgical department to discharge. Post-operative LOS was recorded as continuous days from operation to discharge. Any complication or need of antibiotics that could be derived to the performed operation and that occurred within 30 days was noted. Complications were graded with the Clavien-Dindo grading system for surgical complications. Time to return of gastrointestinal (GI) function was noted from the clinical chart.

Choice of surgery was up to the attending surgeon based on individual preferences, not all senior surgeons were comfortable with doing laparoscopic surgery for SBO. The preferred laparoscopic approach was to go with a Veress needle under the left costal arch in the mid-clavicular line for installation of capnoperitoneum, followed by a 5 mm port and a 5 mm flexible tip camera at the same location. Three more 5 mm ports were then placed to gain optimal access to the area of interest, typically inserted in the left lower quadrant and suprapubic region.

### Statistical analysis

Descriptive data of the study were examined and tabulated. As data did not follow normal distribution, median values, numbers and percentage were presented. Data for converted cases ($n = 30$) compared to all completed laparoscopies ($n = 41$) were described with number of patients and ratios.

Patients that had undergone complete laparoscopic surgery were matched and compared with patients having open surgery in terms of baseline characteristics, outcomes and complications. The nonparametric Wilcoxon rank-sum test was used for analysis of statistical differences between continuous variables. Significant differences

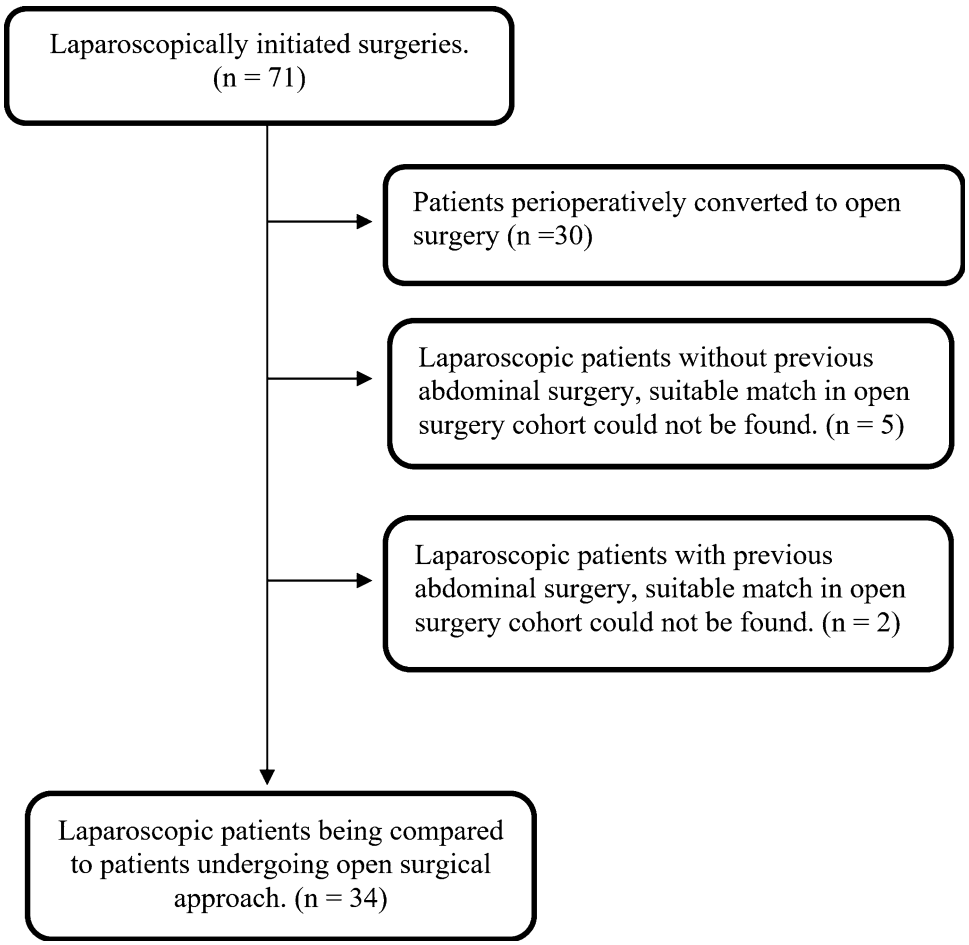


**Fig. 1** Flowchart of exclusion for matched-pair analysis. *n* number

in the distribution between categorical variables were tested by the $\chi^2$ test. All statistical calculations were processed with Sigma plot(tm), (Systat software Inc., San Jose, Ca, USA). A two-sided $P$ value <0.05 was considered statistically significant.

### Ethical considerations

This is a retrospective registry study of manifest clinical practice with ethical approval from the Regional Ethical Review Board in Stockholm County, Dnr 2015/171-31.

## Results

### Demographics

Between November 2010 and January 2015, there were 2453 instances of care for bowel obstruction. 894 of these had a surgical procedure during their hospital stay. Of these, 355 were caused by complications to previous gastric bypass surgery, 186 were caused by abdominal malignancies, 282 had an open exploration and 71 patients underwent laparoscopy for adhesive SBO. Of these, 65 % had previous surgery in the abdomen. Demographics of all completed laparoscopic surgeries and the converted cases are presented in Table 1. Except a higher incidence of ASA-class III in the completed laparoscopic group ($P = 0.048$), no significant differences could be seen between the two groups.

Median age was 65 years (ranging from 15 to 90 years old). The majority (63 %) were women, and the median BMI was 24 (range 16–44). Cardiac disease was the most frequent co-morbidity.

### Laparoscopic versus open surgical approach

Laparoscopic surgery was completed in 41 cases. However, due to inability to find a matching control in the open surgery group, seven patients had to be excluded from this matched-pair analysis. Since the matching was done based on age, sex and previous surgeries no differences were expected in these. There were no significant differences in the remaining patient characteristics between the two groups (Table 2, Fig. 2).

**Table 1** Patient characteristics for all laparoscopic patients

| | Completed laparoscopic surgery ($n = 41$) | | Laparoscopic to open conversion ($n = 30$) | | *P* |
|---|---|---|---|---|---|
| | *n* | % | *n* | % | |
| Sex | | | | | |
| Female | 25 | 61.0 | 20 | 66.7 | NS |
| Male | 16 | 39.0 | 10 | 33.3 | NS |
| Age | | | | | |
| Median | 41 | 68.4 | 30 | 62.3 | NS |
| < 40 | 10 | 24.4 | 7 | 23.3 | NS |
| 40–54 | 4 | 9.8 | 7 | 23.3 | NS |
| 55–69 | 8 | 19.5 | 7 | 23.3 | NS |
| 70–79 | 9 | 22.0 | 5 | 16.7 | NS |
| >80 | 10 | 24.4 | 4 | 13.3 | NS |
| BMI (kg/m$^2$) | | | | | |
| Underweight (<18.5) | 2 | 4.9 | 2 | 6.7 | NS |
| Normal (18.5–24.9) | 27 | 65.9 | 18 | 60.0 | NS |
| Overweight (25–29.9) | 10 | 24.4 | 9 | 30.0 | NS |
| Obese (>30) | 2 | 4.9 | 1 | 3.3 | NS |
| ADL | | | | | |
| Dependent | 6 | 14.6 | 0 | 0.0 | NS |
| Independent | 35 | 85.4 | 30 | 100.0 | NS |
| ASA class | | | | | |
| I and II | 15 | 44.1 | 12 | 70.6 | NS |
| III | 17 | 50.0 | 3 | 17.6 | 0,048 |
| IV | 2 | 5.9 | 2 | 11.8 | NS |
| Comorbidities* | | | | | |
| Hypertension[a] | 6 | 15.0 | 4 | 13.3 | NS |
| Cardiac disease[b] | 11 | 27.5 | 2 | 6.7 | NS |
| Pulmonary disease[c] | 2 | 5.0 | 3 | 10.0 | NS |
| Renal failure[d] | 1 | 2.5 | 1 | 3.3 | NS |
| Neurologic disease[e] | 3 | 7.5 | 0 | 0.0 | NS |
| Prior abdominal surgery | | | | | |
| No | 15 | 37.5 | 9 | 30.0 | NS |
| Laparoscopic | 7 | 17.5 | 3 | 10.0 | NS |
| Open | 12 | 30.0 | 12 | 40.0 | NS |
| Method unspecified | 6 | 15.0 | 6 | 20.0 | NS |

*P* values denote significance between groups

*n* number, *NS* non-significant, *BMI* body mass index, *ADL* activities of daily living, *ASA* American Society of Anesthesiologists

* Patients may appear in more than one co-morbidity category

[a] Hypertension defined as blood pressure >140/90 mmHg

[b] Cardiac disease defined as history of mitral insufficiency, congestive heart failure, angina or cardiac arrhythmia

[c] Pulmonary disease defined as history of chronic obstructive pulmonary disease (COPD) asthma or other chronic respiratory illness

[d] Renal failure defined as any history of chronic renal disease

[e] Neurologic disease defined as any history of neurological disease or sequel after brain injury, i.e., trauma or stroke

## Intra- and post-operative data

Significant differences between laparoscopic and open approach was found in LOS, surgery duration and time under anesthesia. Total LOS was reduced by half in the laparoscopic group compared to the laparotomy group (3 vs. 6 days, $P < 0.001$, range 1–62 vs. 1–29 days). Post-operative LOS was also significantly reduced in the

**Table 2** Patient characteristics for matched cohorts

| | Laparoscopic ($n = 34$) | | Open ($n = 34$) | | $P$ |
|---|---|---|---|---|---|
| | $n$ | % | $n$ | % | |
| Sex | | | | | |
| Female | 21 | 61.8 | 21 | 61.8 | NS |
| Male | 13 | 38.2 | 13 | 38.2 | NS |
| Age | | | | | |
| Median | 34 | 73.2 | 34 | 73.2 | NS |
| <40 | 3 | 8.8 | 3 | 8.8 | NS |
| 40–54 | 4 | 11.8 | 5 | 14.7 | NS |
| 55–69 | 8 | 23.5 | 8 | 23.5 | NS |
| 70–79 | 9 | 26.5 | 11 | 32.4 | NS |
| >80 | 10 | 29.4 | 7 | 20.6 | NS |
| BMI | | | | | |
| Underweight (<18.5) | 1 | 2.9 | 2 | 5.9 | NS |
| Normal (18.5–24.9) | 21 | 61.8 | 22 | 64.7 | NS |
| Overweight (25–29.9) | 10 | 29.4 | 6 | 17.6 | NS |
| Obese (>30) | 2 | 5.9 | 4 | 11.8 | NS |
| ADL | | | | | |
| Dependent | 5 | 14.7 | 9 | 26.5 | NS |
| Independent | 29 | 85.3 | 25 | 73.5 | NS |
| ASA class | | | | | |
| I and II | 11 | 32.4 | 6 | 35.3 | NS |
| III | 17 | 50.0 | 9 | 52.9 | NS |
| IV | 2 | 5.9 | 1 | 5.9 | NS |
| Comorbidities* | | | | | |
| Hypertension[a] | 6 | 17.6 | 15 | 44.1 | NS |
| Cardiac disease[b] | 11 | 32.4 | 9 | 26.5 | NS |
| Pulmonary disease[c] | 2 | 5.9 | 2 | 5.9 | NS |
| Renal failure[d] | 2 | 5.9 | 3 | 8.8 | NS |
| Neurologic disease[e] | 3 | 8.8 | 8 | 23.5 | NS |
| Diabetes mellitus[f] | | | | | |
| No | 32 | 94.1 | 29 | 85.3 | NS |
| Orals | 1 | 2.9 | 3 | 8.8 | NS |
| Insulin | 1 | 2.9 | 2 | 5.9 | NS |
| Prior abdominal surgery | | | | | |
| No | 10 | 29.4 | 9 | 26.5 | NS |
| Laparoscopic | 6 | 17.6 | 2 | 5.9 | NS |
| Open | 12 | 35.3 | 17 | 50.0 | NS |
| Method unspecified | 6 | 17.6 | 6 | 17.6 | NS |
| Hours from admittance to surgery | 25 | | 23 | | NS |
| Largest small bowel diameter (mm) on preoperative radiology | 38 | | 40 | | NS |

*P* values denote significance between groups

*n* number, *NS* non-significant, *BMI* body mass index, *ADL* activities of daily living, *ASA* American Society of Anesthesiologists

* Patients may appear in more than one co-morbidity category

[a] Hypertension defined as blood pressure >140/90 mmHg

[b] Cardiac disease defined as history of mitral insufficiency, congestive heart failure, angina or cardiac arrhythmia

[c] Pulmonary disease defined as history of chronic obstructive pulmonary disease (COPD) asthma or other chronic respiratory illness

[d] Renal failure defined as any history of chronic renal disease

[e] Neurologic disease defined as any history of neurological disease or sequel after brain injury, i.e., trauma or stroke

[f] Fasting plasma glucose ≥7.0 mmol/l, oral glucose tolerance test ≥11.1 mmol/l or HbA1c ≥48

laparoscopic group compared to the laparotomy group (2 vs. 5 days, $P < 0.001$, range 0–62 vs. 0–29 days) (Table 3).

No significant differences could be seen in complications following the two surgical approaches. The laparoscopic group had less major complications, but the difference did not reach statistical significance (Table 4). Rates of unplanned reoperation within 30 days from primary operation were comparable between the laparoscopic and open approach. Reoperation was performed due to iatrogenic bowel perforation in two cases in both groups. No significant difference could be seen in iatrogenic bowel injury between laparoscopic and laparotomy groups. However, five cases of serosal tears were reported in the laparotomy group, while no injury of that character was noted in the laparoscopic group. Laparoscopically treated patients had bowel movement 1 day earlier compared to the open cohort (1.8 vs. 2.8 days, $P = 0.029$, range 1–3 vs. 0–8 days) (Table 3).

### Laparoscopic to open conversion

Conversion to open surgery was performed in 30 cases (42 %), Table 5. The lower right quadrant was the most common site of obstruction (46 %) in completed laparoscopies. The most common site of obstruction for converted was the central abdominal region (42 %). Most conversions 77 % were due to intraoperative complications, reactive conversions. Impaired working space or dense adhesions, preemptive conversions, constituted the remaining 23 % of conversions, Table 6.

Bowel perforation due to trocar insertion was reported in two cases, one of these was converted to open surgery.

Correlation between the number of initiated laparoscopic procedures and conversions to open surgery per year is presented in Fig. 3.

Complication rates after conversions did not differ from patients that were started with an open approach. Minor complications were seen in 10/30 (9/34 for open) patients and major in 4/30 (5/34 for open).

## Discussion

The study showed that hospital length of stay was significantly shorter with laparoscopic treatment of small bowel obstruction than with open surgery, 3 versus 5 days. No statistical difference between groups could be seen in either pre-surgical co-morbidities or in post-operative complication rate. The most common reason for conversion was massive adhesions and impaired access.

The first reported case where a single-band adhesion was successfully lysed through laparoscopic surgery was published in 1991 by Bastug et al. [12]. Despite that several years and multiple studies have passed since then, laparoscopy is not yet fully accepted as treatment of choice for SBO [5, 6, 13, 14]. An increasing amount of literature has compared outcomes between laparoscopic and open surgical management of SBO [2, 5, 6, 15]. Compared to open surgery, the laparoscopic approach is associated with significantly lower rates of complications, less post-operative pain, quicker return of intestinal function, reduced recovery

**Table 3** Comparison of outcomes: laparoscopic versus open surgery

| | Laparoscopic ($n = 34$) | | Open ($n = 34$) | | $P$ |
|---|---|---|---|---|---|
| | | % | | % | |
| Median operative time (min) | 28 | | 55 | | <0.001 |
| Median anesthetic time (min) | 76 | | 116 | | <0.001 |
| Median LOS (days) | 3 | | 6 | | <0.001 |
| Median post-operative LOS (days) | 2 | | 5 | | <0.001 |
| Early readmission[a] ($n$) | 3 | 8.82 | 2 | 5.9 | NS |
| Emergency department visit[b] ($n$) | 2 | 5.88 | 1 | 2.9 | NS |
| Mean time to defecation (days) | 1.8 | | 2.8 | | 0.029 |
| Bowel perforations ($n$); | 5 | 14.71 | 10* | 29.4 | NS |
| discovered during surgery ($n$) | 3 | 8.82 | 4 | 11.8 | NS |
| discovered post-operation ($n$) | 2 | 5.88 | 1 | 2.9 | NS |

*P* values denote significance between groups

*Min* minutes, *n* number, *NS* non-significant, *LOS* length of stay

* Including five cases of serosal rifts

[a] Early readmission defined as readmission to a surgical service within 30 days of discharge

[b] Emergency department visit defined as presentation to an emergency department within 30 days of discharge

**Table 4** 30-day post-operative complications: laparoscopic versus open surgery

| | Laparoscopic ($n = 34$) | | Open ($n = 34$) | | $P$ |
|---|---|---|---|---|---|
| | $n$ | % | $n$ | % | |
| Overall complications | 14 | 41.2 | 14 | 41.2 | NS |
| Minor complications[a] | 11 | 32.4 | 9 | 26.5 | NS |
| Major complications[b] | 3 | 8.8 | 5 | 14.7 | NS |
| Mortality | 1 | 2.9 | 2 | 5.9 | NS |
| Reoperation | 3 | 8.8 | 5 | 14.7 | NS |
| Antibiotics | 9 | 26.5 | 13 | 38.2 | NS |

*P* values denote significance between groups

*n* number, *NS* non-significant

[a] Clavien-Dindo classification I-IIIa

[b] Clavien-Dindo classification IIIb-V

**Table 5** Converted cases; laparoscopic to open surgical approach

| | Laparoscopic approach ($n = 71$) | | Conversion laparoscopic to open approach ($n = 30$) | |
|---|---|---|---|---|
| | | % | | % |
| Age (median) | 73 | | 62 | |
| Women (*n*) | 45 | 63.4 | 20 | 66.7 |
| BMI >25 (kg/m$^2$) | 22 | 31.0 | 10 | 33.3 |
| Converted cases in total (*n*) | | | 30 | 42.3 |
| Preemptive conversions (*n*) | | | 7 | 23.3 |
| Reactive conversions (*n*) | | | 23 | 76.7 |

*n* number, *NS* non-significant, *BMI* body mass index

**Table 6** Reasons for conversions in detail

| | *n* | % |
|---|---|---|
| Impaired visibility | 1 | 3.3 |
| Inadequate access | 6 | 20.0 |
| Cyanotic bowel | 5 | 16.7 |
| Adhesions[a] | 11 | 36.7 |
| Bowel perforation | 5 | 16.7 |
| Other[b] | 2 | 6.7 |

*n* number

[a] Including dense adhesions and complicated fibrous adhesions

[b] Including suspected malignancy and pus in abdominal cavity

time and shorter length of stay [1, 5, 10, 16]. Previous studies reports a total LOS ranging between 4.7 and 8.4 days for laparoscopic surgery and between 7 and 12.8 days for open surgery [5, 6, 14, 15].

The present study demonstrated a significant reduction in operative time and time under anesthesia. In a previous study, open adhesiolysis had shorter procedural times than laparoscopic approach [5]. More recent studies have not found any significant differences in duration of surgery and time under anesthesia between laparoscopic and open surgical approaches [2, 5, 15]. It is likely that a growing experience in the laparoscopic approach [6] is a key to the reduced surgical duration reported in the more recent studies. This might also be the reason why the present study compares favorably to previous studies in that regard.

This study showed no significant differences in complication rates between laparoscopic and open surgery approaches. Although, when studying the numbers of major complications, re-operations and the need for post-operative antibiotics, a slight non-significant decrease can be seen in laparoscopic group. The less frequent use of antibiotics could be a reflection of a lower incidence of post-operative infections such as pneumonia and surgical site infections as a response to the smaller incisions and a shorter time bound to bed. In a propensity-score matched study, Lombardo et al. [5] found that patients treated with laparoscopy for SBO had half as many post-operative complication [odds ratio (OR) 0.48; 95 % confidence interval (CI) 0.30–0.77]. The authors explained the reduction by lower rates of wound infection, sepsis and blood transfusions. An important distinction between that and the present study is that the former includes patients with internals hernias after gastric by-pass operations. However, in a study where all non-adhesional obstructions were excluded, Byrne et al. [15] found an overall significantly lower complication rate of 27.7 versus 43.6 % in a

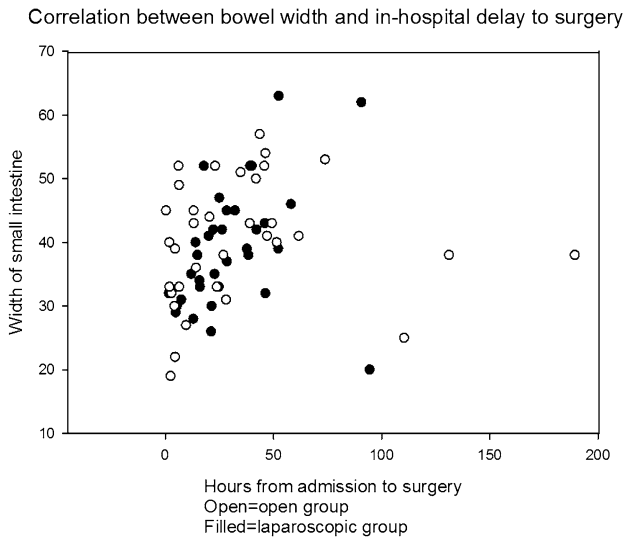


**Fig. 2** Distribution of in-hospital delay to surgery and small bowel distention

multivariable analysis comparing laparoscopic to open adhesiolysis. Unlike the present study, Byrne et al. used multiple logistic regression to examine the relationship between overall complications and surgical approach. Further, a meta-analysis by Li et al. concluded that laparoscopic adhesiolysis was associated with a reduced overall complication rate (odds ratio 0.42, CI 0.25–0.70,) compared to open adhesiolysis.

No significant difference in iatrogenic injury between groups was found in the present study. Interestingly, Byrne et al. [15] found iatrogenic injury to be significantly more common in an open surgery cohort than in a laparoscopically treated cohort. Contrary to those findings, Wullstein et al. [17] found a higher percentage of bowel perforations in the laparoscopic cohort compared to the open cohort (26.9 vs. 13.5 %). Their findings support evidence that laparoscopic treatment of acute SBO is associated with an increased risk of bowel perforations compared to the traditional open surgery. Due to the small and retrospective nature of the present study, no conclusion can be drawn regarding this matter, but together with other studies showing similar results it may at least serve as an indication that laparoscopic management of acute SBO might be less associated with iatrogenic injury than previously assumed [1, 15, 16].

The conversion rate at 42 % in this study corresponds rather well with the findings by Byrne et al. who reported a conversion rate at 39 %. In yet another retrospective comparative study Wullstein et al. found a conversion rate of 52 %. Slightly lower percentages, 29 and 33 %, were presented in two large review articles covering over 2000, respectively, 1000 patients [1, 16]. The rather wide range of conversion rates might be a result of the heterogeneity in the available studies and could a selection bias where, in the early experience, easier cases are selected for laparoscopy. When including internal hernias into the studies, groups get larger and conversion rate might be further reduced due to the different character of SBO of that etiology. However, the importance of a low threshold for conversion to open surgery throughout the entire surgical procedure is emphasized in most reports [1, 8, 16]. The results in the present study showing that both the number of initiated laparoscopies and conversions are increasing might be seen as proof of widening indication for the laparoscopic method with a maintained option to convert.

In the present study, the primary cause for conversion was adhesions followed by impaired access. The obstruction was in converted cases located in the peri-umbilical area in a higher extent compared to the completed

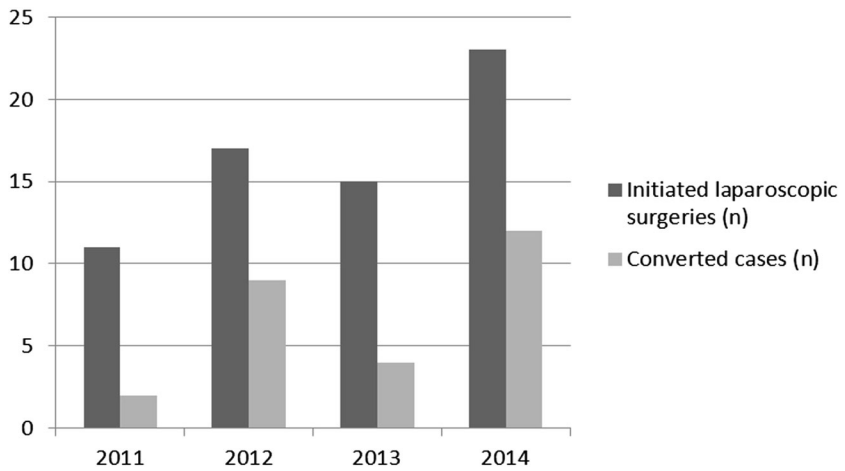


**Fig. 3** Number of laparoscopic surgeries and converted cases. *n* number

laparoscopic surgeries, were the obstruction was most commonly found in lower right quadrant. These findings are mirroring the findings of Khaikin et al. [18], and a correlation has been seen between location of obstruction and conversion to open surgery where anterior peritoneal adhesions being a common cause of conversion [19]. O'Connor and Winter found that dense adhesions were the reason for conversion in 29 % of cases. Unlike in the present study, ischemic bowel was the second most common reason representing 24 % [16]. Conversion has been associated with increased morbidity compared with patients that undergo laparoscopic surgery [13, 19]. It has even been stated that morbidity rates for conversion are higher than those for open surgery [13]. This was not found in the present study which is in accordance with a previous study by Byrne et al. [15]. Conversion has not been found to correlate with the number of previous abdominal surgeries [1] although might be predicted by factors like bowel distension $\geq$4 cm on preoperative CT, a history of dense adhesion and presence of complete distal obstruction [1, 15]. This study could not find any difference between the matched groups regarding in-hospital delay to surgery or bowel distention. These are, however, not perfect ways to describe the severity of the disease because the patients delay has not been included and can be anywhere from a couple of hours to many days before seeking help at the emergency department. Patients in severe pain will have early surgery and patients with obstruction without severe pain will wait longer in hope of spontaneous resolution. Bowel distension can also be an inadequate marker of severity as patients with chronic obstruction will have a larger distention, and it will also vary with the level of obstruction and frequency of vomiting or naso-gastric tube clearance.

Laparoscopically initiated surgeries were increasing over time in this study. The choice of surgical method does not only depend on characteristics of the obstruction. The patient presentation and co-morbidities, including perceived ability to tolerate laparoscopy, must be considered [5]. Additionally, the surgeons' experience, training and comfort level is central in choice of method [5, 9]. The laparoscopic proficiency among surgeons is growing as this minimal invasive approach is gaining in acceptance. In 2008 11.4 % of all operations for adhesiolysis in the USA were performed with a laparoscopic approach, 5 years later that number was 14.9 % (6, 22). Surgeons at teaching hospitals are more likely to consider laparoscopic adhesiolysis. Recent surgical training and interest or membership in minimally invasive surgical associations are also factors that affect the choice of method (9). This introduces a degree of selection bias that may be difficult to circumvent when comparing outcomes between the two methods (5).

There are several important limitations with this study that needs to be recognized. As this was a retrospective observational study, it was impossible to adjust for all possible confounders in the analysis. The decision whether a patient should undergo laparoscopic or open surgery was non-random. This carries concerns that the decision to perform laparoscopy already from the start was biased and that 'healthier' patients were chosen to a greater extent. To circumvent this problem, patients were matched based on age, sex, activities of daily life and previous abdominal surgery. Deficiencies in data reporting in patient records, ambiguities and missing information may still, however, aggravate an accurate comparison between the two groups. Unobserved variables affecting the outcome might still be present such as differences in perioperative care. However, data presented in the present study were considered to be overall truly representative of laparoscopy and open surgery for adhesive SBO at Danderyd University Hospital during the investigated time period. A strength of the study is that except for the cases of missing data no limitations due to pre-decided factors affected the study design.

Diagnoses and surgical interventions were obtained as ICD-codes, which are highly dependent on accurate record keeping. The database was broadly searched in order to find and include all patients that had undergone laparoscopic surgery for adhesive SBO. Despite this, there may still be patients that met the inclusion criteria but were not found in the search due to incorrect ICD-coding. Data from private Swedish health care centers and/or foreign hospitalizations were not obtained and potential re-admissions and post-operative care in these facilities may have been missed, although this is very unlikely, as the private healthcare sector for emergent surgeries is virtually non-existent in the Stockholm area.

The cases in the present study corresponds well with the normal incidence of SBO in the population, the hospital does not admit a preselected profile of patients. This ensures a good generalizability of the study.

The results in the present study indicate that laparoscopic adhesiolysis of SBO results in a faster recovery and shorter LOS for this group of patients. This advantage combined with morbidity and mortality rates that are similar to those in open surgery implies that laparoscopy is a safe and feasible complement to the palette of treatments for SBO.

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**Compliance with ethical standards**

**Disclosures** Ann Nordin and Jacob Freedman have no conflicts of interest or financial ties to disclose.

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