



The impact of laparoscopy on emergency surgery for adhesional small bowel obstruction: prospective single centre cohort study

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ABSTRACT

Introduction Laparoscopic adhesiolysis is increasingly being used to treat adhesional small bowel obstruction (ASBO) as it has been associated with reduced postoperative length of stay (LOS) and faster recovery. However, concerns regarding limited working space, iatrogenic bowel injury and failure to relieve the obstruction have limited its uptake. This study reports our centre's experience of adopting laparoscopy as the standard operative approach.

Methods A single-centre prospective cohort study was performed incorporating local data from the National Emergency Laparotomy Audit Database; January 2015 to December 2019. All patients undergoing surgery for ASBO were included. Patient demographic, operative and in-hospital outcomes data were compared between different surgical approaches. Linear regression analysis was performed for LOS.

Results A total of 299 cases were identified. Overall, 76.3% of cases were started laparoscopically and 52.2% were completed successfully. Patients treated laparoscopically had lower Portsmouth – Physiological and Operative Severity Score for the enuMeration of Mortality and morbidity (P-POSSUM) predicted mortality (median 2.1 (interquartile range (IQR) 1.3–5.0) vs 5.7 (IQR 2.0–12.4), $p < 0.001$) and shorter postoperative LOS compared with open (median 4.2 days (IQR 2.5–8.2) vs 11.3 days (IQR 7.3–16.6), $p = 0.000$). In-hospital mortality was lower in the laparoscopic group (2 vs 7 deaths, $p < 0.001$). In regression analysis, laparoscopic surgery was found to have the strongest association with postoperative LOS ($\beta -8.51$ (–13.87 to –3.16) $p = 0.002$) compared with open surgery.

Conclusions Laparoscopy is a safe and feasible approach for adhesiolysis in the majority of patients with ASBO. It is associated with reduced LOS with no impact on complications or mortality.

KEYWORDS

Laparoscopy – Adhesiolysis – Intestinal obstruction

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Introduction

Adhesional small bowel obstruction (ASBO) is one of the most common general surgical emergencies and places a substantial burden on health services, accounting for approximately 4,000 emergency laparotomies annually in England and Wales alone.^{1,2} While adhesiolysis has been performed traditionally using an open approach, laparoscopic adhesiolysis has been gradually adopted for selected cases in some centres.^{3,4}

Recent meta-analyses have suggested that a laparoscopic approach may be associated with a reduction in postoperative pain, length of hospital stay and faster recovery from surgery.^{5,6} The recent laparoscopic versus open adhesiolysis for adhesive small bowel obstruction (LASSO) randomised trial reported that laparoscopic adhesiolysis reduced length of stay (LOS) and postoperative pain, with quicker return to normal bowel function, without increasing complications.⁷ The latest iteration of the World Society of Emergency Surgery

guidelines for ASBO recognises the laparoscopic approach to ASBO, while highlighting the need for careful patient selection and sufficient surgical experience. Specifically, these recommendations identify patients with two or fewer previous laparotomies, or in whom a single adhesional band is expected, as those most likely to benefit from laparoscopy.⁸

Portsmouth Hospitals NHS Trust is a high-volume tertiary referral centre for gastrointestinal (GI) surgery and has been an early adopter of laparoscopy in both elective and emergency surgery. The emergency surgery service is staffed by a specialist upper and lower GI consultant surgeon each day. This allows provision of subspecialist care for all abdominal surgical emergencies, by surgeons with expertise in laparoscopy.⁹

This paper describes our centre's experience of adopting laparoscopy as the standard operative approach to ASBO. Its primary objective is to describe and compare the characteristics and outcomes of patients having either open or laparoscopic adhesiolysis during the study

period. Its secondary objectives include analysis of temporal trends; comparison of intention to treat vs treatment received; impact of time to surgery (TTS) on outcomes; and linear regression analysis with a uni- and multivariable model.

Methods

This was a single-centre prospective cohort study performed using data from the National Emergency Laparotomy Audit (NELA) database, for Portsmouth Hospital NHS Trust. NELA is a prospectively maintained database of all patients in England and Wales requiring major emergency abdominal surgery. Inclusion criteria and data collection for NELA have been described previously.² The study used data extracted from January 2015 to December 2019.

Only patients who underwent surgery for ASBO were included in the study. Patients with other recorded causes of small bowel obstruction, such as malignancy or hernia, were excluded. The following variables were extracted from the NELA database: patient age and gender, pre-operative American Society of Anaesthesiology (ASA) physical status classification and Portsmouth – Physiological and Operative Severity Score for the enumeration of Mortality and morbidity (P-POSSUM) scores, operative approach, findings and procedure performed, TTS, LOS, return to theatre and in-hospital mortality. The primary outcomes measured were postoperative LOS, death and return to theatre. For cases where there was a death or return to theatre, electronic medical records were also interrogated to provide further information (see Tables 3 and 4). The NELA dataset does not record individual complications beyond return to theatre or death, and thus more generalised complications have not been included in the study.

Surgical approach is classified in the database as laparoscopic, open, laparoscopically (lap) assisted and laparoscopic converted to open. Surgical approach was analysed both by intention-to-treat and by treatment received. For the purposes of analysis on the basis of treatment received, both lap-assisted and converted cases were considered to have been completed open. To assess the effect of a delay in surgery on outcomes, data was divided into three groups based on TTS: TTS <24h, TTS <48h and TTS <72h. The effect timing of surgery had on laparoscopy rates was compared by dividing the dataset into timeslots: day (8am–5pm), evening (5pm–12 midnight) and night (12 midnight–8am). Temporal trends were assessed in annualised increments.

Risk adjustment to compare different treatment groups was performed using ASA grade and pre-operative P-POSSUM predicted mortality.^{10,11} ASA grade is a classification system used routinely to provide an overall assessment of physical health and fitness prior to surgery.¹⁰ P-POSSUM is an established and well-validated risk prediction tool for providing

postoperative risk adjustment for abdominal surgery.^{11,12} Both tools have been demonstrated to be reasonably effective and well-validated tools in systematic review of validation studies.¹²

Data were compared using Pearson χ^2 test, Fisher's Exact and Mann-Whitney U tests. Univariable associations between variables and postoperative LOS were assessed using linear regression analysis; variables with a p -value <0.1 were included in a subsequent multivariable linear regression model. Mortality was not used as an outcome in regression analysis due to an insufficient number of events.¹⁵ Data analysis was performed in Microsoft Excel (Microsoft Corp, Redmond, WA) and statistical analysis in R software (R Foundation, Vienna, Austria).

Results

Data extracted from the local NELA database contained 1,240 operative episodes between January 2015 and December 2019. Of these, 494 patients were operated for small bowel obstruction, of which 299 cases with a recorded aetiology of adhesions were included in the final analysis.

Outcomes

Demographic, operative and outcomes data according to intention-to-treat are shown in Table 1. Patients in whom laparoscopic surgery was attempted (intention-to-treat comparison) were of similar age to open surgery but had a significantly lower mortality risk and ASA grade, and experienced a lower mortality rate and LOS.

Comparing patients for whom surgery was successfully completed laparoscopically versus open surgery (comparison of treatment received) revealed similar trends, with lower pre-operative mortality risk, and less mortality and lower LOS (see Table 2).

Patients for whom surgery was started laparoscopically but required conversion to laparoscopically assisted or laparotomy did not exhibit significantly different pre-operative mortality risk or ASA grade from the laparoscopically successful group (see Table 2) but experienced a longer LOS (see Figure 1). A further subgroup comparison between the converted group and patients who went straight to open surgery demonstrated lower pre-operative P-POSSUM scores ($p=0.005$) and ASA grade ($p=0.014$), but no differences in lengths of stay ($p=0.333$) or mortality ($p=0.088$).

No differences were observed in TTS between operative approaches (see Table 1). Additional subanalysis on timing of surgery found that approximately two-thirds of cases for each operative approach were done during the day, with no significant increase in rates of open surgery at night ($p=0.3628$; Fisher's Exact test). The majority of procedures were performed by a consultant surgeon. Of the 11 cases performed by a specialty trainee, 10 were completed laparoscopically and 1 open. There were no deaths or returns to theatre for this group.

Table 1 Demographic and operative characteristics for cases started laparoscopy or open (intended treatment)

	Started LAP n=228	Started Open n=71	p-value
Males	95 (41.7%)	25 (35.2%)	0.406
Age (years)	70 (53–78)	69 (52.5–80.5)	0.894
TTS (days)	1.7 (0.9–3.4)	1.9 (1.1–4.4)	0.220
Surgery < 24h (%)	70 (30.7%)	17 (23.9%)	0.275
Surgery < 48h (%)	126 (55.3%)	37 (52.1%)	0.643
Surgery < 72h (%)	159 (69.7%)	46 (64.8%)	0.434
Pre-operative P-POSSUM (%)	2.1 (1.3–5)	5.7 (2–12.4)	<0.001
Mean ASA grade (SD)	2.2 (0.8)	2.6 (0.8)	<0.001
LOS (days)	8.3 (5.2–15.7)	14.4 (11.2–24.9)	<0.001
Postoperative LOS (days)	5.6 (3.2–12.5)	11.3 (8.1–17.2)	<0.001
Inhospital mortality	2 (1%)	7 (10%)	<0.001
Bowel resection (%)	29 (12.7%)	21 (29.6%)	0.002

Data are median (IQR) unless otherwise stated. p-values calculated with Pearson χ^2 for gender, deaths and resection and Mann–Whitney *U* test for all other variables
 ASA = American Society of Anaesthesiology; IQR = interquartile range; LAP = laparoscopically; LOS = length of stay; P-POSSUM = Portsmouth – Physiological and Operative Severity Score for the enuMeration of Mortality and morbidity; SD = standard deviation; TTS = time to surgery

Table 2 Demographic and operative characteristics for treatment received, comparing laparoscopic group to open group (including both laparoscopically assisted and converted to open in the ‘open’ group); and just the converted group (containing both laparoscopically assisted and converted to open)

	LAP (n=156)	Open (n=143)	p-value	Converted (n=72)	p-value vs LAP
Males	69 (44.2%)	51 (35.7%)	0.164	26 (36.1%)	0.312
Age (years)	68.5 (52.8–79)	70 (53–79)	0.581	70 (57–77)	0.561
TTS (days)	1.8 (0.9–3.7)	1.8 (0.9–3.4)	0.735	1.7 (0.9–2.9)	0.627
Surgery < 24h, N (%)	49 (31.4%)	38 (26.6%)	0.359	21 (29.2%)	0.734
Surgery < 48h, N (%)	84 (53.8%)	79 (55.2%)	0.809	42 (58.3%)	0.528
Surgery < 72h, N (%)	105 (67.3%)	100 (69.9%)	0.627	54 (75%)	0.241
Pre-operative P-POSSUM (%)	2.1 (1.2–5)	3 (1.8–10.5)	0.001	2.5 (1.5–5)	0.215
Mean ASA grade (SD)	2.2 (0.8)	2.4 (0.8)	0.008	2.2 (0.7)	0.419
LOS (days)	6.5 (4.4–12.4)	13.7 (9.2–20.7)	0.000	12.9 (8.4–19)	<0.001
Postoperative LOS (days)	4.2 (2.5–8.2)	11.3 (7.3–16.6)	0.000	10.4 (6.6–16.1)	<0.001
Inhospital mortality	1 (1%)	8 (6%)	0.014	1 (1%)	0.286
Bowel resection (%)	6 (3.8%)	44 (30.8%)	0.000	23 (31.9%)	<0.001

Data are median (IQR) unless otherwise stated. p-values calculated with Pearson χ^2 for gender, deaths and resection and Mann–Whitney *U* test for all other variables
 ASA = American Society of Anaesthesiology; IQR = interquartile range; LAP = laparoscopically; LOS = length of stay; P-POSSUM = Portsmouth – Physiological and Operative Severity Score for the enuMeration of Mortality and morbidity; SD = standard deviation; TTS = time to surgery

Bowel resection or stoma formation was required in 17.7% of procedures and, in almost all cases, resulted in conversion to open or lap-assisted surgery.

Complications, such as iatrogenic bowel injury, are not recorded in NELA. However, rates of unplanned return to theatre in patients having either laparoscopic or open

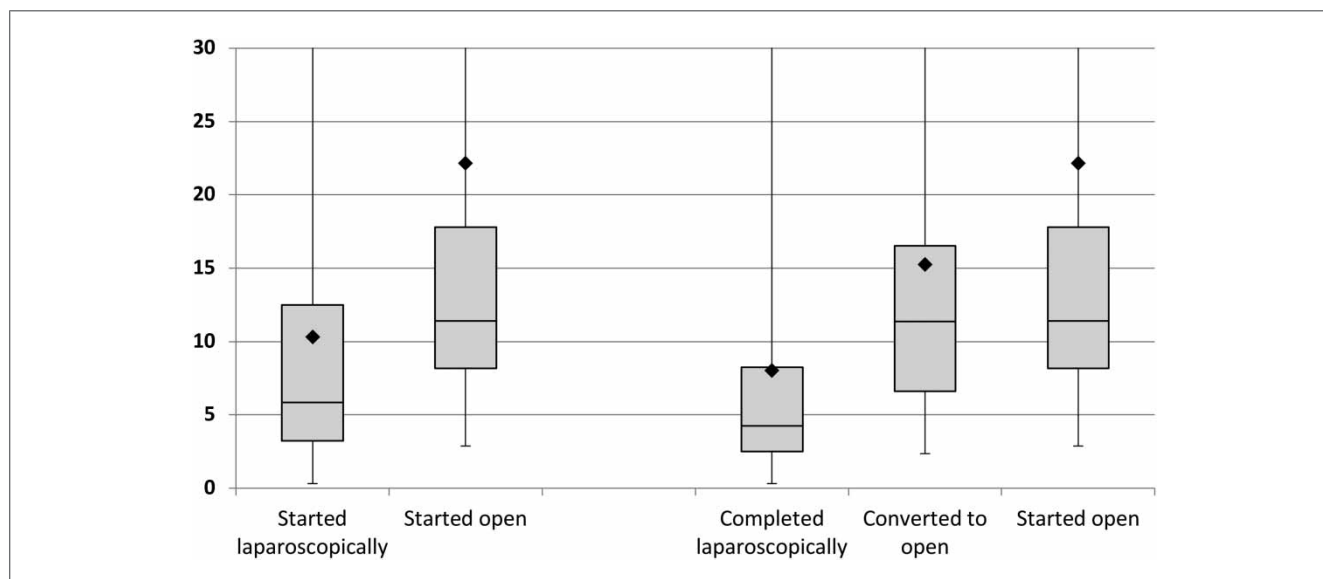


Figure 1 Median postoperative LOS (days) by procedure displayed as boxplots with mean denoted by ♦. LOS = length of stay.

Table 3 Case summary for each return to theatre

Age	Sex	First surgery	Second surgery	Total postoperative LOS
87	Female	Laparoscopic adhesiolysis	Laparotomy day 10 for ongoing ASBO	62 days
83	Female	Laparoscopic adhesiolysis, repair port site hernia & small bowel resection	Anastomotic leak - laparotomy day 7 & small bowel resection & stoma	87 days
45	Male	Laparoscopic adhesiolysis	Laparotomy day 10 for ongoing ASBO	52 days
63	Female	Laparoscopic adhesiolysis; tear noted & repaired	Laparotomy day 2 for resection & anastomosis	16 days
52	Female	Laparotomy, adhesiolysis & small bowel resection	Unwell day 1, re-laparotomy & further resection & anastomosis	9 days
70	Male	Laparotomy, adhesiolysis & small bowel resection for small bowel adenocarcinoma	Leak from join; relaparotomy day 6 for further small bowel resection & anastomosis.	35 days

ASBO = adhesional small bowel obstruction; LOS = length of stay

surgery were low and not significantly different, 4/155 (2.6%) versus 2/142 (1.4%), respectively ($p=0.189$, see Table 3). Overall inhospital mortality was low (3%), with the majority of deaths occurring with open adhesiolysis (see Table 4).

Temporal trends

The proportion of cases started laparoscopically increased incrementally between 2015 and 2019 (64.5% to 85.3%), with the number of cases completed successfully following the same trend (41.9% to 61.1%, Figure 2). The rate of conversion to open remained broadly similar at around 25%, and there was a concomitant reduction in the proportion of cases started with a laparotomy (35.5%

to 16.7%). No significant difference was found ($p=0.262$, Fisher’s Exact test).

Regression analysis

Multivariable linear regression was applied to all demographic and operative factors (see Table 5). Laparoscopic surgery was found to have the strongest association with postoperative LOS (beta coefficient -8.51 (-13.87 to -3.16) $p=0.002$) compared with open surgery. No significant difference was seen between open and converted groups (beta coefficient -4.90 (-10.88 – 1.08) $p=0.108$). Bowel resection, ASA grade, and P-POSSUM scores were also found to have positive associations with LOS.

Table 4 Case summary for each mortality

Age	Sex	P-POSSUM	Approach	Pathology	Operation	Survival	Cause of death
48	Male	2.3	Laparoscopic	ASBO	Adhesiolysis	3 days	Massive systemic inflammatory response with multiorgan failure
95	Male	23.7	Lap-to-open	Adhesions with small bowel volvulus	Untwisting of volvulus	2 days	Frailty – multiorgan failure
65	Female	9.6	Open	ASBO and pancreatic cancer	Adhesiolysis & resection	49 days	Disseminated pancreatic cancer
87	Female	12.5	Open	ASBO after right hemicolectomy	Adhesiolysis & resection	6 days	Massive systemic inflammatory response with multiorgan failure
80	Male	61.1	Open	ASBO with small bowel twisted around ileostomy	Adhesiolysis & reduction of small bowel	1 day	Massive systemic inflammatory response with multiorgan failure
86	Female	7.1	Open	ASBO	Adhesiolysis & resection	6 days	Stroke
60	Female	16.5	Open	ASBO	Adhesiolysis	5 days	Upper gastrointestinal bleed
62	Male	5.9	Open	ASBO and metastatic rectal cancer	Adhesiolysis & bypass	9 days	Metastatic rectal cancer
75	Male	23.7	Open	ASBO with internal hernia after cystoprostatectomy	Adhesiolysis & resection	50 days	Internal hernia after cystoprostatectomy

ASBO = adhesional small bowel obstruction; P-POSSUM = Portsmouth – Physiological and Operative Severity Score for the enuMeration of Mortality and morbidity

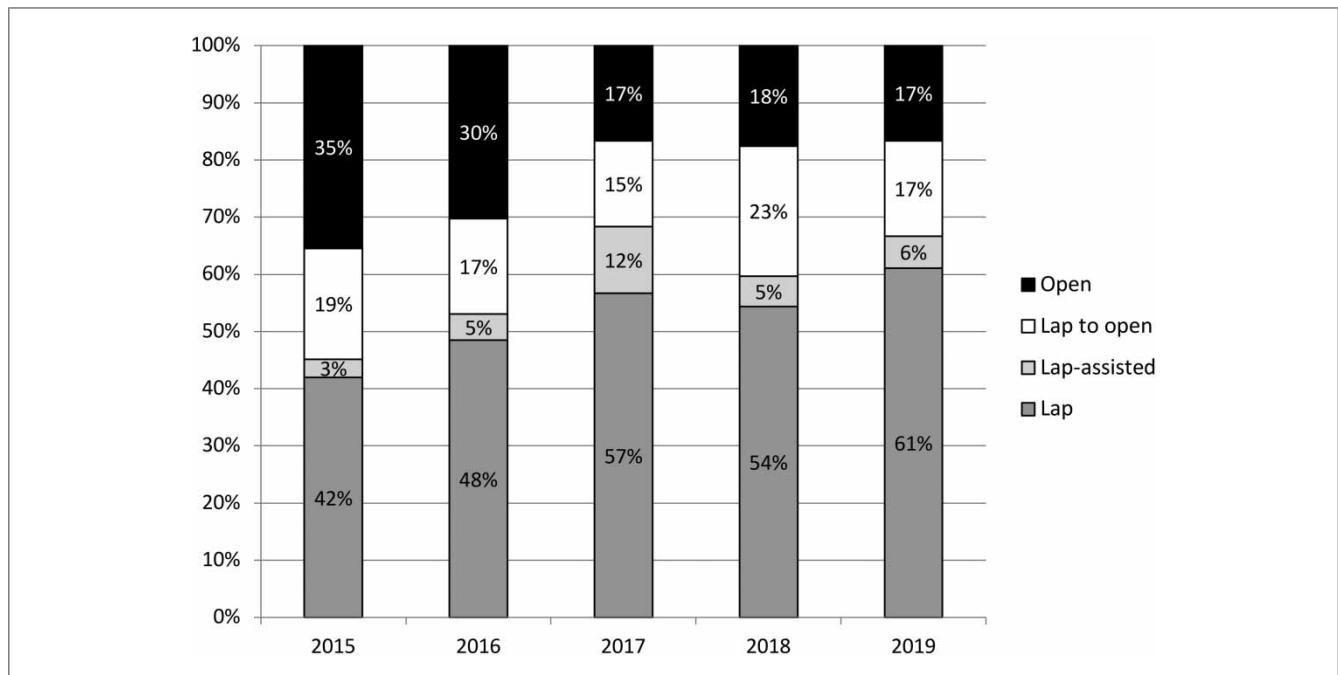


Figure 2 Number of cases (%) completed open, laparoscopy and lap-assisted/converted to open from 2015 to 2019. Lap = laparoscopically.

Table 5 Uni- and multivariable linear regression analysis for postoperative LOS

	Univariable beta-coefficient (95% CI)	p-value	Multivariable beta-coefficient (95% CI)	p-value
Gender (female)	2.26 (−2.31–6.84)	0.331		
Age	0.16 (0.03–0.29)	0.018		
P-POSSUM	0.53 (0.38–0.68)	<0.001	0.43 (0.27–0.59)	<0.001
ASA grade	5.99 (3.16–8.82)	<0.001	2.54 (0.27–0.56)	<0.001
Bowel resection	10.63 (4.63–16.62)	<0.001	6.50 (0.62–12.38)	0.030
TTS	0.18 (−0.44–0.80)	0.572		
<24hr to surgery	−0.39 (−5.29–4.51)	0.875		
Surgical approach				
Open	1		1	
Laparoscopic	−13.22 (−18.70 to −7.75)	<0.001	−8.51 (−13.87 to −3.16)	0.002
Converted	−7.54 (−13.91 to −1.17)	0.020	−4.90 (−10.88–1.08)	0.108

ASA = American Society of Anaesthesiology; CI = confidence interval; LOS = length of stay; P-POSSUM = Portsmouth – Physiological and Operative Severity Score for the enumeration of Mortality and morbidity; TTS = time to surgery

Discussion

Our centre has successfully adopted the laparoscopic approach as the preferred treatment for ASBO, with 76.3% of cases routinely attempted via this approach, with an acceptable safety profile and shorter postoperative LOS compared with open surgery. We recommend a ‘laparoscopy-first’ approach wherever possible. Careful pre-operative discussion with a subspecialist radiologist is useful for operative planning and can help determine optimal port placement for laparoscopy, likelihood of success or need for major resection. Where diagnostic uncertainty remains, initial laparoscopy is unlikely to add significant comorbidity or operative time and should be considered. Adequate surgical experience, anaesthetic and theatre support are necessary. However, many of the skills obtained from minimal access approaches to elective GI cancer and benign surgery are readily transferrable to emergency adhesiolysis and could be safely adopted in many centres. Furthermore, supervised trainees have been allowed to perform parts of these procedures, with 6.4% of laparoscopic cases successfully completed by a specialty trainee as lead surgeon. We believe these are skillsets and mindsets that should be encouraged in the next generation of surgeons.

The significant differences seen, between patients for whom a laparoscopic approach was attempted and those for whom it was not, for pre-operative patient ASA and predicted P-POSSUM mortality risk reflects the fact that some patient selection is still required. Patients who require major or complex resectional surgery, or have severe intraperitoneal contamination, may still need to be considered for traditional laparotomy. Patient age, or duration of symptoms, as reflected in the data presented here, need not influence decision-making in this context. Even in cardiovascularly compromised patients, low

pressure pneumoperitoneum can often be tolerated.¹⁴ Particularly if an upper abdominal incision is required, studies in the context of elective surgery have demonstrated that respiratory complications may be reduced with laparoscopy, as the postoperative reduction in pain, resulting atelectasis, and infective risk outweigh any transient intraoperative insult to ventilation.^{6,15} Similar findings have been reported in obese populations, suggesting body mass index (BMI) need not be a factor in considering surgical approach; intraoperative exposure and visualisation may in fact be superior via a laparoscopic approach compared with laparotomy.¹⁶

When controlling for P-POSSUM – which includes physiological, demographic, and diagnostic variables – as well as ASA, age and the need for bowel resection, laparoscopic completion of surgery remained the variable most strongly associated with a reduced LOS. Patients who could not be completed laparoscopically and were converted to open surgery experienced similar outcomes (LOS and mortality) to those who underwent primary laparotomy, despite differences in pre-operative risk and comorbidity.

It has been suggested that one of the effects of laparoscopy is to minimise systemic surgical insult; studies have suggested this may reduce the physiological and inflammatory response to injury.¹⁴ This has potential implications not only for patient outcomes, but hospital systems. Patients in whom the systemic effect of surgery can be minimised may be less likely to require prolonged admission in high-intensity care settings (high dependency units (HDUs) or intensive care units (ICUs)), reduction in ICU stays and overall admission LOS can have significant impact on hospital resource usage.

While operative times were not recorded as part of this study, it has been our experience that, in many cases, a

laparoscopic approach can be as quick, if not quicker, than open surgery. Particularly in cases of simple band or limited adhesiolysis, avoiding full laparotomy and abdominal closure can reduce operative times substantially. In addition, patients undergoing laparoscopy may also require less anaesthetic intervention such as central venous access or placement of epidural catheters.

Where compromised bowel is identified, this can be addressed through a limited open incision, as demonstrated in our data. Unsurprisingly, the requirement for bowel resection leads to a significantly longer postoperative stay. However, our data demonstrates that it is still of benefit to start such cases laparoscopically. This may be because an initial laparoscopy allows freeing up of intra-abdominal adhesions, the selection of an appropriate region of the abdominal wall to make a small laparotomy, and the inspection of the closed laparotomy wound on completion of the anastomosis. It is clear that a smaller, appropriately sited laparotomy wound, using a wound retractor, and rectus sheath cannulas for postoperative analgesia, retains most of the benefits of the laparoscopic approach.

Concerns regarding limited working space, iatrogenic bowel injury, and failure to relieve the obstruction have limited the uptake of laparoscopic adhesiolysis in the past. In the 2018 national audit of ASBO in the UK, only 15% of cases were attempted laparoscopically, with only 7% of all cases completed successfully without conversion to laparotomy.¹⁷ This study demonstrates an increasing use of laparoscopy across the 5 year study period. However, the rate of conversion to open surgery has hardly altered and the requirement for bowel resection has not changed. This is the result of learning among the specialist upper and lower GI surgeons, with both laparoscopic enthusiasts and sceptics increasingly implementing laparoscopy in their emergency practice. Weekly governance meetings, incorporating the sharing of good practice in a no-blame culture, have helped to move the culture of the entire surgical team.

Evidence investigating the use of laparoscopy in ASBO remains limited. The most recent meta-analysis identified 18 studies containing 38,927 patients, with the mean number of cases completed laparoscopically (38.1%). Its findings very much support those demonstrated in this study, with laparoscopy conferring a lower mortality rate and shorter total LOS compared to laparotomy (1.6% vs 4.9% ($p=0.001$) and 6.7 vs 11.6 days ($p=0.001$), respectively) with a reduction in both complications and reoperation rate.⁶ The LASSO trial is the only randomised controlled trial comparing laparoscopy with laparotomy for a limited population of ASBO patients, where obstruction is deemed secondary to simple band adhesions only. Its major findings, with laparoscopy conferring a mean reduction in LOS of 1.3 days and no significant difference in complications or mortality ($p=0.23$), are in keeping with our findings reported here. In our broader cohort of ASBO patients, the rate of conversion to open surgery was also similar to that reported in the LASSO (23% vs 25%). However, LASSO's strict inclusion/exclusion criteria meant only 1 in 5 patients screened were

considered eligible, which contrasts with our centre's more forthcoming approach.⁷ We believe the high rates of attempted laparoscopy, which increases throughout the study period (64.5% to 83.3%) demonstrates how our centre has adopted an 'all comers' approach to laparoscopy, with laparotomy reserved for cases where open surgery is clearly needed from the start.

A key strength of our study is that it uses longitudinal data collected prospectively from a national database. This has allowed us to observe reliably the impact of adopting laparoscopy in the treatment of ASBO in our centre. The limitations of the data included in this study, such as lack of information on prior surgery, comorbidity and severity of adhesions, means that we are unable to definitively identify those patients who should not be selected for laparoscopy, or that are most likely to require conversion (beyond those requiring bowel resection). The dataset also does not provide information on the size of the incisions used in lap-assisted and converted to open cases. Thus, we have grouped both types of conversion together, recognising that this may include patients who had small utility ports with those who had larger open incisions. While such a cohort study must be expected to reflect a degree of selection bias, we believe the high rates of attempted laparoscopy, demonstrates how laparoscopy has been adopted as the standard operative approach in our centre. Larger scale observational data in future should aim to identify appropriate algorithms to aid surgical decision-making in this context

Conclusion

This study demonstrates that laparoscopy should be the operative approach of choice for the surgical management of ASBO; it is safe, feasible, and widely applicable. It confers significantly reduced LOS and inhospital mortality compared with open surgery. These findings challenge the currently held view that laparoscopy should be reserved for selected, straightforward cases.

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Conflicts of Interests

None declared.

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