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REVIEW

Laparoscopic adhesiolysis for acute small bowel obstruction: systematic review and pooled analysis

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Abstract

Background Adhesional small bowel obstruction (SBO) occurs in 14–17 % of patients within 2 years of open colorectal or general surgery. The aim of this pooled analysis is to compare the safety and efficacy of laparoscopic versus open treatment of SBO.

Methods An electronic search of Embase, Medline, Web of Science, and Cochrane databases was performed. Weighted mean differences (WMDs) were calculated for the effect size of laparoscopic surgery on continuous variables, and pooled odds ratios (PORs) were calculated for discrete variables.

Results There were eleven non-randomized comparative studies included this review. Laparoscopic surgery was associated with a significant reduction in mortality (POR = 0.31; 95 % CI 0.16–0.61; $P = 0.0008$), overall morbidity (POR = 0.34; 95 % CI 0.27–0.78; $P < 0.0001$), pneumonia (POR = 0.31; 95 % CI 0.20–0.49; $P < 0.0001$), wound infection (POR = 0.29; 95 % CI 0.12–0.70; $P = 0.005$), and length of hospital stay (WMD = −7.11; 95 % CI −8.47 to −5.75; $P < 0.0001$). The rates of bowel injury and reoperation were not significantly different between the two groups. Operative time was significantly longer in the laparoscopic group (WMD = 72.31; 95 % CI 60.96–83.67; $P < 0.0001$).

Conclusion Laparoscopic surgery for treatment of adhesional SBO improves clinical outcomes and can be performed safely in selected cases with similar rates of bowel injury and reoperation to open surgery. Large scale randomized controlled trials are needed to validate the findings of this pooled analysis of non-randomized data.

Keywords Laparoscopic surgery · Intestinal obstruction · Adhesiolysis

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Adhesional small bowel obstruction (SBO) is a common consequence of intra-abdominal surgery, and is thought to occur in 14–17 % of patients within two years of open colorectal or general surgery [1]. Although cases may resolve with conservative management, surgical intervention is frequently necessary with laparotomy and open adhesiolysis being the procedure of choice for many surgeons. However, this procedure may result in development of further intra-abdominal adhesions, with up to 46 % of patients developing further episodes of SBO following initial laparotomy and adhesiolysis [2].

Laparoscopy offers an alternative approach for operative intervention in adhesional SBO and was first described by Bastug et al. in 1991 [3]. In 2002, it was shown that only 11 % of cases of SBO requiring surgery were performed laparoscopically [4], but since this time the use of laparoscopy for intestinal surgery has become more widespread and a greater proportion of surgeons have become proficient in laparoscopic techniques. There has been an increasing uptake of laparoscopy for the management of adhesional SBO. However, some surgeons still suggest that the use of laparoscopy for adhesional SBO may be associated with increased risk of inadvertent bowel injury, may increase operative time, and be unsuitable in cases of dense adhesions or in patients with multiple medical comorbidities who represent greater anesthetic risk.

Laparoscopic surgery has previously been shown to result in decreased adhesion formation compared to laparotomy [5]. In colorectal resections, laparoscopy is associated with reduced postoperative stay and intra-operative blood loss, as well as decreased episodes of postoperative adhesional SBO [6–9]. These benefits could potentially be translated into improved patient outcome through the use of laparoscopy for adhesiolysis in SBO.

The aim of this systematic review and pooled analysis is to compare patient outcomes following laparoscopic adhesiolysis for acute adhesional SBO to those for patients undergoing conventional laparotomy and adhesiolysis. The hypothesis under investigation is that laparoscopic treatment of adhesional SBO can be performed safely and improves postoperative outcomes compared to conventional open surgery.

Materials and methods

Literature search strategy

An electronic literature search was undertaken using Embase, Medline, and Web of Science databases up to August 2014. The search terms 'laparoscopy,' 'bowel obstruction,' and Medical Subject Headings (MeSH) 'laparoscopy' (MeSH) and 'intestinal obstruction' (MeSH), were used in combination with the Boolean operators AND or OR. Two authors (TW and SRM) performed the electronic search independently in August 2014. The electronic search was supplemented by a hand-search of published abstracts from meetings of the Surgical Research Society, the Society of Academic and Research Surgery, the Association of Surgeons of Great Britain and Ireland, Society of American Gastro-Intestinal and Endoscopic Surgeons, and European Association of Endoscopic Surgeons from 2005 to 2013. The reference lists of articles obtained were also searched to identify further relevant citations. Abstracts of the articles identified by the electronic search were scrutinized by two of the authors (TW and SRM) to determine their suitability for inclusion in the pooled analysis.

Publications were included if they were case-matched controlled or comparative studies in which patients underwent laparoscopic adhesiolysis or conventional open surgery for acute adhesional small bowel obstruction. Studies were excluded if they were non-comparative or investigated laparoscopic adhesiolysis for chronic SBO.

Surgical technique

Laparoscopic surgery for adhesional SBO was defined as any procedure in which the laparoscopic approach was used to complete the operation. Cases which were considered laparoscopic assisted (where the predominant section of the procedure was completed laparoscopically but a mini-laparotomy of less than 5 cm was necessary for completion) were included within the laparoscopic group for analysis. Laparoscopic cases that required conversion to a conventional laparotomy were analyzed separately.

Outcome measures

Primary outcome measures were mortality (in-hospital and 30-day) and overall morbidity (defined as a complication developing within 30 days of the procedure and occurring as a direct result of surgery). Secondary outcome measures were intra-operative bowel injury, reoperation, prolonged ileus, pneumonia, wound infection, operative time, and length of hospital stay.

Statistical analysis

Data from eligible trials were entered into a computerized spreadsheet for analysis. Statistical analysis was performed using StatsDirect 2.5.7 (StatsDirect, Altrincham, UK). Weighted mean difference (WMD) was calculated for the effect size of laparoscopy on continuous variables. Pooled odds ratios (PORs) were calculated for the effect of laparoscopy on discrete variables. All pooled outcome measures were determined using random-effects models as described by DerSimonian Laird [10]. Heterogeneity among trials was assessed by means of the Cochran's Q statistic, a null hypothesis in which $P < 0.05$ is taken to indicate the presence of significant heterogeneity [11]. The Egger test was used to assess the funnel plot for significant asymmetry, indication of possible publication or other biases.

Results

The literature search identified eleven case-matched control or comparative studies which were included for analysis [4, 12–21]. Figure 1 shows the PRISMA flowchart for the literature search. In total, there were 13,728 patients included with 1712 cases included in the laparoscopic group and 11,329 in the open surgery group. 687 cases in the laparoscopic group (40 %) were reported as being converted to open surgery.

All included studies were non-randomized, retrospective studies. No study reported any objective criteria for patient allocation to the laparoscopic or open groups. Most studies stated that allocation to either group was based upon the individual patient's previous history (including number of prior laparotomies) and clinical condition as well as operating surgeon familiarity with the laparoscopic approach.

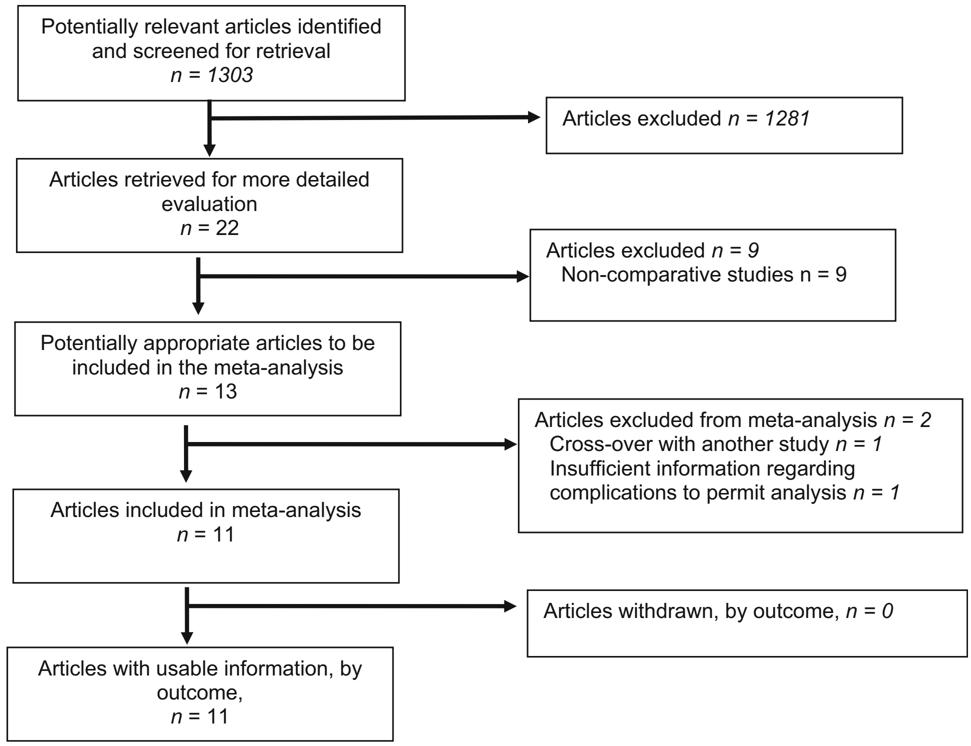


Fig. 1 PRISMA flow chart

Exclusion criteria were similar for all studies and in most part were patient's with any non-adhesional cause for obstruction (including tumor, hernia, or volvulus) or undergoing adhesiolysis for chronic adhesion-related symptoms.

Table 1 describes the patient demographics and Table 2 describes the reasons for conversion from the studies included. Tables 3 and 4 describe the results from the individual studies for the clinical outcome measures evaluated in this pooled analysis.

Laparoscopic versus open management of bowel obstruction

Mortality (Fig. 2)

The incidence of mortality was reported by eight studies [4, 12–14, 16–18, 21]. Laparoscopic surgery for bowel obstruction was associated with a significant reduction in mortality compared to open surgery (POR = 0.31; 95 % CI 0.16–0.61; $P = 0.0008$). There was no evidence of significant heterogeneity (Cochran $Q = 9.92$; $P = 0.19$; $I^2 = 29.4$ %) or bias (Egger = −0.25; $P = 0.73$).

Morbidity (Fig. 3)

Nine studies reported the incidence of postoperative morbidity [4, 12, 13, 16–21]. Laparoscopic management of bowel obstruction was associated with a significant reduction in postoperative morbidity (POR = 0.34; 95 % CI 0.27–0.78; $P < 0.0001$). There was no evidence of significant heterogeneity (Cochran $Q = 12.60$; $P = 0.13$; $I^2 = 36.5$ %) or bias (Egger = −0.67; $P = 0.31$).

Bowel injury

Six studies reported the incidence of bowel injury during surgery [12, 14, 15, 18, 20, 21]. There was no significant difference between the groups in the incidence of intraoperative bowel injury (POR = 0.77; 95 % CI 0.24–2.46; $P = 0.65$). There was no evidence of significant heterogeneity (Cochran $Q = 7.40$; $P = 0.19$; $I^2 = 32.4$ %) or bias (Egger = −0.71; $P = 0.58$).

Reoperation

Six studies reported the incidence of reoperation [12–15, 17, 18]. There was no significant difference between the groups in the incidence of reoperation (POR = 0.77; 95 % CI 0.57–1.04; $P = 0.09$). There was no evidence of significant heterogeneity (Cochran $Q = 2.54$; $P = 0.77$; $I^2 = 0$ %) or bias (Egger = 0.53; $P = 0.20$).

Ileus

Five studies reported the incidence of prolonged postoperative ileus [12, 16, 18, 19, 21]. There was no significant

Table 1 Patient demographics for the studies included in the pooled analysis

Author	Patient number			Age (years)*			Male gender		
	Lap	Open	Converted	Lap	Open	Converted	Lap	Open	Converted
Chopra [12]	23	52	11	59.7	58.7	55	–	–	–
Davies [13]	38	64	–**	52.5 (43.0–57.0)	57.0 (42.5–71.0)	–	13 (34 %)	28 (44 %)	–
Grafen [14]	66	3	24	59 ± 2	75 ± 4	63 ± 4	19 (29 %)	2 (66 %)	10 (42 %)
Johnson [15]	38	56	25	67 ± 17	69 ± 15	67 ± 18	14 (37 %)	26 (46 %)	10 (40 %)
Khaikin [16]	21	31	10	–	–	–	–	–	–
Lombardo [17]	834	5506	422	57.4 ± 17.3	63.4 ± 17	61.0 ± 16.6	252 (30 %)	2077 (38 %)	163 (39 %)
Mancini [4]	702	5463	–**	56.6 ± 18.5	63.1 ± 17.4	–	218 (31 %)	2021 (37 %)	–
Mathieu [18]	62	60	34	57 (16–102)***	68.7 (20–91)***	57.0 (18–94)***	17 (27 %)	27 (45 %)	17 (50 %)
Okamoto [19]	25	25	3	62 (23–85)	58.8 (12–87)	69	14/25 (56 %)	11/25 (44 %)	1/3 (33 %)
Simmons [20]	9	11	17	–	–	–	9 (100 %)	11 (100 %)	17 (100 %)
Wullstein [21]	52	52	–**	59.3	64.8	–	14 (27 %)	12 (23 %)	–

Author	Body mass index (kg/m^2)*			ASA*			Previous surgery		
	Lap	Open	Converted	Lap	Open	Converted	Lap	Open	Converted
Chopra [12]	–	–	–	–	–	–	–	–	–
Davies [13]	27 (21–29.22)	22.43 (19.23–25.59)	–	–	–	–	1 (1–3)	2 (1–3)	–
Grafen [14]	–	–	–	2.3 ± 0.1	3 ± 0	2.8 ± 0.1	2 ± 0.2	4.3 ± 1.3	2.2 ± 0.2
Johnson [15]	–	–	–	–	–	–	1.5 ± 1.5	2.0 ± 1.7	1.8 ± 1.1
Khaikin [16]	23	23	24	2	2	2	1.2	1.0	1.2
Lombardo [17]	27.5 ± 7.2	25.9 ± 6.6	26.4 ± 6.1	I—38 (4.6 %) II—448 (53.8 %) III—315 (37.8 %) IV—32 (3.8 %) V—0	I—136 (2.5 %) II—1787 (32.5 %) III—2827 (51.4 %) IV—732 (13.3 %) V—20 (0.4 %)	I—15 (3.6 %) II—178 (42.4 %) III—199 (47.4 %) IV—27 (6.4 %) V—1 (0.2 %)	–	–	–
Mancini [4]	–	–	–	–	–	–	–	–	–
Mathieu [18]	–	–	–	–	–	–	–	–	–
Okamoto [19]	–	–	–	–	–	–	25/25 (100 %)	25/25 (100 %)	3/3 (100 %)
Simmons [20]	–	–	–	–	–	–	–	–	–
Wullstein [21]	–	–	–	–	–	–	1.5	1.5	

* Presented as median (range) or mean ± standard deviation

** Converted cases analyzed within laparoscopic group for demographic purposes

*** Presented as mean (range)

Table 2 Details of reasons for conversions

Author	Patient number				Reasons for conversion (with percentage causes for conversion)				
	Total attempted laparoscopic	Completed laparoscopic	Converted	% Converted	Dense adhesions	Ischemic bowel	Intestinal distension	Visceral injury	Other
Chopra [12]	34	23	11	32	4 (36 %)	1 (9 %)	–	–	–
Davies [13]	38	28	10	26	7 (70 % %	0	0	1 (10 %)	Excessive bleeding (1); bowel mass (1).
Grafen [14]	90	66	24	27	7 (29 %)	2 (8 %)	10 (42 %)	5 (21 %)	–
Johnson [15]	63	38	25	40	4 (16 %)	6 (24 %)	5 (20 %)	4 (16 %)	Bowel mass (5); pre-existing perforation (1).
Khaikin [16]	31	21	10	32	5 (50 %)	4 (40 %)	–	–	Inability to ascertain viability of small bowel (1)
Lombardo [17]*	1256	834	422	34	–	–	–	–	–
Mancini [4]*	702	581	121	17	–	–	–	–	–
Mathieu [18]	96	62	34	35	8 (24 %)	14 (41 %)	5 (15 %)	2 (6 %)	–
Okamoto [19]	28	25	3	11	3 (100 %)	–	–	–	–
Simmons [20]**	9	–	–	–	–	–	–	–	–
Wullstein [21]	52	25	27	34	10 (37 %)	6 (22 %)	–	7 (26 %)	Need for resection (4)
Total	2643	2077	566	33	48/144 (33 %)	33/141 (23 %)	20/93 (22 %)	19/120 (16 %)	–

* No information regarding reasons for conversions provided

** No data provided for conversions

difference between the groups in the incidence of postoperative ileus (POR = 0.55; 95 % CI 0.18–1.69; $P = 0.30$). There was no evidence of significant heterogeneity (Cochran $Q = 9.30$; $P = 0.06$; $I^2 = 57$ %) or bias (Egger = −0.91; $P = 0.86$).

Pneumonia (Fig. 4)

Six studies reported the incidence of postoperative pneumonia [12, 16–19, 21]. Laparoscopic management of bowel obstruction was associated with a significant reduction in postoperative pneumonia (POR = 0.31; 95 % CI 0.20–0.49; $P < 0.0001$). There was no evidence of significant heterogeneity (Cochran $Q = 1.08$; $P = 0.96$; $I^2 = 0$ %) or bias (Egger = −0.39; $P = 0.16$).

Wound infection (Fig. 5)

Eight studies reported the incidence of postoperative wound infection [12, 13, 16–21]. Laparoscopic surgery for bowel obstruction was associated with a significant reduction in postoperative wound infection (POR = 0.29; 95 % CI 0.12–0.70; $P = 0.005$). There was evidence of significant statistical heterogeneity (Cochran $Q = 14.65$; $P = 0.04$; $I^2 = 56.3$ %); however, there was no evidence of bias (Egger = 0.79; $P = 0.45$).

Operative time

Four studies reported operative time (inclusive of standard deviation to permit analysis) for laparoscopic and open groups [13–15, 17]. Laparoscopic approach to the surgical management of bowel obstruction was associated with a significant increase in average operative time (WMD = 72.31; 95 % CI 60.96–83.67; $P < 0.0001$). There was evidence of significant statistical heterogeneity (Cochran $Q = 760.90$; $P < 0.0001$; $I^2 = 99.6$ %); however, there was no evidence of bias (Egger = 5.90; $P = 0.64$).

Table 3 Details of morbidity/mortality

Author	Mortality			Total morbidity			Bowel injury			Reoperation		
	Lap	Open	Conv	Lap	Open	Conv	Lap	Open	Conv	Lap	Open	Conv
Chopra [12]	1 (4 %)	0	0	9 (39 %)	39 (75 %)	7 (64 %)	1 (4 %)	10 (19 %)	–	1 (4 %)	0	–
Davies [13]	0	3 (5 %)	–	9 (32 %)	29 (45 %)	–	–	–	–	6 (21 %)	14 (22 %)	–
Grafen [14]	3 (5 %)	1 (33 %)	2 (8 %)	–	–	–	2 (3 %)	–	5 (21 %)	7 (11 %)	0	2 (8 %)
Johnson [15]	0	0	0	–	–	–	4 (11 %)	–	–	1 (3 %)	2 (4 %)	0
Khaikin [16]	0	1 (3 %)	0	5 (24 %)	14 (45 %)	3 (30 %)	–	–	–	–	–	–
Lombardo [17]	9 (1 %)	246 (4 %)	–	104 (12 %)	1762 (32 %)	–	–	–	–	44 (5 %)	378 (7 %)	–
Mancini [4]	10 (2 %)	184 (3 %)	2 (2 %)	97 (17 %)	1643 (30 %)	38 (31 %)	–	–	–	–	–	–
Mathieu [18]	0	12 (20 %)	3 (9 %)	17 (27 %)	32 (53 %)	10 (29 %)	0	1 (2 %)	2 (6 %)	1 (2 %)	0	2 (6 %)
Okamoto [19]	0	0	–	2 (8 %)	14 (56 %)	–	0	0	0	0	0	0
Simmons [20]	0	0	–	0	3 (18 %)	–	0	2 (12 %)	–	–	–	–
Wullstein [21]	0	2 (4 %)	0	10 (19 %)	21 (40 %)	9 (33 %)	9 (17 %)	7 (13 %)	5 (19 %)	–	–	–
Totals	23/1722	449/11323	7/252	253/1608	3557/11270	67/635	16/248	20/206	12/88	60/1076	394/5766	4/86
Percentage (%)	1.3	4.0	2.8	15.6	31.6	10.6	6.5	9.7	13.6	5.6	6.8	4.7

Author	Ileus			Pneumonia			Wound infection		
	Lap	Open	Conv	Lap	Open	Conv	Lap	Open	Conv
Chopra [12]	2 (9 %)	21 (40 %)	–	0	5 (10 %)	–	1 (4 %)	12 (23 %)	–
Davies [13]	–	–	–	–	–	–	6 (21 %)	16 (25 %)	–
Grafen [14]	–	–	–	–	–	–	–	–	–
Johnson [15]	–	–	–	–	–	–	–	–	–
Khaikin [16]	3 (14 %)	3 (10 %)	–	0	3 (10 %)	0	2 (10 %)	1 (3 %)	–
Lombardo [17]	–	–	–	17 (2 %)	329 (6 %)	0	8 (0.9 %)	419 (8 %)	–
Mancini [4]	–	–	–	–	–	–	–	–	–
Mathieu [18]	5 (8 %)	2 (3 %)	3 (9 %)	0	4 (7 %)	0	0	10 (17 %)	0
Okamoto [19]	1 (4.00 %)	6 (24 %)	–	0	2 (8 %)	–	0	2 (8 %)	–
Simmons [20]	–	–	–	–	–	–	0	1 (6 %)	–
Wullstein [21]	4 (8 %)	7 (13 %)	4 (15 %)	1 (2 %)	2 (4 %)	1 (4 %)	3 (6 %)	6 (12 %)	0
Totals	15/156	39/220	7/61	18/990	345/5726	1/493	20/1027	467/5807	0/61
Percentage (%)	9.6	17.7	11.5	1.8	6.0	0.2 %	2.0 %	8.0 %	0 %

Table 4 Operative time and length of stay

Author	Operative time (min)*			Length of stay (days)*		
	Lap	Open	Conv	Lap	Open	Conv
Chopra [12]***	123	184	189	7.3	13.3	12.6
Davies [13]	93.5 ± 3.8	117.6 ± 5.6		3.8 ± 1	9.5 ± 1.6	–
Grafen [14]	74 ± 4	113 ± 32	151 ± 14	8.6 ± 0.9	20.7 ± 1.4	15.1 ± 2.6
Johnson [15]	96 ± 53	124 ± 59	134 ± 37	5.4 ± 2.8	9.1 ± 4.7	8.2 ± 4.7
Khaikin [16]**	75	70	84	4	9	6.5
Lombardo [17]	81 ± 6.2	97 ± 6.9	–	4.5 ± 1.2	10.5 ± 1.4	–
Mancini [4]**	–	–	–	6	9	6
Mathieu [18]	–	–	–	10.5 ± 2.7	24.7 ± 4.6	17.2 ± 3.1
Okamoto [19]***	112	79	–	11	22	–
Simmons [20]	–	–	–	3 ± 1	7 ± 4	–
Wullstein [21]***	103	84	–	11.3	18.1	8.5

* Presented as median (range) or mean ± standard deviation

** Median

*** Mean

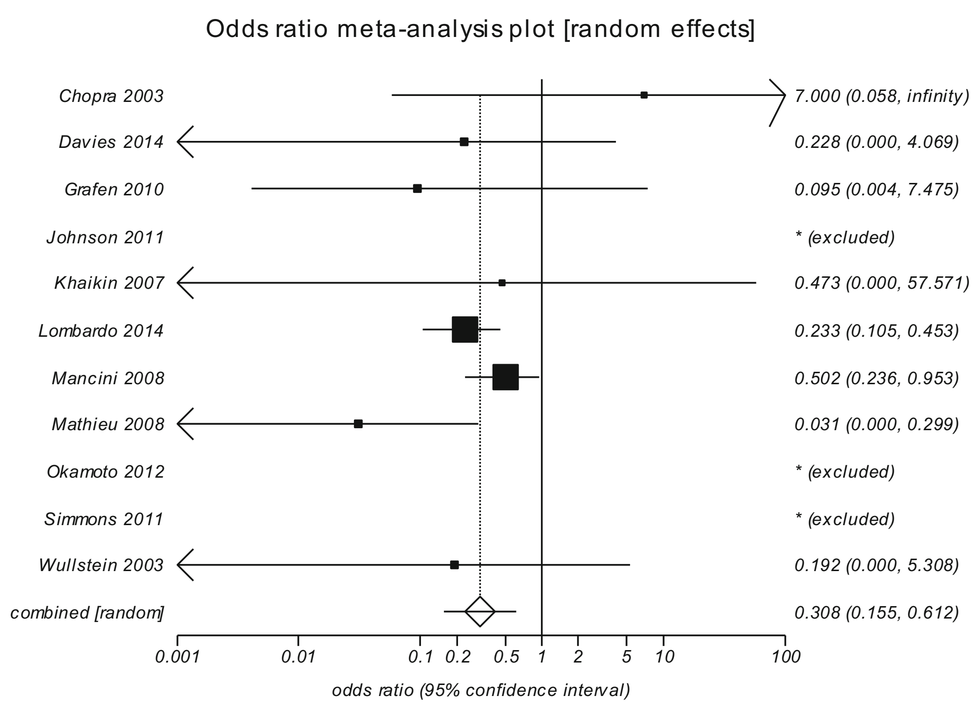


Fig. 2 Laparoscopic surgery for bowel obstruction was associated with a significant reduction in mortality compared to open surgery (POR = 0.31; 95 % CI 0.16–0.61; $P = 0.0008$)

Length of hospital stay

Six studies reported the average length of hospital stay (including standard deviation) for laparoscopic and open groups [13–15, 17, 18, 20]. Laparoscopic management of bowel obstruction was associated with a significant reduction in length of hospital stay (WMD = −7.11; 95 % CI −8.47 to −5.75; $P < 0.0001$). There was evidence of significant statistical heterogeneity (Cochran $Q = 270.66$; $P < 0.0001$; $I^2 = 97.8$ %); however, there was no evidence of bias (Egger = −2.55; $P = 0.51$).

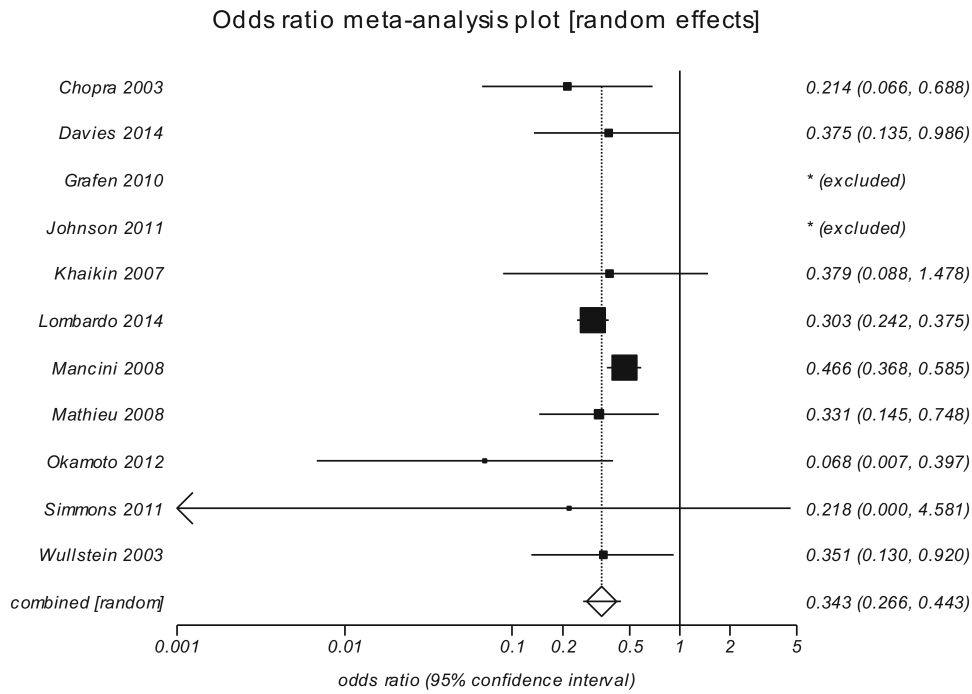


Fig. 3 Laparoscopic management of bowel obstruction was associated with a significant reduction in postoperative morbidity (POR = 0.34; 95 % CI 0.27–0.78; $P < 0.0001$)

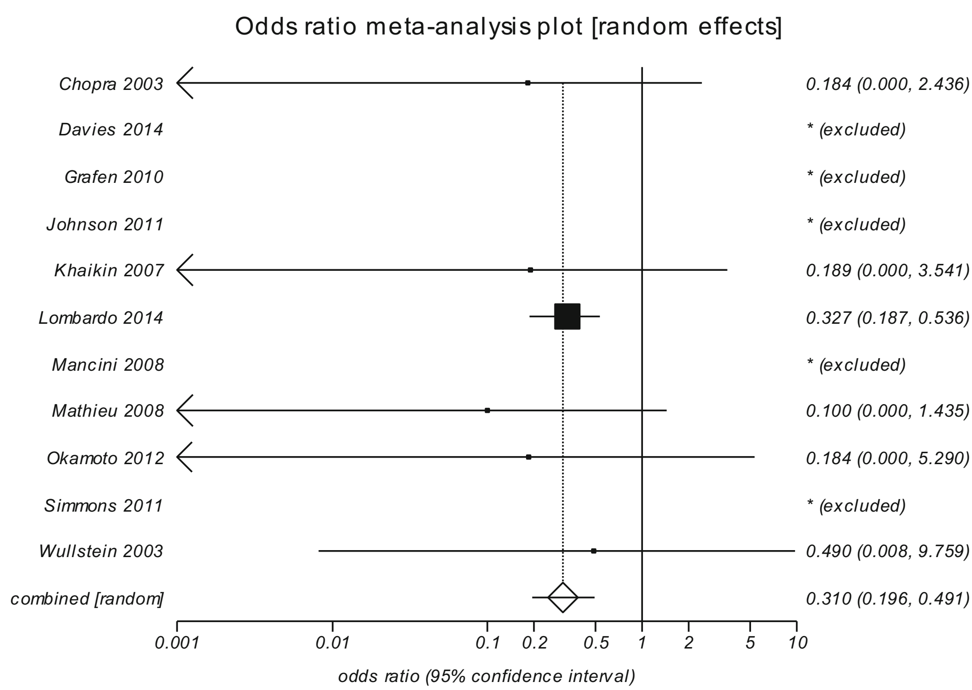


Fig. 4 Laparoscopic management of bowel obstruction was associated with a significant reduction in postoperative pneumonia (POR = 0.31; 95 % CI 0.20–0.49; $P < 0.0001$)

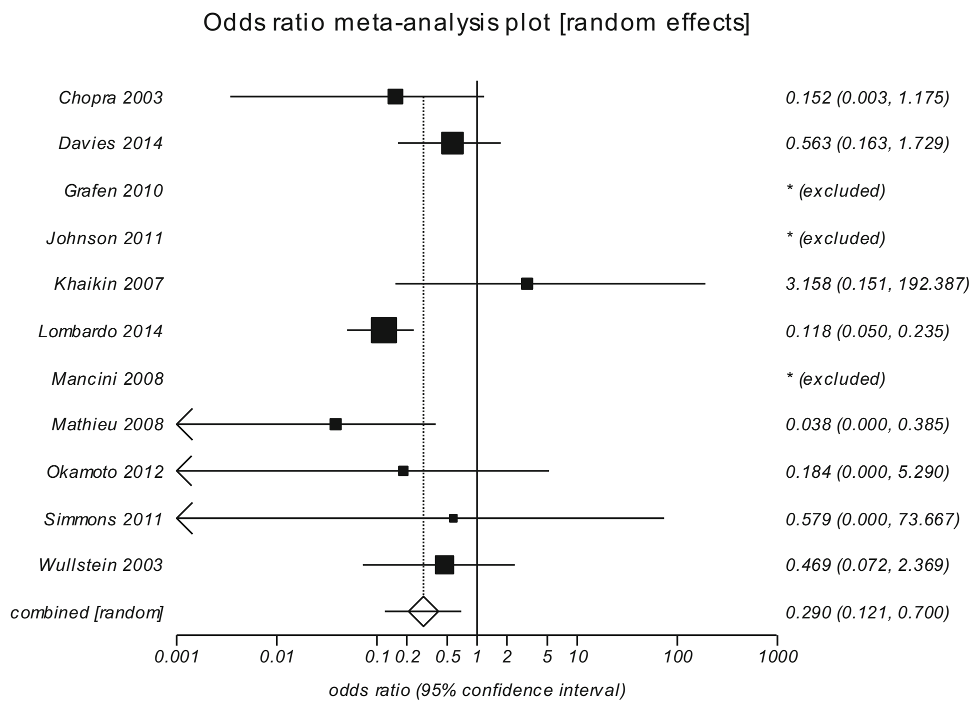
Laparoscopic conversion versus open management of bowel obstruction

There were only sufficient data available to allow analysis of two postoperative outcomes.

Mortality

Seven studies compared mortality between laparoscopic converted to open and open surgery groups [4, 13, 14, 16–18, 21]. There was a significant reduction in postoperative

Fig. 5 Laparoscopic surgery for bowel obstruction was associated with a significant reduction in postoperative wound infection (POR = 0.29; 95 % CI 0.12–0.70; $P = 0.005$)



mortality in the laparoscopic converted to open group when compared to the open surgery group (POR = 0.33; 95 % CI 0.14–0.83; $P = 0.02$). There was no evidence of statistical heterogeneity (Cochran $Q = 7.18$; $P = 0.30$; $I^2 = 16.4$ %) or bias (Egger = −0.49; $P = 0.63$).

Morbidity

Eight studies compared morbidity between laparoscopic converted to open and open surgery groups [4, 12, 13, 16–19, 21]. There was no significant difference between the groups in postoperative morbidity (POR = 0.24; 95 % CI 0.05–1.08; $P = 0.06$). There was evidence of significant statistical heterogeneity (Cochran $Q = 90.62$; $P < 0.0001$; $I^2 = 92.3$ %), and evidence of significant bias (Egger = −2.46; $P = 0.01$).

Discussion

This pooled analysis of 13,728 patients suggests that the utilization of a laparoscopic approach for the treatment of adhesional SBO is safe with equivalent results for intraoperative bowel injury and reoperation rate compared to open surgery. Laparoscopy was associated with reduced mortality and overall morbidity. Patients undergoing laparoscopic adhesiolysis had a shorter inpatient hospital stay as well as reduced incidence of wound infection and pneumonia. The reduced rate of pneumonia following laparoscopic adhesiolysis can be explained by better pulmonary function following laparoscopic abdominal surgery compared to laparotomy [22]. This benefit is related to improved diaphragmatic function following laparoscopic surgery, and decreased postoperative pain (due to reduced abdominal wall trauma) will also contribute toward enhanced respiratory function. Reduced postoperative pain may also provide an explanation for the reduced length of hospital stay following laparoscopic adhesiolysis. Decreased wound infection rates identified in the laparoscopic group are likely to be related to the smaller incisions necessary in this approach and reduced risk of wound contamination intra-operatively.

Although laparoscopic colorectal resection has been associated with a reduced rate of postoperative ileus [23], this pooled analysis showed no difference in the incidence of postoperative ileus following laparoscopic or open adhesiolysis for SBO. This may indicate that postoperative ileus following adhesiolysis is more a consequence of the primary condition of SBO, rather than being affected by the operative approach. It is generally considered that ileus is affected by degree of tissue handling; however, the results of this pooled analysis suggest that instrument (laparoscopic) and manual handing of bowel are equivalent in this regard.

To date, there are no published randomized controlled trials (RCT) that have been undertaken to compare the open and laparoscopic approaches for adhesional SBO. The present pooled analysis is based upon non-randomized data and therefore there are important limitations that must be considered in the interpretations of the results gained. Patient selection may have introduced some selection bias in favor of the laparoscopic group. A previous study by Levard et al. showed that laparoscopy for SBO had a significantly higher success rate for patients who had undergone one or two previous operations compared to those who had undergone more than two procedures [24]. It is more likely that complex cases that have had multiple previous operations would preferentially be undertaken as an open procedure as surgeons ascend through their laparoscopic learning curve. Furthermore, there are some patients in whom attempting laparoscopic entry may be contraindicated (for example, patients with a very tight, distend abdomen) due to a greater risk of bowel perforation on port insertion. It was not possible to assess the influence upon the results of this and other important confounding variables including age, body mass index, and American Society of Anesthesiologists Grading (ASA). It is important to consider the potential effect of this selection bias when interpreting these results. However, this source of heterogeneity was quantified by measurement of the Cochran Q and I^2 statistics and the use of random affects modeling to limit the effect upon the results of the meta-analysis. There was some variation between individual studies as to how converted cases were reported with not all studies analyzing these patients as a separate group. Due to the small number of studies that reported the converted group separately, it was only possible to undertake a limited analysis between open and converted cases. Finally, no studies provided long-term follow-up data to assess whether the use of laparoscopy reduced the rate of recurrence of adhesional SBO.

Despite these limitations, this pooled analysis suggests that laparoscopy can be used safely and is associated with improved patient outcomes used in selected cases of adhesional SBO. Due to the potential effect of selection bias on these results from retrospective non-randomized data, it is important to consider that these benefits are likely to be most applicable to patients with few previous laparotomies and without gross intestinal distension (dilatation greater than 4 cm being previously associated with need for conversion [25]).

The use of laparoscopy can represent a method for initial evaluation of intra-abdominal adhesions in SBO. At the stage of initial laparoscopy, it can be possible to identify whether it is feasible for the procedure to be completed via this approach, or whether conversion to an open procedure is necessary due to dense intra-abdominal adhesions. A previous study has shown that pre-emptive conversion (where dense adhesions or lack of working space necessitated conversion to open procedure) was associated with a significantly lower postoperative morbidity (20 %) than where conversion was a result of intra-operative complications such as bowel injury (48.6 %) [26]. This highlights the need for experienced intra-operative surgeon evaluation, where laparoscopy is utilized for adhesional SBO. One study included in this pooled analysis identified no significant difference in operative time between cases treated with primary laparotomy and those who were converted to laparotomy following initial laparoscopy [15]. This indicates that laparoscopy could be utilized initially to assess the suitability of this approach without unnecessarily lengthening the operative time if it becomes apparent that conversion to a conventional laparotomy is required.

There is currently a lack of RCTs investigating laparoscopy in adhesiolysis for SBO and these are required in order to definitively establish the benefits of this approach. Such an RCT with robust standardized inclusion criteria would provide an objective, unbiased evaluation of the use of laparoscopy in adhesiolysis for adhesional SBO. Any RCT would require stringent criteria for patient inclusion but would remove the potential confounding effect of patient selection. This would also allow for a robust evaluation of additional factors including an assessment of postoperative pain and the cost-effectiveness of laparoscopy in this setting. Adhesion severity has previously been assessed according to the length of time necessary for the laparoscopic adhesiolysis [27]. The use of an objective adhesion severity scale such as this as part of an RCT could standardize risk-adjusted outcomes according to severity of adhesions and provide a more unbiased assessment of the effect of laparoscopy independent of adhesion density. Long-term follow-up would help establish any reduction in the recurrence rate of SBO following laparoscopic adhesiolysis compared to the open approach.

Conclusion

This pooled analysis showed that the use of laparoscopy was safe in the setting of adhesional SBO and was associated with a reduced length of stay and postoperative morbidity and mortality. These improved outcomes are likely to be most relevant to selected cases of adhesional SBO with few previous laparotomies and in the absence of gross intestinal distension. Randomized controlled trials with long-term follow-up are required to further validate the findings of this pooled analysis and to determine the recurrence of SBO following laparoscopic treatment.

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