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Review

Laparoscopic peritoneal lavage or surgical resection for acute perforated sigmoid diverticulitis: A systematic review and meta-analysis☆

Faisal M. Shaikh [a, b, *], Peter M. Stewart [c], Stewart R. Walsh [b, d], R. Justin Davies [c]

[a] Department of Surgery, Royal College of Surgeons in Ireland, Dublin, Ireland
[b] Department of Surgery, Galway University Hospital, Galway, Ireland
[c] Cambridge Colorectal Unit, Addenbrooke's Hospital, Cambridge University Hospitals NHS Foundation Trust, Cambridge, UK
[d] Department of Surgery, Lambe Institute for Translational Research, National University of Ireland, Galway, Ireland

HIGHLIGHTS

- The pooled analysis from randomised controlled trials between LPL and SR for APSD showed no difference in peri-operative mortality or serious adverse events between the two groups.
- Future trials should be conducted with a more standardised approach to the highlighted limitations of this analysis in an attempt to reach more definitive conclusions.

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ABSTRACT

Background: Laparoscopic peritoneal lavage (LPL) has been proposed as an alternative, less invasive technique in the treatment of acute perforated sigmoid diverticulitis (APSD). The aim of this meta-analysis is to compare the effectiveness of LPL versus surgical resection (SR) in terms of morbidity and mortality in the management of APSD.

Methods: A comprehensive search was conducted for randomised controlled trials (RCTs) comparing LPL versus SR in the treatment of APSD. The end points included peri-operative mortality, severe adverse events, overall mortality, post-operative abscess, percutaneous reinterventions, reoperation, operative time, postoperative stay, and readmissions.

Results: Three RCTs with a total of 372 patients, randomised to either LPL or SR were included. There was no significant difference in peri-operative mortality between LPL and SR (OR 1.356, 95% CI 0.365 to 5.032, $p = 0.649$), or serious adverse events (OR = 1.866, 95% CI = 0.680 to 5.120, $p = 0.226$). The LPL required significantly less time to complete than SR (WMD = −72.105, 95% CI = −88.335 to −55.876, $p < 0.0001$). The LPL group was associated with a significantly higher rate of postoperative abscess formation (OR = 4.121, 95% CI = 1.890 to 8.986, $p = 0.0004$) and subsequent percutaneous interventions (OR = 5.414, 95% CI 1.618 to 18.118, $p = 0.006$).

Conclusion: Laparoscopic peritoneal lavage is a safe and quick alternative in the management of APSD. In comparison to SR, LPL results in higher rates of postoperative abscess formation requiring more percutaneous drainage interventions without any difference in perioperative mortality and serious morbidity.

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1. Introduction

Colonic diverticular disease is a common abdominal disorder, especially in the western world, and occurs most commonly in the sigmoid colon [1]. An estimated 10–25% of patients will develop diverticulitis and 10–20% with diverticulitis will necessitate an

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* Corresponding author. Department of Surgery, University Hospital Galway, Galway, Ireland.
E-mail address: faisalshaikh@rcsi.ie (F.M. Shaikh).

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Table 1
Patients' demographics and study information.

Study/Year	Country	Total randomised	Included per protocol			Mean age		Previous diverticulitis		Previous surgery		Hinchey grade					Conversion to open (%)	Jadad score
			Total	Lap	Resection	Lap	Resection	Lap	Resection	Lap	Resection	I	II	III	IV	Total		
LADIES (LOLA)/ 2015	Netherland/ Belgium/Italy	90	88	46	42	62.3	64	12	10	4	3	0	0	88	0	88	1 (2.17)	3
SCANDIV/2015	Sweden/Norway	199	144	74	70	69.9	85.7	19	24	34	36	5	5	134	0	144	3 (4.05)	3
DILALA/2016	Sweden/Denmark	83	83	43	40	64	68	5	5	16	11	0	0	83	0	83	2 (4.65)	3

emergency colectomy, often including a colostomy, at initial presentation [2,3]. Moreover most of these patients remain at lifetime risk for developing recurrent episodes [4]. Furthermore, diverticular disease imposes significant clinical burden to the health care system. The estimated annual cost in North America is around US$2.7 billion per year, with nearly 152,000 hospitalizations per year [5,6].

Diverticulitis represents a spectrum of disease, ranging from mild, self-limiting inflammation to generalised peritonitis and death. Accordingly, the management of acute sigmoid diverticulitis depends on the clinical manifestation of the disease, and this generally corresponds to the Hinchey classification [7]. There is little debate that diverticulitis with paracolic abscess (Hinchey I) and sigmoid diverticulitis with pelvic abscess (Hinchey II) can generally be managed non-operatively with or without image guided percutaneous drainage of amenable abscesses. Historically, the standard approach for Hinchey III and IV (generalised purulent and feculent peritonitis respectively) has been an emergency sigmoid resection by way of Hartmann's Procedure, or less commonly primary colorectal anastomosis with or without diverting stoma [8]. While it is clear that the presence of feculent peritonitis (Hinchey IV) requires resection of the diseased sigmoid colon, the optimal surgical management of sigmoid diverticulitis with generalised purulent peritonitis (Hinchey III) has been questioned in recent years [9,10].

The evolution of laparoscopy prompted some surgeons to extend the clear benefits of laparoscopic surgery in general to the management of acute perforated sigmoid diverticulitis (APSD) with purulent peritonitis in order to avoid the morbidity associated with emergency laparotomy, sigmoid colon resection, stoma formation, and the cumulative morbidity of subsequent stoma reversal [9,10]. Laparoscopic peritoneal lavage (LPL) has gained considerable interest as a surgical strategy in the management of APSD since it was described in 1996 [9]. Several non-randomised reports favoured LPL in this patient group, while others have cautioned against the practice [10–13].

Three randomised controlled trials have recently been published comparing LPL with colonic resection, with varying results. The aim of this meta-analysis is to compare the effectiveness, morbidity and mortality of LPL versus surgical resection (SR) in the management of APSD.

2. Methods

The meta-analysis was performed in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analyses) Statement [14].

2.1. Data source and search strategy

A search of online databases, including PubMed, EMBASE, and the Cochrane Library was performed to identify studies evaluating the feasibility and safety of LPL in the treatment of acute perforated sigmoid diverticulitis. Search terms used were “Colonic Diverticulitis”, “Diverticula”, “Abdomen”, “Acute”, “Peritonitis”, “Perforation”, and “Emergency”, “Laparoscopy”, “Minimally invasive”, and “Lavage”. All the clinical studies comparing LPL and SR for APSD were retrieved.

2.2. Study selection criteria

Any randomised controlled trial comparing the use of LPL with SR for APSD addressing one or more of our end points was considered eligible for meta-analysis. Patients or trials with APSD

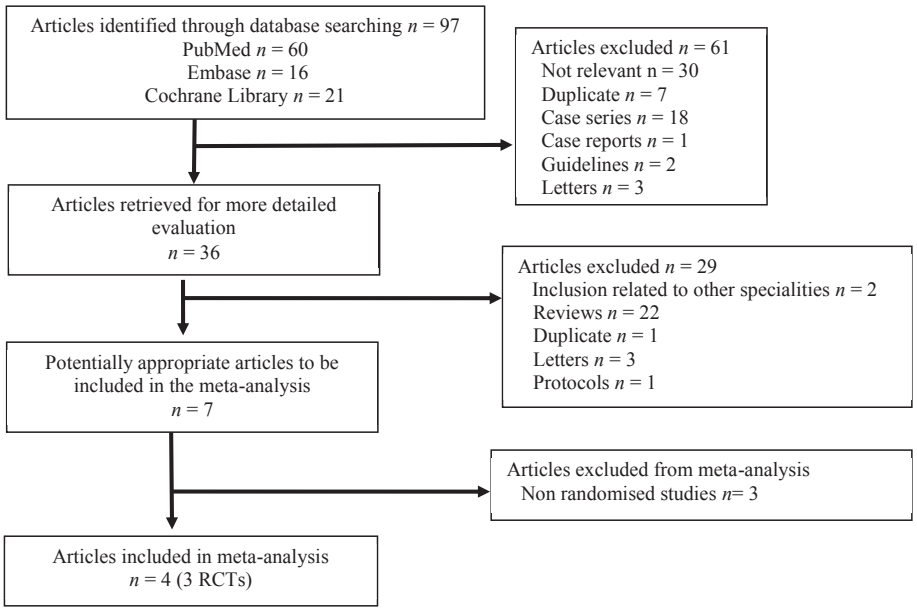


Fig. 1. PRISMA diagram for the systematic review.

with faecal peritonitis were excluded from the analysis.

2.3. Data extraction

Data from the included studies were then extracted, tabulated, and analysed by 2 researchers (FS and PS) and conflicts were solved by consensus. The end points were perioperative mortality, severe adverse events, postoperative abdominal or pelvic abscess formation, operative time, postoperative hospital stay, re-admission, re-operation and overall mortality at the end of the trials. For the analysis we defined perioperative mortality as mortality either at 30 days or during the index admission. Serious adverse events were defined as any event above 3a, as per the Clavien-Dindo classification at 90 days and included postoperative interventions requiring general anaesthesia, life-threatening complications requiring intensive care management and single or multi-organ dysfunction [15]. Overall mortality was defined as mortality reported at the end of the trial. Re-operations were defined as any re-operation following LPL or SR, except related to stoma, either creation or reversal or due to complications of stoma.

2.4. Statistical analysis

Data from eligible studies were entered into a computerized spread sheet for analysis. Statistical analysis was made using the Comprehensive Meta-Analysis software (version 2.2.034). All pooled outcome measures were determined using a random-effects model as described by DerSimonian and Laird [16]. The odds ratio (OR) was estimated with its variance and 95% confidence interval (CI). The random-effects analysis weighted the natural logarithm of each study's OR by the inverse of its variance plus an estimate of the between-study variance in the presence of between-study heterogeneity.

For continuous data (e.g., total operative time, total hospital stay), we used the Hedges *g* statistic to calculate weighted mean differences (WMD). We summarized binary data (e.g., mortality, serious adverse events, abscess formation etc.) as risk ratios (RR). When standard deviations (SDs) were not reported in the studies, we estimated SDs from means or *p* values or on the basis of the sample's reported median and range [17,18].

Heterogeneity between different studies was assessed by use of the I^2 inconsistency test and chi-square-based Cochran's Q statistic [19] test in which $p < 0.05$ is taken to indicate the presence of significant heterogeneity. Subgroup and sensitivity analyses were not feasible owing to the limited number of studies available for inclusion in our review.

2.5. Quality assessment

The quality of the included studies for randomised clinical trials was assessed by using Jadad's scoring system [20].

3. Results

3.1. Description of eligible studies

The literature search revealed four articles from three randomised controlled trials comparing LPL with SR for APSD [21–24]. These were included for final analysis. No reference was identified through hand searching reference lists of the identified studies. Table 1 shows the patients demographics and characteristics of included studies. All studies were restricted to emergency treatment for APSD. Most of the characteristics were not significantly different between treatment groups (Table 1). Although all three trials included patients with Hinchey grade III, the SCANDIV trial randomised patients before laparoscopy and included some cases of diverticulitis with Hinchey grades I and II, in addition to Hinchey grade III, while both the DILALA and LADIES (LOLA) trials randomised subjects once Hinchey Grade III was confirmed at laparoscopy. All studies were performed on adult patients. Fig. 1 depicts a PRISMA Flow Diagram, detailing the literature search. The total number of patients assigned to treatment from the three studies was 372. After adjusting for those excluded from each trial, the total number examined was 315.

3.2. Methodological quality of included studies

The methodological quality scores of included trials are shown in Table 1. In general, the quality of the studies was moderate (mean quality score 3). All data were analysed in accordance with the intention to-treat principle.

3.3. Outcomes assessment

1, Perioperative mortality

Overall, perioperative mortality occurred in 4.4% of the patients treated with LPL and in 2.7% of the patients who underwent SR. The test of heterogeneity was not significant. There was no statistically significant difference in the incidence of mortality between LPL and SR (OR 1.356, 95% CI 0.365 to 5.032, p = 0.649, Fig. 2).

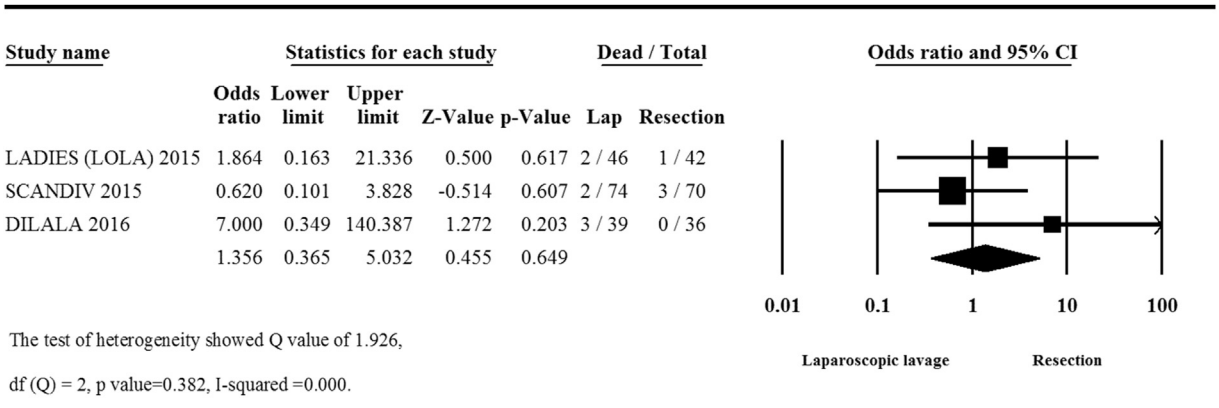


Fig. 2. Forest plot of odds ratios for perioperative mortality.

2, Serious adverse events

There was evidence of statistical heterogeneity between the trials. Pooled analysis showed no significant difference in morbidity rates between the LPL and SR groups (OR = 1.866, 95% CI = 0.680 to 5.120, p = 0.226, Fig. 3).

4, Postoperative abdominal or pelvic abscess formation

There was no significant heterogeneity between the trials. The analysis showed a significantly higher rate of postoperative abscess formation in the LPL group as compared to SR group (OR = 4.121, 95% CI = 1.890 to 8.986, p = 0.0004, Fig. 5).

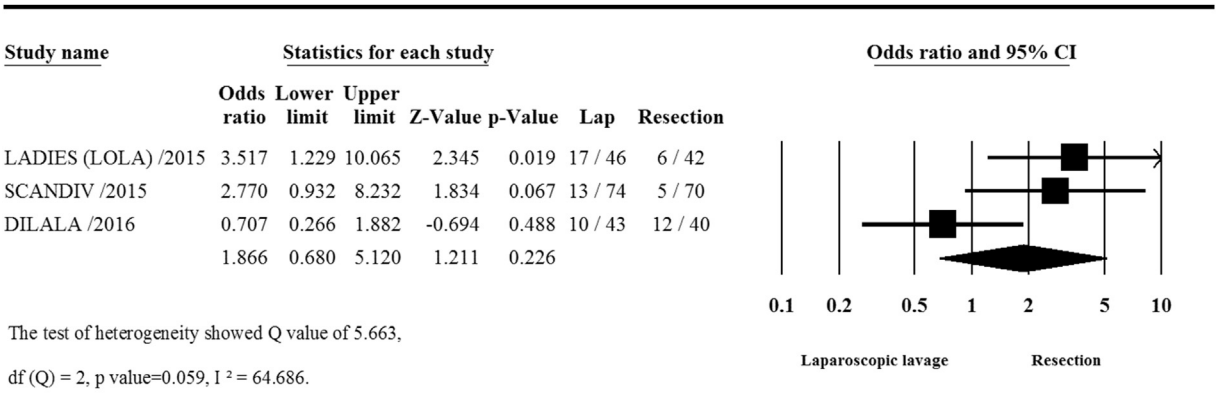


Fig. 3. Forest plot of odds ratios for serious adverse events.

3, Overall mortality at the end of the trials.

There was no significant heterogeneity among the trials. There was no significant difference in overall mortality at the end of the trials comparing LPL and SR (OR 0.863; 95% CI = 0.416 to 1.789, p = 0.692. Fig. 4).

5, Percutaneous drainage of postoperative abscess

Only two trials reported percutaneous drainage of post-operative abscess. There was no significant heterogeneity between trials. The LPL group required significantly more percutaneous interventions than the SR group. (OR = 5.414, 95% CI = 1.618 to 18.118, p = 0.006, Fig. 6).

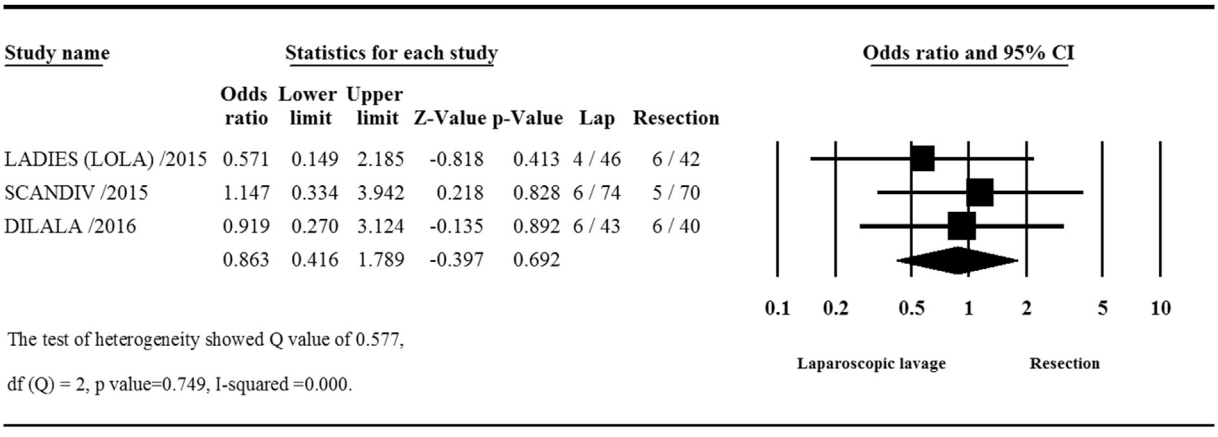
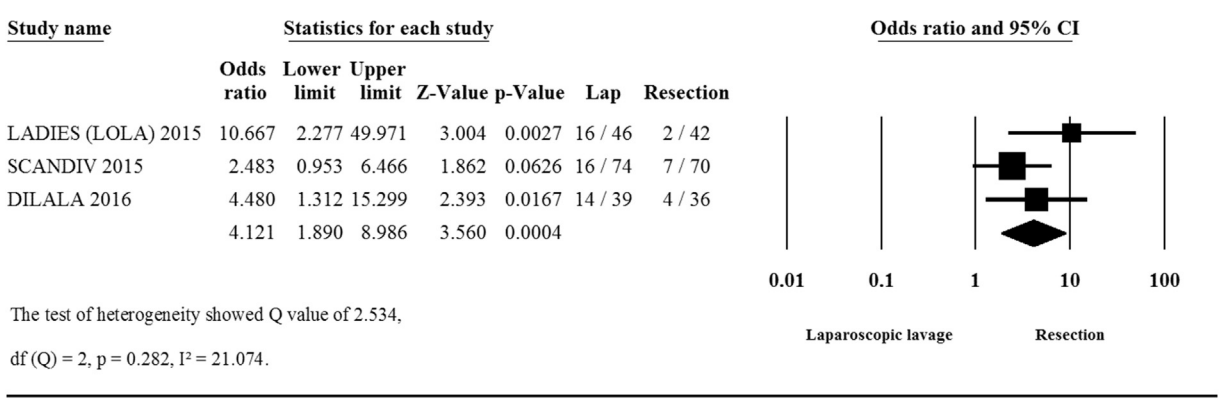
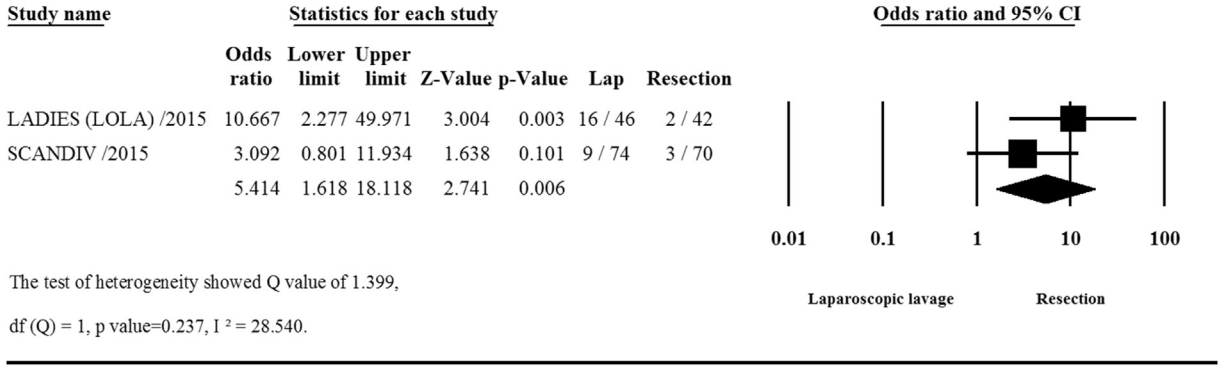


Fig. 4. Forest plot of odds ratios for overall mortality at the end of the trails.



Meta-analysis of postoperative abscess

Fig. 5. Forest plot of the odds ratio for post-operative Abscess formation.



Meta-analysis of percutaneous drainage of postoperative abscess

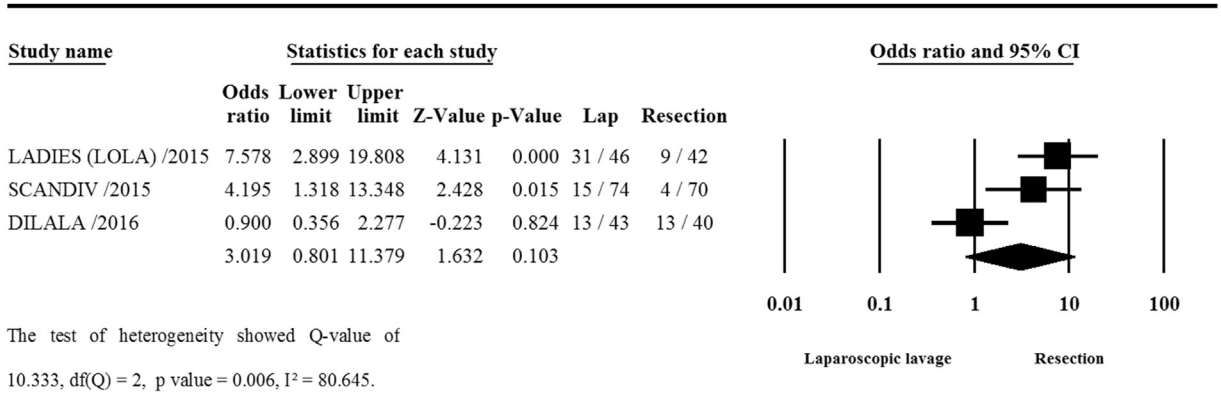
Fig. 6. Forest plot of odds ratios for percutaneous drainage of postoperative abscess.

6, Reoperation rate

There was significant heterogeneity among the trials. Although there was an apparent higher reoperation rate in the LPL (36.2%) than in the SR (17.1%) group, the analysis showed no statistically significant difference in the reoperation rates between the two groups. (OR = 3.019, 95% CI = 0.801 to 11.379, p = 0.103, Fig. 7).

7, Operative time

There was significant heterogeneity between trials. There was a significant reduction in operative time with LPL treatment as opposed to SR (WMD = −72.105, 95% CI = −88.335 to −55.876, p < 0.0001, Fig. 8).



Meta-analysis of reoperation

Fig. 7. Forest plot of odd ration for reoperations.

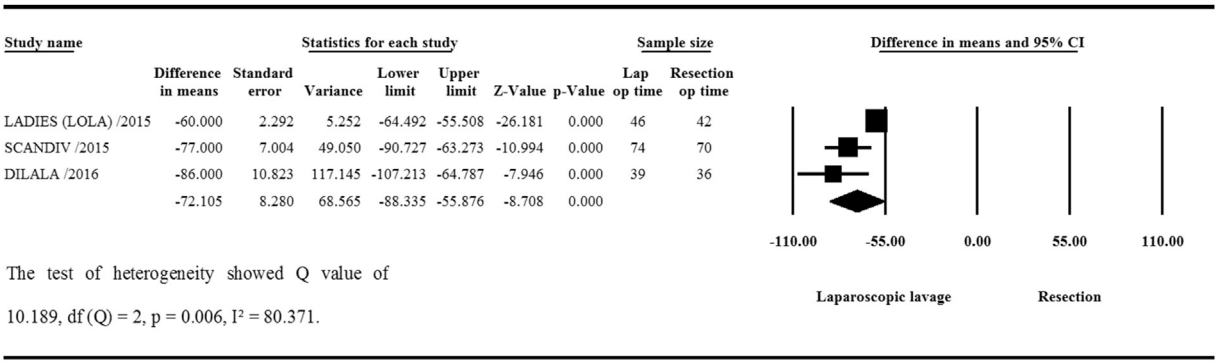


Fig. 8. Forest plot of the weighted mean difference for operative time.

8, Postoperative hospital length of stay

There was no significant heterogeneity between the trials. In pooled analyses, patients undergoing LPL had a mean postoperative hospital length of stay of 2 days less than those undergoing SR (WMD = −1.550, 95% CI = −2.633 to - 0.468, p = 0.005, Fig. 9).

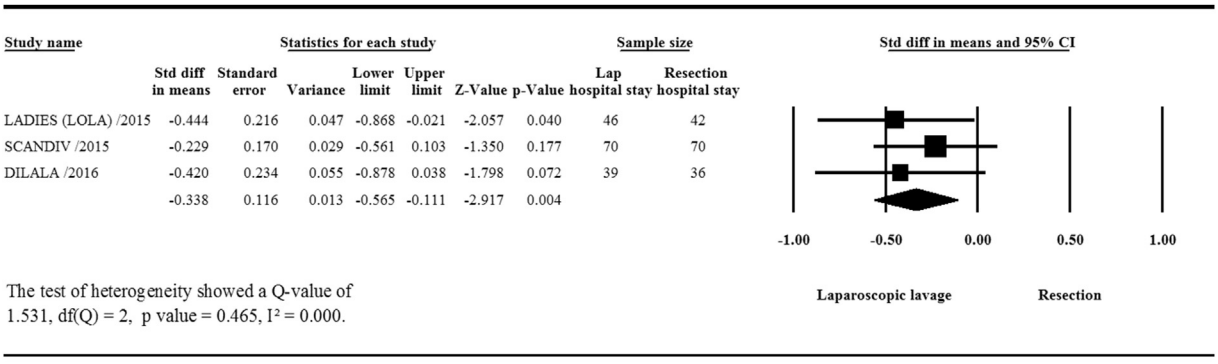


Fig. 9. Forest plot of weighted mean difference of postoperative hospital stay.

9, Readmission rate

There was evidence of statistical heterogeneity among the trials. Pooled analysis showed no significant difference in readmission rates between the LPL and SR groups (OR 0.809; 95% CI, 0.337–1.945, p = 0.636, Fig. 10).

4. Discussion

This meta-analysis from the pooled data from randomised controlled trials between LPL and SR for APSD showed no significant difference between the two groups with respect to perioperative mortality, or mortality at the end of the trials. A perioperative mortality of 4.4% in the LPL group is higher than the 1.7–2.9% of some previous non-randomised reports [13,25]. However, a recent retrospective population study using an Irish national database reported a mortality of 4% with LPL, similar to our analysis [26]. There was heterogeneity between the trials when serious adverse events were considered, thus any firm conclusion from this cannot be made.

We found a significantly higher rate of postoperative abdominal or pelvic abscess formation in the LPL group, with an OR of 4.1. This finding was highlighted in the LPL arm of the LADIES (LOLA) trial, in which an independent safety board deemed the adverse event rate in the LPL group unacceptably high, after 90 of its calculated 264 patients were accrued. In particular, the re-intervention rate in the LPL group of the LADIES (LOLA) trial was significantly higher than in the Hartmann's group. Although the rate of reoperation did not reach significance in our meta-analysis, the rate of percutaneous intervention in the LPL group was significantly higher as a direct result of greater abscess formation.

As expected, the LPL group had a significantly shorter operative time than the SR group. This has obvious potential benefits to the acutely unwell patient with purulent peritonitis, whereby the added physiological stress of prolonged anaesthesia and operation is minimised. However, this is offset against the higher rate of ongoing sepsis in the ensuing days in the LPL group. Whether there is a future role for LPL as a temporising measure to stabilise a certain group of patients as a bridge to surgical resection 24–48 h later, to improve the physiological status of the patient, reduce the amount of peritoneal contamination, and prior to abscess formation remains to be proven.

The length of stay was significantly shorter in the LPL group, with a mean reduction of two days, which has potential benefits to the individual patient, as well as reductions in healthcare costs. Reasons for a shorter length of stay may include faster recovery time of laparoscopic surgery over midline laparotomy, or the added time required for the patients undergoing SR with stoma formation to achieve competence in their stoma management. Despite the

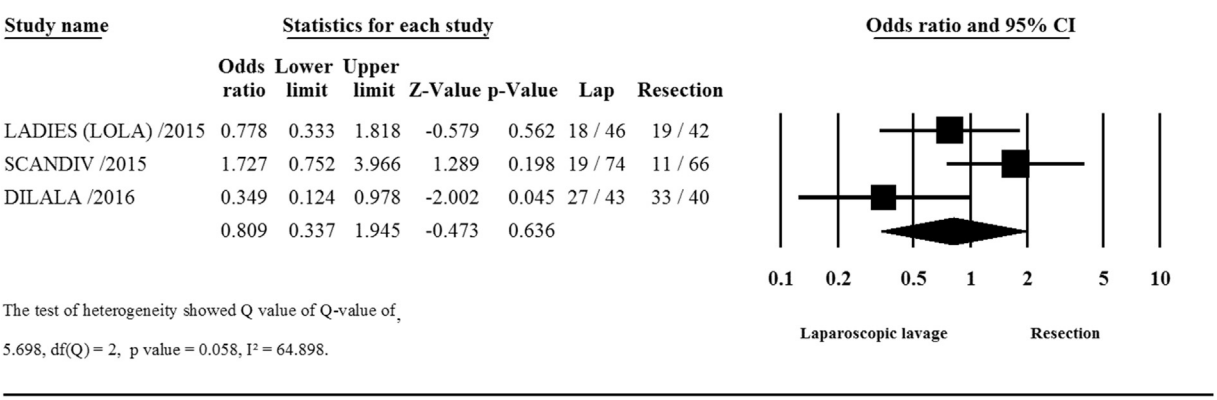


Fig. 10. Forest plot of odds ratios for readmission rates.

finding of significantly higher rates of postoperative abscess formation and percutaneous intervention, there were no available data on the proportion of patients undergoing LPL who were discharged with a percutaneous drain in situ despite leaving hospital earlier. There was no significant difference in rates of readmission between groups, although the heterogeneity of the available data prohibits meaningful interpretation of this aspect of analysis. What is clear from this meta-analysis is that the rate of ongoing abdominal and pelvic sepsis is significantly higher when the diseased segment of colon remains in situ. However, based on our findings, this does not appear to change perioperative mortality or overall mortality reported at the end of the analysed studies. The data from the pending LapLAND trial [27] may improve the certainty of these meta-analysis results.

The strength of this meta-analysis is through comprehensive analysis of clinically relevant outcomes that only include randomised controlled trials. However, a limited number of available studies with associated difference in methodology along with disproportionate measure of dispersion constituted the main limitation. In this analysis, we have included a small number of patients, with Hinchey grades I and II in addition to III, due to the fact that SCANDIV did include such patients in their study, however only 10 of 305 (3%) patients were Hinchey I or II, with the remainder having purulent peritonitis. Another limitation was difference in methodology in resection groups. In the LADIES (LOLA) trail, 21 patients had a Hartmann's procedure while 22 had primary anastomosis; in the DILALA trial 36 underwent Hartmann's procedure while in the SCANDIV trial, out of 70 randomised to SR, 49 underwent Hartmann's procedure, 18 had a primary anastomosis and 3 with protocol violation ended with lavage only. Future trials should be conducted with a more standardised approach to the highlighted limitations of this analysis in an attempt to reach more definitive conclusions.

5. Conclusion

Laparoscopic peritoneal lavage for APSD is a safe and quick procedure with a shorter hospital stay. The rate of on-going abdominal sepsis was significantly higher in patients managed with LPL compared to SR, although we did not identify a significant difference in perioperative or overall mortality or the rate of serious adverse events. The meta-analysis is limited by small numbers and heterogeneity between included trials. The addition of further randomised controlled trials may improve the certainty of our results.

Ethical approval

Not applicable.

Sources of funding

None.

Author contribution

Faisal. M. Shaikh Data collection, Analysis, final drafting.
Peter. M. Stewart writing, critical revision, final drafting.
Stewart. R. Walsh Data analysis, criticism and final drafting.
R. Justin. Davies Conception and Design, critical revision, final drafting.

Conflicts of interest

None.

Research registration unique identifying number (UIN)

review registry 127.

Guarantor

Faisal M Shaikh.
R. Justin. Davies.

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