Evaluation of laparoscopic peritoneal lavage for perforated diverticulitis: a national registry-based study

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Abstract

Background: Laparoscopic lavage (LPL) has been suggested for treatment of non-feculent perforated diverticulitis. In this observational study, the surgical treatment of diverticular disease in Sweden outside prospective trials was investigated.

Methods: This population-based study used the National Patient Register to identify all patients in Sweden with emergency admissions for diverticular disease, as defined by ICD codes from July 2014 to December 2020. Demographics, surgical procedures and outcomes were assessed. In addition, register data since 1997 were retrieved to assess co-morbidities, previous abdominal surgeries, and previous admissions for diverticular disease.

Results: Among 47,294 patients with emergency hospital admission, 2035 underwent LPL (427 patients) or sigmoid resection (SR, 1608 patients) for diverticular disease. The mean follow-up was 30.8 months. Patients selected for LPL were younger, healthier and with less previous abdominal surgery for diverticular disease than those in the SR group (P < 0.01). LPL was associated with shorter postoperative hospital stay (mean 9.4 versus 14.9 days, P < 0.001) and lower 30-day mortality (3.5% versus 8.7%, P < 0.001). Diverticular disease–associated subsequent surgery was more common in the SR group than the LPL group except during the first year (P < 0.001). LPL had a lower mortality rate during the study period (stratified HR 0.70, 95% c.i. 0.53–0.92, P = 0.023).

Conclusion: Laparoscopic lavage constitutes a safe alternative to sigmoid resection for selected patients judged clinically to require surgery.

Lay summary

Diverticulitis is inflammation in pouches of the large bowel. Rarely, diverticulitis can lead to a bowel perforation causing peritonitis. Traditionally, it was treated by resection of the inflamed bowel with a stoma. A milder treatment has been proposed in which the abdomen is rinsed with saline laparoscopically and drained (laparoscopic lavage). This study aimed to examine the outcomes of laparoscopic lavage in Sweden. Our findings support the use of this method in younger and healthier patients with a history of no or only minor previous abdominal surgery.

Introduction

Sigmoid diverticulitis is a common gastrointestinal disorder in Western societies1,2. It has been suggested that 10–25% of patients with diverticulosis will eventually develop diverticulitis3. However, more recent data suggest that this figure is exaggerated4,5. The estimated lifetime risk of hospitalization for diverticular disease in Sweden is up to 5%6. Furthermore, the incidence of diverticulitis has been rising in recent years7, with a substantial increase in younger patients5,6.

Perforated diverticulitis is a potentially life-threatening condition, and its management has been much debated in recent years. Up to 35% of patients will have perforated disease with purulent or feculent contamination7. Laparoscopic peritoneal lavage (LPL) is a minimally invasive approach that was first reported in 19968. It has emerged as a promising alternative to sigmoid resection (SR) in patients with purulent peritonitis due to perforated diverticulitis. The concept of less-invasive and organ-preserving surgery has always been appealing, because of the faster surgery and recovery times and the avoidance of stoma and anastomosis.

Several case series9–35, three RCTs (DILALA, SCANDIV, Ladies trial)36–42 and several meta-analyses43–48 have been published, but they have used different definitions and reached opposing conclusions. Several controversies remain about LPL and conclusions. Several controversies remain about LPL and numerous surgeons are sceptical. Thus, it is evident that more

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information is needed in order to prove the efficacy of the new method.

The aim of this study was to analyse the emergency surgical treatment of diverticular disease in Sweden outside clinical trials concerning short- and long-term outcomes.

Methods
The unique personal identity number assigned to all residents in Sweden was used to enable individual-level linkages across three nationwide registers: the National Patient Register (NPR), the National Cancer Register and the Cause of Death Register. The NPR contains healthcare administrative data, with national coverage on inpatient care since 1987, including diagnostic codes (according to the current Swedish version of the International Classification of Diseases, ICD), and procedure codes (the Nordic Medico-Statistical Committee, NOMESCO, Classification of the Surgical Procedures, in use since 1997). The National Cancer Register was founded in 1958 and contains nationwide medical data about all malignancies and date of diagnosis. Since 1961, the Cause of Death Register has comprised data from all deaths of people registered in Sweden, including underlying and contributory causes of death recorded by ICD codes.

The study was based on a national cohort gathered from these registers, obtained by the Swedish National Board of Health and Welfare.

Ethics
The study was approved by the Swedish Ethical Review Authority (registration number 2021–01441) and registered at ClinicalTrials.gov (NCT05893095). The STROBE guidelines for reporting observational studies were followed.

Patient inclusion
All individuals aged 18 or older who were admitted to a Swedish hospital between 1 July 2014 and 31 December 2020, with an ICD-10 code for diverticular disease of the large intestine (K57.2–K57.9, primary or secondary diagnostic codes) were identified in the NPR (Table S1, Supplementary Material). The study inclusion start date was selected to avoid including patients in the most recent Nordic RCT. Only emergency admissions were included. Patients who underwent surgical procedures because of diverticulitis were studied. Procedures were grouped into two categories: SR with or without stoma and LPL (Table S2, Supplementary Material). Patients who were diagnosed with colorectal cancer, as recorded in the National Cancer Register, before LPL or SR for diverticular disease, were excluded. All operation codes were analysed separately. Patients with synchronous surgeries that were assumed to be irrelevant to acute diverticulitis during analysis of the data set were excluded (Table S3, Supplementary Material).

Data collection and analysis
Baseline patient characteristics and outcome variables were obtained from the NPR, including age, sex, date of admission, type of admission (emergency/elective), length of hospital stay and NOMESCO codes for previous abdominal surgery (Table S4, Supplementary Material). The first emergency operation because of diverticular disease during the study period was considered as the index operation.

The cohort was studied from 1 January 1997 until the index date, aiming to assess co-morbidities, previous abdominal surgeries and admissions for diverticular disease. A Charlson Co-morbidity Index (CCI) system adjusted to the Swedish ICD-10 version was used to calculate a composite score to reflect co-morbidity.

In addition, crossover operations (records of CR on the same date as LPL on the index date, presumably representing conversions) were specifically noted. All operations on stomas, including stoma creations and stoma reversals, from 1 January 1997 until the end of the study period or death, were analysed. Diverticular disease-associated subsequent surgery was defined as an operation involving the bowel or abdominal wall after the index surgery and during the study period, and presumably related to the index surgery for acute diverticular disease (Table S5, Supplementary Material). The outcomes of interest were crossover operations (SR after LPL), diverticular disease-associated subsequent surgery, mortality, colorectal cancer diagnoses and non-elective readmission for diverticular disease. Another outcome of interest was the number of living patients who had a stoma during the first 3 years of follow-up (Table S6, Supplementary Material). Patients were followed up from the index date until the end of the study period (31 December 2020) or death. This information was retrieved from the Cause of Death Register. All cancer diagnoses during the study period were derived from the National Cancer Register.

Statistical analysis
Categorical variables, presented as number of patients and percentage, were analysed using the chi-square test, whereas ordinal data were analysed using the Mann–Whitney U test. Quantitative variables, presented as mean with standard deviation, were analysed using the Student’s t-test. Median and interquartile range were also presented. Both uni- and multivariable Cox proportional hazard models were constructed to assess risk of mortality after each category of surgical procedure. Results are presented as HRs with 95% confidence intervals, and two-sided \( P < 0.05 \) was considered significant. A stratified Cox proportional hazards regression model was used to address violation of the proportional hazards. Visual assessment of log(-log) plots was used to assess the proportional hazard assumption. In this model, the CCI was classified into three categories (0 if CCI = 0; 1 if CCI = 1; and 2 if CCI ≥ 2). The group of patients was also divided into two subgroups, one younger than or equal to the median (age ≤ 70.1 years) and the other subgroup older than the median (age > 70.1 years). Overall survival was used as an endpoint and defined as time from index surgery to death or end of follow-up. Kaplan–Meier curves were created for comparing survival outcomes for patients who had undergone LPL with those who had undergone SR. The log-rank test was used to assess survival differences between the groups. The cumulative incidence was used to quantify the cause-specific failure probability with mortality as a competing risk. The correlation between the different surgical centres in every county was measured adjusted for the catchment area. A two-way mixed model for calculation of intraclass correlation coefficient was used. The results of the analysis were performed using Stata Statistical Software: Release 17. College Station, TX, USA: StataCorp LLC.
results

demographic data

In all, 52,863 patients were admitted to hospital for colonic diverticular disease (DD) between 1 July 2014 and 31 December 2020 (Fig. S1, Supplementary Material), of whom 47,294 (89.5%) were admitted through the emergency department, with a mean age of 68.5 years (s.d. 15). A total of 2227 patients underwent surgery with LPL or SR during an emergency admission for diverticular disease. One patient from the LPL group and 51 from the SR group had a diagnosis of colorectal cancer before the index date and they were therefore excluded. Other than that, 16 and 124 patients from the LPL and SR groups respectively were excluded because their surgery was assumed to be irrelevant to acute diverticulitis.

After exclusions, there were 427 patients who underwent LPL and 1608 patients who underwent SR. A primary diagnostic code was found in 1822 (89.5%) of all cases, whereas 1801 had a diagnostic code for diverticular disease as a secondary code. No patient had a code for diverticular bleeding. The mean age was 67.3 years (s.d. 13.6). Crossover surgery to SR was performed in 9 of 427 patients in the LPL group (2.1%). A stoma was created in 8 of the 418 patients (1.9%) who underwent LPL without surgery record for diverticular disease treated by LPL or SR

<table>
<thead>
<tr>
<th>LPL</th>
<th>SR</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number (n)</td>
<td>427</td>
<td>1608</td>
</tr>
<tr>
<td>Age (mean(s.d.))</td>
<td>62.3±14.9</td>
<td>69.4±12.8</td>
</tr>
<tr>
<td>Sex ratio (male:female)</td>
<td>1.1</td>
<td>0.6</td>
</tr>
<tr>
<td>CCI = 0</td>
<td>294 (68.9%)</td>
<td>768 (47.3%)</td>
</tr>
<tr>
<td>CCI &gt; 0</td>
<td>83 (19.4%)</td>
<td>578 (35.9%)</td>
</tr>
<tr>
<td>Previous abdominal surgery</td>
<td>95 (22.2%)</td>
<td>445 (27.7%)</td>
</tr>
<tr>
<td>Previous diverticular disease</td>
<td>88 (20.6%)</td>
<td>542 (33.7%)</td>
</tr>
</tbody>
</table>

CCI, Charlson Co-morbidity Index. * Student’s t-test. † Chi-square test. ‡ Mann–Whitney U test.

Postoperative outcomes

The mean length of follow-up of patients was 30.8 months (s.d. 23.2), and the mean length of hospital stay was 13.8 days (s.d. 11.6). More specifically, the mean length of follow-up of patients who had undergone LPL was 30.5 months (s.d. 22.2) compared to 30.9 months (s.d. 23.6) for those who had undergone SR (P=0.563). The length of postoperative hospital stay was shorter after LPL (mean 9.4 days, s.d. =8.5) compared to SR (mean 14.9 days, s.d.=12), P<0.001. Mortality within 30 days was lower in the LPL group (15 of 427 patients, 3.5%) compared to the SR group (142 of 1608 patients, 8.8%), P<0.001. Non-elective readmission for diverticular disease was more frequent in the LPL group (117 of 427 patients, 27.4%), compared to the SR group (102 of 1608 patients, 6.3%), P<0.001.

The cumulative incidence of diverticular disease-associated subsequent surgery, when death was taken into account as a competing risk event, was statistically significantly different between the LPL and the SR groups, P<0.001 (Fig. 2). The 5-year, cause-specific, cumulative incidence of diverticular disease-associated subsequent surgery was 44.2% in the SR group and 36.3% in the LPL group.

More specifically, 20 patients from LPL group underwent an incisional hernia repair compared to 96 from the SR group. The 5-year cumulative incidence of incisional hernia repair, when death was taken into account as a competing risk event was.

Fig. 1 Type of surgery for diverticular disease (July 2014–December 2020).
### Disease-associated subsequent surgery

<table>
<thead>
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<th>No. at risk</th>
<th>Follow-up (years)</th>
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<tr>
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</tr>
<tr>
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</tr>
<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
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</table>

**Fig. 2** Cumulative incidence of disease-associated subsequent surgery among patients who underwent LPL or SR when death was taken into account as a competing risk event (log rank test \( P < 0.001 \)).

### Mortality

<table>
<thead>
<tr>
<th>No. at risk</th>
<th>Follow-up (years)</th>
</tr>
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<tbody>
<tr>
<td>LPL 427</td>
<td>0</td>
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<tr>
<td>SR 1608</td>
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**Fig. 3** Probability (with 95% confidence intervals) of all-cause mortality among patients who underwent LPL or SR (log rank test \( P < 0.001 \)).

7.4% in the LPL group and 8.2% in the SR group, \( P = 0.592 \) (Fig. S3, Supplementary Material).

Moreover, the fraction of patients from LPL group that had a stoma at 3 years after the index date was 7.7% compared to 36.1% from SR group. This fraction represents the percentage of patients that were alive during this period and had a stoma (Fig. S4, Supplementary Material).

The mortality during the study period was lower in the LPL group compared to the SR group (Fig. 3). In a crude model from Cox regression analysis, patients who underwent LPL had a lower mortality rate than patients with SR (HR 0.48, 95% c.i. 0.36 to 0.63, \( P < 0.001 \)). A stratified proportional hazard model was used, in which the CCI and age were stratified in order to address violation of the proportional hazards assumption. Sex and type of procedure were used as additional covariates. Stratified Cox regression with Breslow’s method for ties showed that LPL was associated with a lower mortality rate than SR (HR 0.70, 95% c.i. 0.53 to 0.92, \( P = 0.021 \); Table S8, Supplementary Material).

Finally, it was observed that the 5-year cumulative incidence of colorectal cancer, when death was taken into account as a competing risk event was 2.7% in the LPL group and 2.8% in the SR group (log rank test \( P = 0.981 \); Fig. 4).

### Discussion

This study shows that, in Sweden, LPL for diverticular disease is used preferentially in younger and healthier patients without previous abdominal surgery or previous episodes of diverticular disease. Additionally, it was observed that from 2018, only 8 years after publication of the first prospective trial, there has been a change in the preferred strategy for surgical treatment of diverticular disease, where LPL has been used increasingly. Nevertheless, sigmoid resection is still the most frequent procedure in Sweden.

Our results also indicate that LPL is associated with a shorter hospital stay and a more than 50% reduced 30-day mortality compared with SR. Overall, LPL is associated with an increased need for diverticular disease-associated subsequent surgery during the first year. Meanwhile, it is worth mentioning that 2.1% of patients who were intended to be treated with LPL needed a crossover operation. This can be explained by a more advanced stage of acute diverticulitis, such as feculent peritonitis, or by technical problems with laparoscopy. Moreover, the higher frequency of reoperations during the first year can be related to recurrent diverticulitis. In addition, a stoma was created in 1.9% of patients who underwent LPL without crossover on the index date compared to 77.1% from the SR group. On the other hand, after the first year, SR is associated with a higher need for diverticular disease-associated subsequent surgery compared to the LPL group. More patients from the SR group had a stoma at three years after the index date compared to LPL group, as would be expected.

Moreover, as seen by the late postoperative results after a mean length of follow-up of 30 months, LPL was associated with a lower mortality rate than SR when stratified Cox regression was used. No statistical difference in colorectal cancer occurrence was observed between the two groups. As would be assumed, LPL is associated with a higher risk for non-elective readmission for diverticular disease compared to SR. Overall, LPL is associated with an increased need for diverticular disease-associated subsequent surgery compared to the SR group. More patients from the SR group had a stoma at three years after the index date compared to LPL group, as would be expected.

Moreover, as seen by the late postoperative results after a mean length of follow-up of 30 months, LPL was associated with a lower mortality rate than SR when stratified Cox regression was used. No statistical difference in colorectal cancer occurrence was observed between the two groups. As would be assumed, LPL is associated with a higher risk for non-elective readmission for diverticular disease compared to SR because of the removal of inflamed sigmoid colon in the latter group.

The findings of reduced duration of hospitalization after LPL in our study are in line with the results of previous prospective studies. The DILALA trial and the SCANDIV trial were designed to compare laparoscopic lavage with colon resection. In the DILALA study 83 patients were considered to have perforated diverticulitis with purulent peritonitis (Hinchey grade...
laparoscopic lavage did not differ when compared with the Hartmann procedure. Laparoscopic lavage resulted in shorter operating time, shorter time in the recovery unit and shorter hospital stay. No difference was found in mean number of readmissions after 24 months from the index date. Likewise, the SCANDIV trial showed that LPL was associated with a greater need for subsequent surgery. Indications for subsequent surgery that were included in that study were stoma reversal, missed colonic carcinoma, recurrent diverticulitis, anastomotic leak, wound dehiscence or small bowel obstruction. Our study included a wider variety of operations in the abdomen and a longer follow-up period. Mortality at 90 days and length of postoperative hospital stay did not significantly differ between the two groups in this trial. It is, however, important to mention that among these patients in the trials, there is no clear distinction between evident of occult and large or small perforations, as well as minimal or absent faecal contamination. Besides that, the SCANDIV trial authors did in fact report that major disagreements between trial monitors and investigators were on Hinchey grading, which led to a change of grade in 17% of patients.

Numerous retrospective studies have shown good results when acute perforated diverticulitis is treated by LPL. reported that LPL was associated with an increased rate of disease-associated subsequent surgery. The largest retrospective study was performed in Ireland by Rogers et al., who investigated national trends in the management of perforated diverticulitis based on national databases. Patients selected for LPL had lower mortality, fewer complications and shorter length of hospital stay than those requiring laparotomy/resection. Similarly, another retrospective study showed that LPL should not be considered in elderly patients and those with severe systemic co-morbidity. These results are in line with ours, where LPL was used more regularly in younger and healthier patients.

A strength of this study is the use of a population-based national cohort that enables evaluation of LPL in emergency care. Unlike prospective studies, our study has used unselected real-world data, and it was not surprising to find that around 90% of admissions for diverticular disease was because of emergency presentations. The Swedish National Patient Register has been validated and has high coverage, because reporting is mandatory for all healthcare providers. A further strength is that the cohort is recent and patient inclusion started after the end of the last prospective study, to avoid including patients previously covered.

The main limitations of this study are those inherent to most register studies. We did not have access to individual patient charts and thus results are restricted by the quality of information stored in the database. According to the inclusion criteria based on ICD-10 codes, it was not possible to determine the proportion of patients admitted with acute diverticulitis and other manifestations of diverticular disease. Likewise, it was impossible to determine whether the identified disease-associated subsequent surgery was associated with previous surgery for diverticular disease or with another medical condition, for example bowel obstruction. The diagnostic codes used during readmission for a subsequent surgery were studied but it was not feasible to ascertain the actual medical condition from the patient’s previous or chronic diseases. Moreover, our study cannot identify patients with feculent or purulent peritonitis at the time of surgery. Patients with feculent peritonitis are included in the resection group, indicating a more severe disease stage with worse outcomes. It is also worth mentioning that nine patients had a crossover surgery, which is based on operation dates. No access to medical records was obtained, but it was assumed that LPL was performed before SR. Furthermore, it was chosen to exclude patients who were diagnosed with colorectal cancer before the SR or LPL. Patients with synchronous operations that were supposedly irrelevant to acute diverticulitis were also excluded. Another restriction is that this study does not provide any clue whether all operated patients really needed surgery. Our study does not prove that laparoscopic lavage is superior to sigmoid resection in acute diverticulitis. Rather, it demonstrates that the technique is preferentially utilized in healthier and younger patients, who have had no previous abdominal surgery or episode history of diverticular disease, and that those patients selected for LPL have acceptable postoperative outcomes. Whether LPL might also be beneficial in the elderly and co-morbid population cannot be answered based on our results and further studies are needed to address this question. The laparoscopic approach may also offer an alternative diagnostic tool in patients with acute peritonitis.

Conclusion

This study adds to the increasing literature on the benefits of using laparoscopic lavage in the management of perforated diverticular disease and provides a reflection of everyday surgical practice. The importance of this therapeutic choice was emphasized in the subgroup of younger and healthier patients, without previous abdominal surgery, who can be selected for laparoscopic lavage and who may thereby avoid the mortality and morbidity associated with surgical resection and a potentially permanent colostomy.

Funding

The authors have no funding to declare.

Disclosure

The authors declare no conflict of interest.

Supplementary material

Supplementary material is available at BJS online.

Data availability

Application for data sharing can be available upon reasonable request following contact with the corresponding author.

Author contributions

Christos Kollatos (Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Software, Validation, Visualization, Writing—original draft), Filip Sköldberg (Conceptualization, Formal analysis, Methodology, Project administration, Software, Supervision, Validation, Writing—review & editing), and Wilhelm Graf (Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation,
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