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# Comparative study of postoperative complications after open and laparoscopic surgery of the perforated peptic ulcer: Advantages of the laparoscopic approach

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ABSTRACT

*Background:* Despite the acceptance of the laparoscopic approach for the treatment of perforated peptic ulcers, its definitive implantation is still a matter of discussion. We performed a comparative study between the open and laparoscopic approach focused on postoperative surgical complications.

*Methods:* Retrospective observational study in which patients operated on for perforated peptic ulcus in our center between 2001 and 2017 were analyzed. Only those in whom suture and/or omentoplasty had been performed were selected, either for open or laparoscopic approach. Demographic, clinical, and intraoperative variables, complications, mortality and length of stay were collected. Both groups, open and laparoscopic surgery patients, were compared.

*Results:* The final study sample was 250 patients, 190 (76%) men and 60 (24%) women, mean age 54 years (SD ± 16.7). In 129 cases (52%), the surgical approach was open, and in 121 (48%) it was laparoscopic. Grades III-V complications of the Clavien-Dindo Classification occurred in 23 cases (9%). Operative mortality was 1.2% (3 patients). Laparoscopically operated patients had significantly fewer complications ($p = 0.001$) and shorter hospital stay ($p < 0.001$). In multivariate analysis, laparoscopic approach ($p = 0.025$; OR:0.45−95%CI: 0.22−0.91), age ($p = 0.003$; OR:1.03−95%CI: 1.01−1.06), and Boey score ($p = 0.024$ − OR:1.71 − CI95%: 1.07−2.72), were independent prognostic factors for postoperative surgical complications.

*Conclusion:* Laparoscopic surgery should be considered the first-choice approach for patients with perforated peptic ulcer. It is significantly associated with fewer postoperative complications and a shorter hospital stay than the open approach.



## 1. Introduction

Despite the wide use of proton pump inhibitors, patients with perforated peptic ulcer, a serious and potentially fatal complication of ulcer disease, continue to be admitted relatively frequently in the emergency setting.[1] The prevalence of perforation in patients with peptic ulcer is estimated to be approximately 5%.[2] Mortality remains relatively high, and can reach 25% of the patients, even in Western countries.[3] The long-term prognosis of these patients is also worrying.[4]

Regarding surgical treatment of perforated peptic ulcer, several clinical trials[5–8] have shown that the laparoscopic approach achieved less postoperative pain, a shorter hospital stay, and an earlier return to normal patient activity, but the analysis of outcomes in these studies did not favor either approach in terms of morbidity, mortality, and reoperation rate.

Three published meta-analysis[9–11] showed that laparoscopic repair also had similar rates of postoperative surgical complication except of the lower surgical site infection rate. Antoniou et al[12] also concluded that current evidence does not clearly demonstrate the

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advantages of laparoscopic versus open repair for any of the examined outcomes measured in his meta-analysis. Another more recent meta-analysis[13] demonstrated that laparoscopic repair for perforated peptic ulcer had a reduced morbidity and total hospital stay compared with open approach, but there were no significant differences in mortality, post-operative sepsis, abscess and re-operation rates.

Therefore, although many evidences suggest that laparoscopic repair is better than open repair for perforated peptic ulcer,[14,15] laparoscopy has not been clearly associated with fewer global postoperative complications, including deaths.

The objective of this study was to compare these two surgical approaches for perforated peptic ulcer, open versus laparoscopic repair, in a sample of patients who underwent the same surgical procedure, suture and omentoplasty, with emphasis on the presentation of postoperative surgical complications.

## 2. Method

An observational study was conducted on 272 consecutive patients who were operated on for perforated peptic ulcus in our institution between 2001 and 2017. The setting was a university tertiary-care referral center. The study was approved by the Ethics and Clinical Investigation Committee of the Hospital (code 140184).

Inclusion criteria included patients with perforated peptic ulcer in whom closure of the perforation by suture with omentoplasty had been performed, either by open approach or by laparoscopic approach. Exclusion criteria included patients in whom the peptic perforation was treated by any procedure other than suture with omental patch, such as gastric resection (10 patients), ulcer exclusion (8 patients), or bypass (4 patients), with or without vagotomy.

After admission in the emergency department, a surgeon preoperatively evaluated all patients, and a complete anamnesis and physical examination were completed. The diagnosis of perforation was made by the existence of generalized tenderness on the abdominal examination and/or the presence of air under the diaphragm dome in chest or abdominal X-ray. In doubtful cases, computed tomography was used. Laboratory tests, electrocardiograms, and additional tests were also performed based on each patient's underlying condition.

The sample was divided into two groups: patients operated by laparoscopic approach and patients operated by open approach. Selection of the procedure depended on the on-call surgeon's preference, and therefore, there was no randomization.

The following data were recorded:

Preoperative variables: age, gender, personal medical history, and time onset of symptoms to admission at the hospital categorized in three periods of time (<6 h vs 6–12 h vs > 12 h). The decision to set the value of 12 h as the superior limit of the time was based on the fact that the value of the median of the distribution of this variable was approximately 12 h. Boey score was also calculated for each patient. Boey et al[16] defined a risk scale for mortality of perforated patients from 0 to 3 points based on the presence of a history of severe medical illness according to the American Society of Anesthesiologists (ASA) Physical Status (ASA III-V), preoperative shock and/or evolution of the perforation greater than 24 h. The mortality in his series was 0% (no risk factors), 10% (one factor), 45.5% (two factors) and 100% (three factors).

Surgical variables: type of surgical approach (open vs laparoscopic surgery), ulcus location (gastric vs juxtapiloric vs duodenal location), Mannheim Peritonitis Index, and rate of conversion to open surgery. Mannheim Peritonitis Index[17] include 8 proven risk factors related to a poor prognosis in patients with peritonitis, and classified according to their predictive power: age >50 years (5 points), female sex (5 points), organ failure (7 points), malignancy (4 points), preoperative duration of peritonitis >24 h (4 points), origin of sepsis not colonic (4 points), diffuse generalized peritonitis (6 points), cloudy, purulent exudate (6 points), and fecal exudate (12 points).

Postoperative variables: surgical wound infection, postoperative ileus, intra-abdominal collections, postoperative complications according to Clavien-Dindo score (grades I-II vs grades III-V), median postoperative stay, and operative mortality. Operative mortality was defined as either any death occurring within 30 days of surgery or any later death that was considered to be a direct consequence of a postoperative complication.

### *2.1Statistical analysis*

Data were analyzed using the statistical package SPSS 26.0 for Windows (IBM Corp, Armonk, NY, USA). First, a descriptive study of the sample was carried out. Categorical variables were expressed as frequencies and percentages, and the numerical variables by the mean (±standard deviation) or the median (interquartile range) if the distributions were nonparametric.

The time between the start and the end of the study was categorized into three consecutive periods: 2001–2006, 2007–2012, and 2013–2017. Linear-by-linear association (Chi Square test) was used to highlight a possible linear trend across the different periods.

Next, a univariate analysis was performed to determine which of the predictive variables, including type of surgical approach, were associated with postoperative complications. Both groups, laparoscopic and open approach, were also compared to detect any significant difference between the independent variables. Then, the possible association between postoperative complications, mortality, median stay, and the two types of approach, open and laparoscopic surgery, was analyzed.

The Chi-squared test or Fisher test was used to compare categorical data. For the parametric distribution of numerical variables, Student t test was used to compare the mean values of two groups. For nonparametric and ordinal variables, the Mann–Whitney U test was used to compare the median values of the response variable.

Finally, a stepwise logistic regression analysis was performed. The model included, as explanatory or predictive factors, the variables that were suggested in the univariate analysis to be associated with postoperative complications, and those variables that were unadjusted between the two groups, open and laparoscopic approach. An adjusted odds ratio (OR) with a 95% confidence interval (CI) were used. The odds ratio was calculated as an estimate of relative risk between two groups on the basis of the postoperative complications as outcome. The 95% CI was determined as an indication of the precision of an estimate of a population value. Statistical significance was defined as $p < 0.05$.

## 3. Results

The definitive study sample consisted of 250 patients who underwent surgery for perforated peptic ulcer. Closure of the perforation by suture with omentoplasty was performed in all of them, 190 men (76%) and 60 women (24%) ($p < 0.001$), with a mean patient age of 54 years (SD ± 16.7).

Only 31 patients (12%) had been screened for *Helicobacter pylori*. Time onset of symptoms to admission was less than 6 h in 55 patients (21%), between 6 and 12 h in 73 patients (29%), and longer than 12 h in 122 patients (49%).

The location of the ulcer was juxtapyloric in 139 cases (56%), duodenal in 82 cases (33%), and gastric in 29 cases (12%). Boey score mean (±SD) of the total sample was 0.68 (±0.79): 125 patients 0 points, 89 patients 1 point, 30 patients 2 points, and 6 patients 3 points. Mean (±SD) Mannheim index was 17.95 (±4.13).

In 129 patients (52%), the surgical approach was open, and in 121 patients (48%), it was laparoscopic. A significant linear trend over time in favor of laparoscopic surgery was observed for recent years ($p = 0.008$) (Fig. 1). In the period from 2001 to 2006, 57 patients (61%) underwent open repair, and 37 patients (39%) laparoscopic repair. Instead, from 2013 to 2017, 45 patients (66%) were operated on by laparoscopic approach, and only 23 patients (33%) by open surgery. Two of the six patients with a Boey score of 3 underwent laparoscopic surgery.

The laparoscopic procedure could be completed in 113 patients and conversion to open surgery was necessary in 8 cases (6.6%). The most frequent causes of conversion were large perforation size (more than 2 cm) (5 cases), poor tolerance to pneumoperitoneum (1 case), and technical difficulties (2 cases). The reconverted patients were included in the analysis within the laparoscopic approach group.

Of the total sample, 150 patients (60%) did not present any type of complication, whereas 100 of them (40%) developed some type of complication. According to the Clavien-Dindo classification, 77 cases (31%) had minor complications (grades I-II) and only 23 cases (9%) had major complications (grades III-V), including 3 deaths (Table 1). Therefore, operative mortality was 1.2% (3 patients), 2 in the open group and 1 in the laparoscopic group, all of them older than 80 years and with comorbidity.

Twenty-six cases (10%) were complicated by a wound infection, 29 patients (12%) developed postoperative ileus, 12 patients (5%) presented intra-abdominal collections after the procedure, and 14 patients (6%) required reoperation, generally due to wound dehiscence (8 cases) or reperforation (6 cases). All the eviscerated patients belonged to the open surgery group. The reperforated patients were distributed in a similar way between both groups, each one with 3 patients.

Table 2 shows the association between the different study variables and the development of complications in the total sample. Age ($p < 0.001$), Boey score ($p < 0.001$), time onset of symptoms ($p = 0.004$), and type of surgical approach ($p < 0.001$) were related to the presentation of complications. Table 3 shows the postoperative complications according to the type of surgical approach (open vs laparoscopic surgery) and the different Boey scores.

When we compared the two groups (Table 4), open and laparoscopic surgical approach, we observed that, in relation to the independent variables, they were unadjusted in age ($p < 0.001$) and gender ($p = 0.037$).

In the comparative analysis of the results according to the surgical approach (Table 5), we observed that the patients operated by a laparoscopic procedure had a lower number of complications ($p = 0.001$), and a shorter hospital stay ($p < 0.001$). Specifically, a lower number of wound infections was observed ($p < 0.001$; OR: 28.85–95% CI: 3.84–216.57), along with a lower incidence of postoperative ileus ($p = 0.047$; OR: 2.3–95% CI: 1.00–5.24). There was no statistically significant difference regarding the occurrence of postoperative intra-abdominal collections between the two groups.

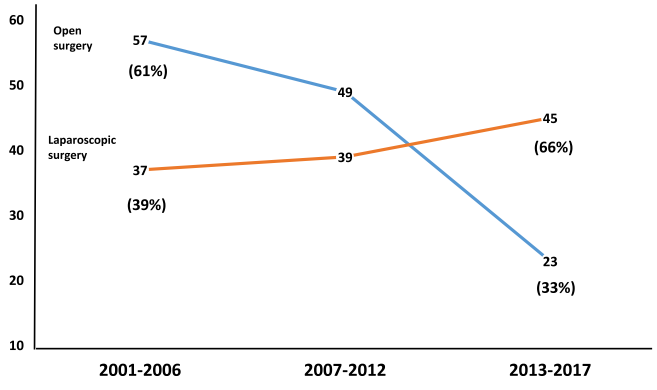


**Fig. 1.** Comparative evolution of both types of surgery, open versus laparoscopic approach, over the years (2001–2017).

**Table 1**
Postoperative complications classified according to Clavien-Dindo score.

| Grade | Frequency | Percentage |
|---|---|---|
| 0 | 150 | 60.0 |
| 1 | 43 | 17.2 |
| 2 | 34 | 13.6 |
| 3 | 11 | 4.4 |
| 4 | 9 | 3.6 |
| 5 | 3 | 1.2 |
| Total | 250 | 100.0 |

A logistic regression model of postoperative complications was constructed to adjust the surgical approach (open vs laparoscopic surgery) and Boey score, for misadjusted variables in the comparative analysis (age and sex). Time onset of the symptoms, variable significantly associated to postoperative complications in univariate analysis, was not included due to the possible existence of collinearity with the variable Boey score. This scale includes the number of hours since the perforation as a risk factor.[16] In the multivariate analysis (Table 6), the surgical approach continued to be an independent prognostic factor for the appearance of postoperative complications ($p = 0.025$; OR: 0.45–95%CI: 0.22–0.91). There was a significantly lower number of postoperative complications in the laparoscopic group. Age ($p = 0.003$; OR:1.03–95%CI: 1.01–1.06), and Boey score ($p = 0.024$ – OR: 1.71 – CI95%: 1.07–2.72) were also independent prognostic factors for postoperative surgical complications. Higher age, and high score of the scale, resulted in higher risk of complications.

## 4. Discussion

The surgical approach to perforated peptic ulcer has changed dramatically in recent decades. In the 1970s, vagotomy and pyloroplasty, with all the risks associated with this type o surgery, was the procedure more frequently performed. In the following decade, a less aggressive approach was recommended: simple suture with or without omentoplasty. Since then, this surgical technique has been most widely used and recommended for the treatment of this complication of peptic ulcer.

In the 1990s, laparoscopic surgery was incorporated.[18] Based on the preliminary results of various series in 2010, this surgical approach was proposed as the first technique of choice, albeit only in selected patients.[14]

Based on the results of our study, we can support that laparoscopic suturing of perforated peptic ulcers, apart from being a safe technique, could provide significant advantages in terms of postoperative complications and hospital stay.

However, the open approach is still widely used and the laparoscopic one somewhat questioned. For many surgeons, exploratory laparotomy and omental patch repair continue to be the best available treatment for this complication.[2] In a recent study[19] it was noted that only 11.4% of US surgeons, still in 2016, used the laparoscopic approach.

Several reports[5,6,8,10,12] do not support that laparoscopic surgery is associated with fewer complications, and found no differences in mortality with respect to open surgery. More recently, in a meta-analysis, Tan et al[9] found that there were no significant differences between these two procedures in some primary outcomes

**Table 2**
Univariate analysis of postoperative complications (no/yes).

| | Total N (%) | Postoperative complications | | P | OR (IC95%) |
|---|---|---|---|---|---|
| | | No N (%) | Yes N (%) | | |
| Age: | | | | | |
| Mean ± SD | 54.3 (±16.7) | 49.3 (±14.5) | 61.8 (±17.2) | <0.001* | 1.1 (1.0–1.1) |
| Gender: | | | | | |
| Men | 190 (76.0) | 119 (79.3) | 71 (71.0) | 0.131 | 1.6 (0.9–2.8) |
| Women | 60 (24.0) | 31 (20.7) | 29 (29.0) | | |
| Tobacco: | | | | | |
| Yes | 144 (57.6) | 88 (58.7) | 56 (56.0) | 0.676 | 1.1 (0.7–1.9) |
| No | 106 (42.4) | 62 (41.3) | 44 (44.0) | | |
| Diabetes: | | | | | |
| Yes | 20 (8.0) | 8 (5.3) | 12 (12.0) | 0.057 | 0.4 (0.2–1.1) |
| No | 230 (92.0) | 142 (94.7) | 88 (88.0) | | |
| Depression: | | | | | |
| Yes | 23 (9.2) | 12 (4.8) | 11 (4.4) | 0.421 | 0.7 (0.3–1.7) |
| No | 227 (90.8) | 138 (92.0) | 89 (89.0) | | |
| Time onset of symptoms: | | | | | |
| <6 h | 55 (22.0) | 41 (27.3) | 14 (14.0) | 0.004* | 1.75 (1.24–2.45) |
| 6–12 h | 73 (29.2) | 48 (32.0) | 25 (25.0) | | |
| >12 h | 122 (48.8) | 61 (40.7) | 61 (61.0) | | |
| Ulcus location: | | | | | |
| Juxtapyloric | 139 (55.6) | 84 (56.0) | 55 (55.0) | 0.109 | – |
| Duodenal | 82 (32.8) | 44 (29.3) | 38 (38.0) | | |
| Gastric | 29 (11.6) | 22 (14.7) | 7 (7.0) | | |
| Boey score: | | | | | |
| 0 | 167 (66.8) | 112 (74.7) | 55 (55.0) | 0.001* | – |
| 1 | 58 (23.2) | 32 (21.3) | 26 (26.0) | | |
| 2 | 21 (8.4) | 5 (3.3) | 16 (16.0) | | |
| 3 | 4 (1.6) | 1 (0.7) | 3 (3.0) | | |
| Mannheim index: | | | | | |
| Mean (±SD) | 17.95 (±4.1) | 18.28 (±4.08) | 17.51 (±4.18) | 0.236 | 1.0 (0.9–1.0) |
| Surgical approach: | | | | | |
| Open | 129 (51.6) | 63 (42.0) | 66 (66.0) | <0.001* | 0.4 (0.2–0.6) |
| Laparoscopic | 121 (48.4) | 87 (58.0) | 34 (34.0) | | |
| Total | 250 (100) | 150 (60.2) | 100 (39.8) | | |

*statistically significant.

**Table 3**
Postoperative complications according to Boey score and type of surgery. †Fisher test. The non-statistical significance observed in Boey score 2 and 3 patients may be explained by the small number of patients included in each of these B scores.

| Boey score | Postoperative Complications N (%) | Open surgery Complications N (%) | Laparoscopic surgery Complications N (%) | P value | OR (CI 95%) |
|---|---|---|---|---|---|
| B 0 (N = 167) Open: 85 Lap: 82 | 55 (32.9) | 34 (40.0) | 21 (25.6) | 0.048* | 0.52 (0.27–0.99) |
| B 1 (N = 58) Open: 28 Lap: 30 | 26 (44.8) | 19 (67.9) | 7 (23.3) | 0.001* | 0.14 (0.05–0.46) |
| B 2 (N = 21) Open: 13 Lap: 8 | 16 (76.2) | 11 (84.6) | 5 (62.5) | 0.262† | 0.30 (0.04–2.42) |
| B 3 (N = 4) Open: 3 Lap: 1 | 3 (75) | 2 (66.7) | 1 (100) | 0.75† | 0.67 (0.30–1.48) |
| Total | 100 (100) | 66 (66.0) | 34 (34.0) | – | – |

*statistically significant.

including overall postoperative complication rate, mortality, and reoperation rate. Subcategory analysis of postoperative complications showed that laparoscopic repair had also similar rates of repair site leakage, intra-abdominal abscess, postoperative ileus, pneumonia, and urinary tract infection as open surgery, except of the lower surgical site infection rate. Cirocchi et al,[11] in another meta-analysis, also concluded that there were no significant differences in most of the clinical outcomes between the two groups; there was less early postoperative pain and fewer wound infections after laparoscopic repair.

This would explain the certain reluctance that persists among certain surgeons to adopting the laparoscopic approach. However, our study, other non-randomized ones,[19–22] and other published meta-analysis,[15] show that this technique does indeed present fewer overall complications and various advantages over the open approach. In the meta-analysis of Zhou et al,[15] high quality evidence suggested that laparoscopic repair was associated with a lower incidence of overall postoperative complications; moderate evidence showed that the two procedures had the similar reoperation rate; and low quality evidence supported that laparoscopic repair

**Table 4**
Differential characteristics between the two groups, open and laparoscopic surgery.

| | Open surgery N (%) | Laparoscopic surgery N (%) | P |
|---|---|---|---|
| Age: | | | |
| Mean (±SD) | 58.6 (±16.8) | 49.7 (±15.4) | <0.001* |
| Gender: | | | |
| Men | 91 (70.5%) | 99 (81.8%) | 0.037* |
| Women | 38 (29.5%) | 22 (18.2%) | |
| Tobacco: | | | |
| Yes | 70 (54.3%) | 74 (61.2%) | 0.270 |
| No | 59 (45.7%) | 47 (38.8%) | |
| Diabetes: | | | |
| Yes | 11 (8.5%) | 9 (7.4%) | 0.751 |
| No | 118 (91.5%) | 112 (92.6%) | |
| Depression: | | | |
| Yes | 12 (9.3%) | 11 (9.1%) | 0.954 |
| No | 117 (90.7%) | 110 (90.9%) | |
| Time onset of symptoms: | | | |
| <6 h | 27 (20.9%) | 28 (23.1%) | 0.860 |
| 6–12 h | 37 (28.7%) | 36 (29.8%) | |
| >12 h | 65 (50.4%) | 57 (47.1%) | |
| Ulcus location: | | | |
| Juxtapyloric | 70 (54.3%) | 69 (57.0%) | 0.753 |
| Duodenal | 45 (34.9%) | 37 (30.6%) | |
| Gastric | 14 (10.9%) | 15 (12.4%) | |
| Boey score: | | | |
| 0 | 85 (65.9) | 82 (67.8) | 0.560 |
| 1 | 28 (21.7) | 30 (24.8) | |
| 2 | 13 (10.1) | 8 (6.6) | |
| 3 | 3 (2.3) | 1 (0.8) | |
| Mannheim Index: | | | |
| Mean (±SD) | 17.75 (±4.34) | 18.11 (±3.94) | 0.577 |
| Total | 129 (52%) | 121 (48%) | – |

*statistically significant.

had reduced hospital mortality and similar operative time than open repair.

Lee et al[23] reported in 2020 a systematic review focused on the variation in descriptors of patient characteristics in randomized clinical trials of peptic ulcer repair. These authors argue that an inadequate description of participants, interventions or outcomes could lead to bias and inaccurate assessment of findings. They found that study participants were described inconsistently in all these studies of a single example surgical condition. This could help to explain the observed variability in the results.

**Table 5**
Outcomes of laparoscopic vs open surgery in the treatment of perforated peptic ulcer related to surgical complications. IQR: Interquartile range.

| | Open surgery N (%) | Laparoscopic surgery N (%) | P |
|---|---|---|---|
| Surgical complications (Clavien-Dindo score): | | | |
| No | 63 (48.8) | 87 (71.9) | 0.001* |
| Grade I-II | 49 (38.0) | 28 (23.1) | |
| Grade III-V | 17 (13.2) | 6.0 (5.0) | |
| Postoperative hospital stay: | | | |
| Median (IQR) | 9.0 (6.0–15.5) | 6.0 (5.0–8.0) | <0.001* |
| Wound infection: | | | |
| Yes | 25 (19.4) | 1 (3.8) | <0.001* |
| No | 104 (80.6) | 120 (53.6) | |
| Postoperative ileus: | | | |
| Yes | 20 (15.5) | 9 (0.8) | 0.047* |
| No | 109 (84.5) | 112 (99.2) | |
| Intra-abdominal colecctions: | | | |
| Yes | 5 (3.9) | 7 (5.8) | 0.480 |
| No | 124 (96.1) | 114 (94.2) | |
| Operative mortality: | | | |
| Yes | 2 (1.6) | 1 (0.8) | 0.559 |
| No | 127 (98.4) | 120 (99.2) | |
| Total | 129 (52) | 121 (48) | – |

*statistically significant.

**Table 6**
Logistic regression of postoperative surgical complications (no/yes). Laparoscopic approach was adjusted for age, gender, and Boey score. B: regression coefficient; S.E.: standard error; Wald: statistic test; OR: odds ratio; (CI95: confidal intervale 95).

| Variables | B | S.E. | Wald | p | OR (CI95) |
|---|---|---|---|---|---|
| Laparoscopic surgery | −0.798 | 0.357 | 5.011 | 0.025* | 0.45 (0.22–0.91) |
| Age | 0.033 | 0.011 | 8.852 | 0.003* | 1.03 (1.01–1.06) |
| Gender | −0.231 | 0.430 | 0.288 | 0.591 | 0.79 (0.34–1.84) |
| Boey score | 0.536 | 0.237 | 5.103 | 0.024* | 1.71 (1.07–2.72) |
| Constant | −0.962 | 1.010 | 0.907 | 0.341 | 0.064 |

*statistically significant.

An intermediate pattern to follow could be to consider the recommendations of Bertleff and Lange.[14] These authors, based on an extensive bibliographic review, concluded that the laparoscopic approach should be contraindicated in patients older than 70 years, a Boey risk scale score of 3 points and/or a symptom evolution time of more than 24 h. The purpose of this score, however, was to select, in the 1980s, which patients should undergo a definitive surgical procedure for ulcus and which patients should only undergo suture and omentoplasty. Some clinical guidelines still recommend stratifying risk in these patients with this scale and/or the ASA, regardless of the type of surgical approach.[24] At present, it is also being used to indicate whether the laparoscopic procedure should be performed or not. For some authors,[25] laparoscopic access should be avoided in patients with a Boey risk of 3 points, discussing grades 1–2 according to the type of patient. In our series, the Boey Risk Score did not conditioned the attitude to follow regarding the indication of the procedure, except in cases of severe hemodynamic instability.

Many surgeons avoid the laparoscopic approach in patients with comorbidity.[19,20] Instead, others[8,21,26] recommend its use from the beginning even in high-risk patients. Nevertheless, it does seem to be an agreement to avoid laparoscopy in patients with hemodynamic instability.[19,21,24,26]

In our study, the mean age of patients with open access was higher, and it was significantly related to the appearance of a greater number of complications in the univariate analysis. However, age was included and adjusted by surgical approach in the multivariate analysis. Both variables, age and laparoscopic access, behaved as independent prognostic factors in multivariate analysis. Therefore, perhaps age should be considered before indicating the procedure, but we believe that there are other variables, no evaluated in this study, such as frailty or age-associated comorbidity, that could be confounding factors.[27] In fact, in our center, age is not a contraindication for laparoscopy despite the risk involved in these cases.

The time interval between the perforation and the operation has been considered a critical risk factor for mortality[28,29] and is included in some risk scales.[16] In our series, a high proportion of patients was admitting to hospital relatively late after onset of symptoms. Approximately 50% of them arrived at hospital 12 h after onset of the abdominal pain. Regarding the time cutoff point, Boey et al[16] proposed the 24 h limit for the worse case scenario, and an increase in morbidity and mortality. Surapaneni et al[28] found that there was no mortality up to 24 h, more morbidity after 24 h, and high rate of deaths after 48 h of the onset of the abdominal pain. Buck et al[29] showed that every hour of delay from admission to surgery was associated with an adjusted 2.4 per cent decreased probability of survival compared with the previous hour. In order to facilitate the analysis, we decided to categorize this variable in three time periods, setting the value of 12 h as the superior limit, coinciding with the median of the distribution of the variable. Although it was associated with a worse prognosis in our study, we

also did not consider the time onset of symptoms as a decisive factor in selecting the type of procedure.

Inadequate ulcer localization, large perforation size (defined by some as > 6 mm diameter, and by others as > 10 mm), ulcers with friable edges, and perforation time more than 12.5 h are considered as conversion risk factors.[30,31] Other authors found that the size of perforation among non-survivors in their series was greater than that of survivors.[32] In our study, this was not addressed because ulcer diameter and ulcer location are variables preoperatively unknown. Therefore, a priori they should not influence the decision about the type of surgical approach.

The Mannheim peritonitis index provides an easy and reliable means of risk evaluation for patients with peritonitis.[17] However, according to our results, it does not appear to be very useful in the context of the perforated ulcus. Boey score seems to be simpler and more feasible and reliable.

Postoperative complications usually occur in 30% of cases.[2] Our results showed a higher percentage (40%), but only 9% were serious complications. There were significantly fewer infections and ileus in the laparoscopic group and no differences were found in the incidence of postoperative collections. Although in some series[9,11,13,14] a lower rate of infection of the surgical site was observed in favor of laparoscopy, one systematic review[33] failed to demonstrate this.

The main cause for reoperation following surgical repair is suture line dehiscence.[21]

One explanation proposed has been the difficulty in laparoscopic knot tying,[11] but we believe that other factors such as ulcer diameter or perforation time may play a more decisive role.

Overall postoperative mortality for perforated ulcers ranges from 1.3 to 10%,[2] but can exceed 25%.[3] Nevertheless, in the reported laparoscopic series mortality rarely exceed 4.5%.[7] In our series, overall mortality was only 1.2%. These comparatively low mortality rates may be related to the fact that those patients with more complex conditions that required more aggressive procedures were excluded from these comparative studies.

It should be noted that, to date, no clinical trial or meta-analysis of clinical trials have found significant differences in mortality between the open and laparoscopic procedures. A recent Danish propensity analysis with a large study population also failed to demonstrate a lower mortality in the laparoscopic group.[34] Only one English retrospective population-based study,[20] and a meta-analysis[15] with non-randomized studies included in the analysis, were able to demonstrate the benefits of laparoscopy in terms of mortality. In this meta-analysis, Zhou et al[15] found significant differences in hospital mortality between the laparoscopic repair and open repair groups in the high quality non-randomized studies, but not in the clinical trials. Like Mirabella et al,[25] we believe that mortality depends more on the risk factors of the patient and the aggressiveness of the ulcer than on the surgical approach.

The proven benefits of the laparoscopic approach, such as better postoperative comfort, shorter average stay and an earlier return to normal activity, are no longer discussed.[5,6,9,11,15,20] In addition, no differences have been found in several cost-efficiency studies.[6,35] Therefore, we support that, if the surgeon has laparoscopic experience, the procedure should always be started by laparoscopy, except for patients with hemodynamic instability.[24]

The limitations of the study include that it is retrospective and not randomized, comparing two groups of patients in which the choice of the operative procedure only depended on the personal experience of the surgeon. This could induce bias: less experienced surgeons could have chosen more often open repair. There is also a lack of information about previous abdominal surgery. However, the main objective of the study was focused on surgical complications. On the other hand, although the surgical technique, suture with omentoplasty, was practiced in all patients in the same way except for the surgical approach, the groups were not comparable in age and gender. For this reason, a multivariate analysis of postoperative complications was conducted, adjusting these variables for surgical approach. The variable surgical approach behaved as an independent prognostic factor of surgical complications.

We conclude that laparoscopic suture of the perforated peptic ulcus represents a technique as viable and safe as the open approach and provides significantly more advantages, especially fewer complications. We believe that this approach should be the procedure of choice in the emergency setting.

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## Declaration of competing interest

The authors declare that they have no financial and non-financial conflicts of interest.

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