Outcome of laparoscopic versus open repair of perforated peptic ulcers in low-risk patients

Ahmed A. Elshora, Gamal I. Moussa, Tarek M. Sehsah, Osama H. Abd-Raboh

General Surgery, General Surgery Department, Faculty of Medicine Tanta University, Egypt

Correspondence to Ahmed Abdel Fattah Elshora, Assistant professor of General Surgery, Faculty of Medicine Tanta University, Egypt, Gharbyea Governorate, Tanta, El-Gaish St. Medical Campus, Tanta University Teaching Hospitals, Post Box Code: 3111, Egypt. Tel : +201001744874; Fax: 2+ 040 3407734; e-mail: ahmed.elshoura@med.tanta.edu.eg, ahmed.elshora28@hotmail.com

Received: 17 May 2023
Revised: 4 June 2023
Accepted: 14 June 2023
Published: 6 October 2023

The Egyptian Journal of Surgery 2023, 42:584–591

Background
Peptic ulcer perforation (PPU) represents the main indication for emergent surgical intervention for peptic ulcer disease. The study aimed to assess the efficacy and safety of laparoscopic repair (PPU) in comparison with open repair in low-risk patients.
Methods
A retrospective study was conducted in a tertiary medical institution that included 98 patients diagnosed with PPU in line with the inclusion criteria. An analysis was performed to compare patients who underwent laparoscopic surgery (LS) (n=31) and patients submitted to open surgery (OS) of PPU (n=67). Characterization of LS and OS was achieved in terms of patients' demographics, Bœy's score, PULP score, and intraoperative and postoperative data.
Results
The patient's mean age in the LS and OS groups were 48.8 and 51.1 years, respectively. Most patients in both groups were men (87.1% and 86.5%, respectively). The mean time for resumption of oral intake after surgery was 2.93 ±1.06 (1–7) days in the laparoscopy group compared with 3.79±0.8 (2–7) days in the laparotomy group (P<0.0001). The average length of hospital stay was 5.77± 1.8 (4–13) days in the LS group and 7.22±1.6 (5–12) days in the OS group (P=0.0001). Early complications (<30 days) were found in 12 patients (12.2%); 3 (9.6%) in the LS group and 9 (13.4%) in the OS group (P=0.5).
Conclusion
Repair of PPU by laparoscopy is a better alternative to the open approach regarding reduction of postoperative hospital stay and fast return to daily activity with less postoperative ileus and wound complications.

Keywords:
laparoscopic repair, open surgery, peptic ulcer perforation

Egyptian J Surgery 42:584–591

1110-1121

Introduction

The long-standing frequency of peptic ulcer disorder (PUD) within the community is 5–10% [1]. The incidence of peptic ulcer sickness based on clinical analysis ranges from 0.12% to 1.50% [2]. The two foremost causes for the etiology of PUD were H. pylori infestation and nonsteroidal anti-inflammatory drugs (NSAIDs), in addition to less common causes such as alcohol use, smoking, persistent stress, and senility [3,4].

As a result of the huge use of proton-pump inhibitors, there has been a reduction in the prevalence of PUD within the last three decades, but morbidities are nevertheless seen in 10–20% of cases [3]. The most common complication of peptic ulcer is gastrointestinal bleeding, and perforation comes after it; however, it shows the main indication for emergent surgical operation for PUD, and surgical intervention is inevitable and emergent. The mortality rate for peptic ulcer perforations is in a range between 1.3% and 20%, and gastric ulcer perforation mortality (40%) is higher than perforation of a duodenal ulcer (10%) [3,5].

The operative treatment for a perforated peptic ulcer (PPU) necessitates the management of peritoneal soiling and occlusion of the defect. The choice of surgical approach, laparoscopy versus laparotomy according to the patient's general condition before the operation, operator preference, expertise, and vicinity of illness to shorten the operative time as possible [6] is also important.

The open abdominal surgical procedure has been widely known to increase the postoperative aches and is associated with more morbidities (hernia, partial or complete wound dehiscence, wound infection, postoperative respiratory complications,

and long time to return to normal daily activity), as compared with a laparoscopic surgical operation [7].

Some studies have demonstrated that laparoscopy reduces the risk of postoperative complications (i.e. fewer chest complications, decreased surgical site pain, reduction of postoperative hospital stay, and fast return to daily activity) than the open repair [6,8].

The use laparoscopy in the management of perforated peptic ulcers has been constrained and takes more time to be accepted. There is much arguing concerning the advantages of laparoscopic repair in studies; although it is applicable, there are few significant advantages because of the limited number of experienced centers, the necessity of significant surgical talent, and the increased occurrence of reoperations owning to leakage on the repaired perforation, and higher prevalence of abdominal fluid accumulation secondary to insufficient washing [8,9].

This study aimed to assess the feasibility, competence, and safety of the laparoscopic repair of PPU in comparison with open repair in low-risk patients.

Patients and methods

Ethical consideration

This study was approved by the Research Ethics Committee, Faculty of Medicine, Tanta University under reference number (36038/11/22). All utilized surgical interventions were matching with the relevant regulations and guidelines of the 1964 Helsinki announcement and its further modification.

An official formal consent form was obtained from each recruited patient. The details of the surgical procedures, possible complications, and risks were fully explained to all patients before enrollment.

Study design

This retrospective, comparative study was carried out at Tanta University Teaching Hospital. We enrolled all patients diagnosed with PPU during the period from June 2017 to June 2022. All patients included in the records analysis meeting the preset inclusion standards were consecutively included. The inclusion criteria for surgery included low-risk patients between the ages of 18 and 70 years with Boey's score $\leq$1 and PULP score $\leq$7. For the prevention of selection bias, patients with generalized peritonitis, and a history of upper-abdominal surgery were excluded, in addition to patients detected intraoperatively with suspicious non-juxtapyloric gastric ulcers, and perforations $>$15 mm.

In all, 223 patients with a preliminary diagnosis of PPU were admitted to the hospital during the study period. Of the patients, 125 were excluded in line with the exclusion criteria. Laparoscopic repair of PPU was attempted in 38 patients. Out of them, seven patients had large defects and/or faced technical issues intraoperatively. They were shifted to laparotomy, and the remaining 31 patients subsequently completed the LS repair, while 67 patients have been repaired through the OS technique.

Characterization of surgical repair was achieved in terms of patients' demographics, Bœy's score, PULP score, ulcer localization, ulcer size, intraoperative data, postoperative recovery, and short-time period results.

During the study period, there have been no strict standards for whether the laparoscopic or open technique should be used for PPU. The choice of technique was made according to the surgeon's technical feasibility, evaluation of the patient's medical condition, and input from the attending anesthetist.

Measured variables

The measured variables were operation time, defect site, and diameter, time to functional recovery, length of hospital stay (LOS), postoperative complications, and mortality. Timing of the technique is from the skin incision to the dressing of the wound.

Severity scores compromised Boey's scoring system and PULP score. Boey's scoring consisted of three dangerous factors for postoperative complications (presence of fundamental comorbidities, preoperative shock (systolic arterial pressure $<$90 mmHg), and duration of symptoms $>$24 h); every element was given a score of 1 point, when positive. Boey's score for each patient was calculated based on the sum of points for each risk factor (score 0–3) and was used for PPU risk stratification [10].

The peptic ulcer perforation (PULP) score was assessed and calculated for each patient as shown in Table 1 [11].

Preoperative preparation

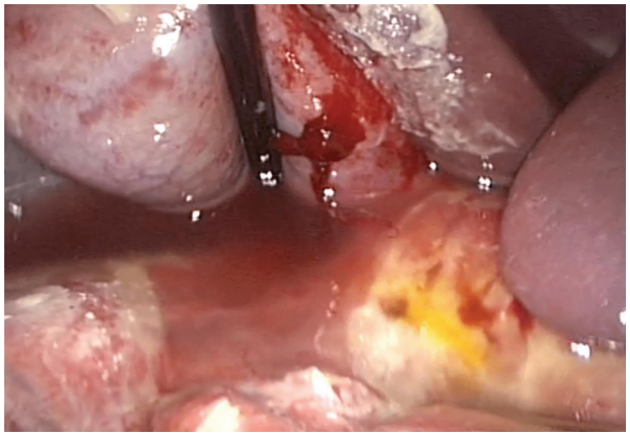
Patients with perforated peptic ulcer were diagnosed radiologically by plain radiograph in an erect position and/or computed tomography (CT) in doubtful conditions. Preoperatively, they had been properly

Table 1 Peptic ulcer perforation (PULP) and Bœy's score

	PULP score (0–18)[a]	Bœy's score(0–3)
Age >65 years	3	
Comorbidity		
Comorbid active malignant disease or AIDS	1	1 (severe medical illness)
Comorbid liver cirrhosis	2	
Concomitant use of steroids	1	
Shock	1	1
Time from perforation to admission >24 h	1	1
Serum creatinine >130 mmol/l	2	
ASA score 2	1	
ASA score 3	3	
ASA score 4e	5	
ASA score 5	7	

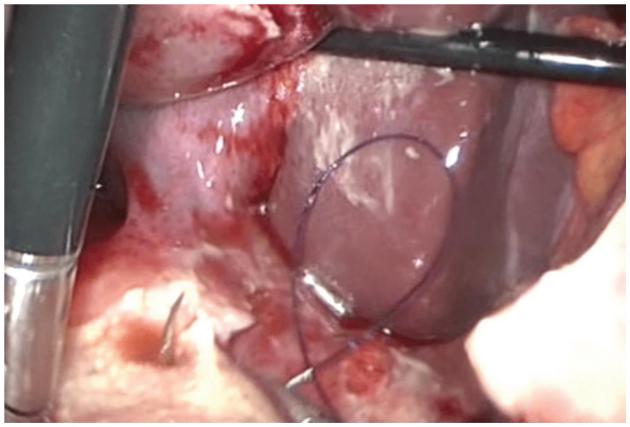
PULP scores of 0- 7 indicate a low risk of mortality; scores of 8-18 indicate a high risk of mortality [11].

Figure 1



Peptic ulcer perforation.

Figure 2



vSuturing the perforation by 2-0 silk.

rehydrated by IV fluids, painkillers, a dose of intravenous proton-pump inhibitor (PPI), and proper antibiotics. For gastric decompression a nasogastric tube was used to reduce peritoneal soiling and prevent aspiration, with urinary catheterization to show urine output, and to calculate the efficacy of fluid resuscitation.

The operative technique of the laparoscopic surgical repair

Patients were placed in the French position in an anti-Trendelenburg position. The camera was introduced throughout the supraumbilical 10 mm port. Two 5 mm trocars were introduced in the right and left mid-clavicular line. The liver retraction was achieved through a 5 mm trocar in the subxiphoid region. The operator works between the patient's legs to help with manipulation and laparoscopic knot tying, and the camera surgeon stood on the patient's left side. The spilled contents intraperitoneally were sucked efficiently in all quadrants as shown in Fig. 1, and the defect site was closed before proper irrigation. The Maryland dissector jaw length (2 cm) was used to measure the defect size. The defect is closed by approximating the edges by intracorporeal knotting using 2–0 nonabsorbable silk sutures in an interrupted manner as shown in Fig. 2. The efficacy of repair is examined by air leak test, and once it was confirmed that there was no leak, the repair was then reinforced by suturing the omental patch over the repaired defect as shown in Fig. 3. After that, the peritoneal cavity was carefully washed with normal saline solution until the fluid became clear and suctioned to remove all pyogenic membranes. Drains were inserted in the dependent area to evacuate any remaining fluid used for irrigation.

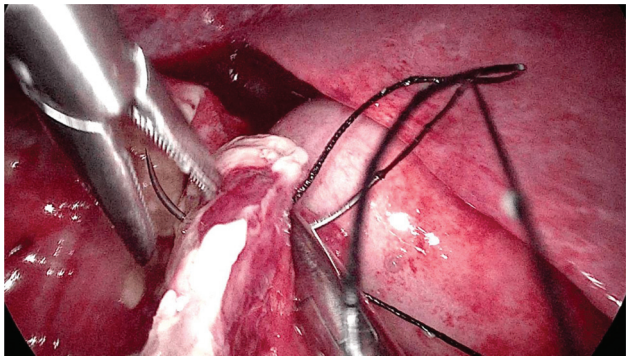
After the surgery, the Ryles tube was removed when the residual gastric aspirates were minimal. The urinary catheter was typically removed after 1 day, except in patients who needed close monitoring of hemodynamic status. Oral intake was started once bowel function returned. During the postoperative period, all patients

were continued on intravenous fluids, broad-spectrum antibiotics, PPI, and painkillers. Drains were removed before discharge, and patients were sent home, whereby they were seen at the clinic within 96 hours after discharge.

Postoperative complications were defined as complications that occurred within 30 days of primary surgery, which can be associated with the disease, or the surgery accomplished.

A surgical site infection (SSI) was an infection occurring within 1 month after the operation, involving the skin, with or without the underlying layers of the incision wound, associated with one or more of the following: (1) pus discharge, (2) organisms isolated from aseptically obtained wound culture, (3) one or more of the following within the wound such as hotness, redness, swelling, and tenderness.

Figure 3



Suturing the omental pedicle to the repaired site.

Prolonged postoperative ileus was defined as failure of return of bowel functions, characterized clinically by abdominal distension, vomiting, lost abdominal peristalsis, and absolute constipation, in the absence of mechanical obstruction.

Statistical analysis

The analysis of recruited data was performed using the IBM Statistical Package for the Social Sciences (SPSS) v23. The comparison of outcome variables between the LS and OS was conducted using an independent *t*-test for normally distributed quantitative data, while for the abnormally distributed data, the Mann–Whitney *U* test was used instead. Fisher's exact and Monte Carlo exact tests were deployed for the qualitative data. The *P*-value was significant at < 0.05.

Results

The present study enrolled 98 patients who had been submitted to surgical repair of PPU in our department; LS repair was attempted in 38; the conversion rate was 18.4%; 7 out of 38 patients was shifted to OS repair. Reasons for conversion were large defects (15 mm) in two cases, tissue friability in three cases, and hemodynamic instability after pneumoperitoneum in two cases. The OS was done on 67 patients.

The patient's demographic data are shown in Table 2. The patient's mean age was 48.8 ±10.9 years (range 26–69 years) in the LS group and 51.1±7.5 years (range, 32-68 years) in the OS group, showing no statistically significant difference (*P*=0.2). The majority of patients in both groups were men (87.1%

Table 2 Distribution of basic characteristics between laparoscopic and open groups

Variable	Laparoscopic (*n*=31)	Open (*n*=67)	Test of significance	*P* value
Age				
Mean±SD	48.8 ±10.9	51.1±7.5	t [a]= 1.21	0.2
Range	(26–69)	(32–68)		
Sex: n (%)				
Male	27 (87.1%)	58 (86.5%)	FET[b]	1
Female	4 (12.9%)	9 (13.4%)		
Bœy score				
Mean±SD	0.19 ±0.4	0.26±0.44	z[c]=0.6	0.5
Range	(0–1)	(0–1)		
Pulp score				
Mean±SD	1.19 ±1.62	1.58±1.67	z[c]=0.78	0. 3
Range	(0–4)	(0–4)		
Perforation site: *n* (%)				
Gastric	19 (61.3%)	35 (52.2%)	FET[b]	0.5
Duodenal	12 (38.7%)	32 (47.8%)		
Perforation size (mm)				
Mean±SD	6.7 ±2.5	6.35±2.18	t[a]=0.7	0.4
Range	(1–12)	(2–15)		

Significant $P < 0.05$, [a] Independent *t*-test, [b] Fisher's exact test, [c]Mann–Whitney *U* test, [d] Monte-Carlo exact test.

and 86.5%, respectively). The Bœy and PULP scores were 0.19 ±0.4 and 1.19 ±1.62 in the LS group and 0.26 ±0.44 and 1.58±1.67 in the OS group, with no statistically significant difference (P=0.5 and 0.3, respectively).

The size of the defect was assessed intraoperatively. The majority of perforations were of size between 0.5 and 1 cm, in both groups. The size of the defect was 6.7 ±2.5 (1–12 mm) in group A and 6.35±2.18 (2–15 mm) in group B, with no statistically significant difference (P=0.4).

In the LS group, 12 (38.7%) patients had perforations located in the anterior wall of the first part of the duodenum, and 19 (61.3%) of them had gastric perforations located in the juxtapyloric region. In the OS group, there were 32 patients (47.8%) who had duodenal perforations, and 35 patients (52.2%) had gastric perforations. The perforations in groups were all repaired using the pedicled omental flap. There was no statistically significant difference (P=0.5) between the two groups regarding the location of perforation.

As shown in Table 3, the operation time was not statistically significantly different (P=0.1) between the two groups, with the average time being 110.1 ±22.6 (range from 70–150) min in the LS group and 103.7±18.8 (range from 70 to 145) min in the OS group. The mean time for resumption of oral intake after surgery was 2.93 ±1.06 (1–7) days in the LS group compared with 3.79±0.8 (2–7) days in the OS group, with a statistically significant difference (P<0.0001*). The average length of hospital stay was 5.77± 1.8 (4–13) days in the LS group, and 7.22 ±1.6 (5–12) days in the OS group, with a statistically significant difference (P=0.0001*).

Postoperative complications were found in 12 cases (12.2%); three (9.6%) in the LS and nine (13.4%) in the OS, with no statistically significant difference (P=0.5).

Four patients in our series had intra-abdominal abscesses: two (6.4%) from the laparoscopic group and two (3%) from the open group. All of them were managed by intravenous antibiotics. The incidence of postoperative ileus was a single case in the open group. However, the incidence of surgical site infection was lower in the laparoscopic group (one patient) versus five patients (7.4%) in the open group. The only case with mortality was found in the open group.

Discussion

Patients who endure peptic ulcer disease usually require urgent surgical intervention to become aware of the perforation location, repair the defect, and irrigate intra-abdominal spaces [12].

However, surgeons are regularly confused about which manner is satisfactory for patients to get hold of laparoscopic surgical treatment or open procedure [13].

The proportion of laparoscopic PPU repairs has nearly tripled from 4.5% in 2010 to 11.4% in 2016 (P<0.001), indicating that more surgeons are utilizing the laparoscopic approach to repair PPUs [14].

On account of that, the surgeon has increasingly attempted to use laparoscopic surgical operation for

Table 3 Comparison of operative data and operative outcomes between laparoscopic and open groups

Variable	Laparoscopic (n=31)	Open (n=67)	Test of significance	P value
Operation time (min)				
Mean±SD	110.1 ±22.6	103.7 ±18.8	t[a]=1.4684	0.1
Range	(70–150)	(70–145)		
A dietary resubmission (days)				
Mean±SD	2.93 ±1.06	3.79±0.8	t [a]=4.45	< 0.0001*
Range	(1–7)	(2–7)		
Length of hospital stay (days)				
Mean±SD	5.77± 1.8	7.22±1.6	t [a]=4.1	0.0001*
Range	(4–13)	(5–12)		
Complication: *n* (%)				
DVT	0 (0%)	1 (1.5%)	MCT[d]	0.5
SSI	1 (3.2%)	5 (7.4%)		
Abscess	2 (6.4%)	2 (3%)		
Ileus	0 (0%)	1 (1.5%)		
Mortality	0	1 (1.5%)	–-	–-

*Significant P< 0.05, [a] Independent t-test, [b] Fisher's Exact test, [C] Mann–Whitney U test, [d] Monte-Carlo exact test.

peptic ulcer disorder, but the findings cannot show a net result favoring its utility [15].

Therefore, to further assess the feasibility of repairing the perforation; we performed this study to offer extra scientific proof concerning this debatable issue.

As known patients suffering from perforated peptic ulcer have diffuse peritonitis, the overall situation may be very terrible. Damage control surgery is a crucial precept within the control of trauma. It is far pressured that we should save the patient with the least iatrogenic tissue injury during the repair. Therefore, the best treatment for these patients is laparoscopic surgery [15–17].

Open surgery is associated with higher surgical stress response, but laparoscopic surgical treatment is a minimally invasive method with plenty of benefits, which include less intraoperative blood loss, postoperative pain, and fewer postoperative complications [18,19]. Therefore, from this angle, patients with a PPU may additionally gain plenty from laparoscopic surgical operations due to its minimally invasive capabilities. The laparoscopic surgical operation must be accomplished by way of experienced laparoscopic surgeons [20,21].

In perforated peptic ulcers, the timing between the appearance of symptoms and the surgical intervention is a crucial prognostic component and is the cause of expanded morbidity and mortality [10,22,23]. Every hour of postponement can also lessen the opportunity of survival by 2–4% [22]. Most of the cases in our research were operated on in the first 48 hours from the incidence of symptoms.

But, not every affected person with PPU is an appropriate applicant for the laparoscopic technique. Bœy's score is a great guide for patient choice that considers several risk factors including shock on admission, major illness, and symptom length (>24 hours). The maximum score is 3, which indicates high surgical risk. The laparoscopic choice is found to be safe in cases of a Bœy score of 0 or 1 [24].

The PULP score was used to expect 30-day mortality in cases operated upon for PPU [11,25]. It incorporates eight variables and the score levels are from 0 to 18 points. Patients are divided into low risk (a score of ≤7 points) with a less than 25%, and high risk (a score of >7 points), with a greater than 25% risk of. Furthermore, a PULP score ≥4 could predict conversion to the open approach, with a sensitivity of 71.1% and specificity of 70.3% [26]. In our study, we excluded high-risk cases (PULP score >7) to fairly compare both techniques (laparoscopic vs. open) to reduce the effect of the bad general condition in high-risk patients on selection bias (i.e. the tendency to select the open technique for high-risk patients) and on postoperative outcome.

The use of the laparoscopic technique was recommended in patients who are hemodynamically stable, with small perforations, as long as the operators are experienced and the required equipment is present [27]. Therefore, many centers used laparoscopy first in the cases, but in some circumstances, conversion became a must, so a definite rate of conversion can be expected [12,28,29].

In our study, PPU happened more often in male patients in both groups and within a median age of 48.8 and 51.1 years for laparoscopic and open groups, respectively, with no significant difference between both groups, in line with other studies [13,26,30]. Our study showed that PPU is more common in the gastric than in the duodenal, which matches with other studies [30–32]. Regarding both groups, they were demographically similar, and there has been no statistically significant difference between them.

In our study, as we were operating on low-risk patients, there were no significant differences regarding Bœy's and PULP scores between the laparoscopic and open groups (P=0.5 and 0.3), respectively. This matches a similar study regarding Bœy's score [33].

When comparing the size of defects between the two groups, the mean was 6.7 mm in LS and 6.3 mm in OS. All of these defects in the open and laparoscopic groups had been sutured and reinforced by the pedicled omental flap.

In spite of plenty of studies showing the merits of laparoscopic repair, in our study, it was associated with longer operative duration (Laparoscopic 110.1 ± 22.6 min, open 103± 18.8 min, P=0.1), which matches with other studies [13,14,34]. The reason is due to the fact that there is a wide field of exposure and more dissection for successful mobilization in open repair. Moreover, copious repeated intraperitoneal wash and simple closure with omental patches during laparoscopy are more time-consuming, and those elements might also contribute to the prolonged period. The overall difference in operative time between both groups was, however, not statistically significant. We can explain the small

difference in operative time, despite the laparoscopic difficulties mentioned above, by the fact that meticulous closure of the abdominal wall in such open cases can be time-consuming in comparison with port site closure in laparoscopic cases.

The conversion rate of this series (18.4%) matches other reports (10–20%) [26,30,35]. There are multiple causes for conversion, the most important are severe peritonitis, huge perforation size, problem locating the perforated site, inflammatory adhesion or shock during operation, difficulty making the operative field, and friable tissue; all of these are part of the intraoperative findings, because of this most of the choices to covert can best be made throughout the operation.

Concerning the course following the operation, this study demonstrated a statistically significant difference in the form of, a lesser period of a Ryles tube, rapid oral intake, shorter hospital stay, and early return to daily work in the laparoscopic group in comparison to the open one, as supported by similar research [13,30,34].

Concerning diet initiation, it was started earlier in laparoscopic patients and was properly tolerated, it took place on the mean postoperative day 2.93+-1.06, in comparison to patients in the open group initiating diet on the mean postoperative day 3.79 +-0.8. This could be explained by less postoperative ileus in the laparoscopic group. It is also essential to show that the length of stay in laparoscopy is significantly lower (5.7±1.8 days) than the OS group (7.3+- 1.6) days.

Postoperative early complications took place in 12.2% of our patients with an overall mortality of 1%. There were no significant differences among groups in postoperative complication rates. The LS group tended to have fewer complications (9.6% LS vs. 13.3% OS, P=0.5); this difference is probably related to wound-associated complications (1 patient LS vs. 5 patients OS). Wound-related complications occur more often after opening than after laparoscopic surgery, as confirmed in other studies [35,36].

Regarding mortality rate, there was one case in the open group who developed deep vein thrombosis (DVT) followed by pulmonary embolism and died on the 10th postoperative day.

Limitations of the study

Our study had a few obstacles. It was a single-center, retrospective, nonrandomized study with a small sample size, which may not be able to show extensive differences and generalizability. The patients were not randomized to laparoscopic or open repair of PPU, because the surgical approach decision was taken case by case and considering the patient's condition, the anesthetist's opinion, and the availability of equipment.

Moreover, the number of patients in the laparoscopic group was small compared with the open group, which may be attributed to the fact of fear performing the laparoscopic technique at the start except in excellent optimum circumstances, availability of the laparoscopic equipment, and expertise in emergency circumstances. Lastly, a patient choice bias might exist, as the enrolled patients were younger than 70 years, hemodynamically stable, had no prior abdominal surgery, and working on low-risk patients.

Conclusion

Laparoscopic repair of perforated peptic ulcer is a better alternative to the open approach regarding shorter postoperative hospital stay, and return to normal activity with less postoperative ileus and wound complications. Despite longer operative time in laparoscopic technique, with a selection of low-risk patients, we can encourage minimally invasive surgery to get benefit from better operative and postoperative outcomes. We recommend a further large number of prospective multicentric studies focusing on the laparoscopic repair of perforated peptic ulcers to determine its efficacy and safety in both low- and high-risk patients while accepting higher rates of conversion. The availability of laparoscopic equipment and high expertise in emergencies are some of the obstacles that should be overcome.

Acknowledgements

Funding statement: This work received no grant from any funding source.

Inclusion criteria in the authors' list: All of the authors are specialized in gastrointestinal surgery (GIT). OA developed the research question. GM and OA performed the surgical procedures (laparoscopic /Open) and obtained the ethical and administrative approvals. AE and TS conducted the statistical analysis, drafted and revised the manuscript, and AE is responsible for the publication process. All authors structured the research methodology. GM reviewed the drafted manuscript thoroughly. All authors revised the manuscript and approved the final form for publishing.

This manuscript has been read and approved by all the authors. And the requirements for authorship which was stated earlier in this document have been met. Each author believes that the current manuscript represents honest work.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

References

1 Lanas A, Chan FKL. Peptic ulcer disease. Lancet 2017; 390:613–624. doi: 10.1016/S0140-6736(16) 32404-7.

2 Sung JJ, Kuipers EJ, El-Serag HB. Systematic review: the global incidence and prevalence of peptic ulcer disease. Aliment Pharmacol Ther 2009; 29:938–946. doi: 10.1111/j. 1365-2036. 2009.03960.x

3 Chung KT, Shelat VG. Perforated peptic ulcer – an update. World J Gastrointest Surg 2017; 9:1–12. doi: 10.4240/wjgs.v9.i1.1

4 Keikha M, Ali-Hassanzadeh M, Karbalaei M. Association of Helicobacter pylori vacA genotypes and peptic ulcer in Iranian population: a systematic review and meta-analysis. BMC Gastroenterol 2020; 20:266. doi: 10.1186/s12876-020-01406-9.

5 Ahmadinejad M, Haji Maghsoudi L. Novel approach for peptic ulcer perforation surgery. Clin Case Rep 2020; 8:1937–1939. doi: 10.1002/ccr3.3030.

6 Vats R, Rehmani B, Agrawal S. The outcome of surgery for perforated peptic ulcer in modern times. Int Surg J 2018; 5:1702–1707. DOI: http://dx.doi.org/10.18203/2349-2902.isj20181418

7 Quan Y, Huang A, Ye M, Xu M, Zhuang B, Zhang P, *et al.* Comparison of laparoscopic versus open gastrectomy for advanced gastric cancer: an updated meta-analysis. Gastric Cancer 2016; 19:939–950. doi: 10.1007/s10120-015-0516-x

8 Sanabria A, Villegas MI, Morales Uribe CH. Laparoscopic repair for perforated peptic ulcer disease. Cochrane Database Syst Rev 2013; 28: CD004778. doi: 10.1002/14651858. CD004778. pub3

9 Bertleff MJ, Halm JA, Bemelman WA, van der Ham AC, van der Harst E, Oei HI, *et al.* A randomized clinical trial of laparoscopic versus open repair of the perforated peptic ulcer: the LAMA Trial. World J Surg 2009; 33:1368–1373. doi: 10.1007/s00268-009-0054-y

10 Boey J, Choi SK, Poon A, Alagaratnam TT. Risk stratification in perforated duodenal ulcers. Prospect validation of predictive factors Ann Surg 1987; 205:22–26. doi: 10.1097/00000658- 198701000-00005.

11 Møller MH, Engebjerg MC, Adamsen S, Bendix J, Thomsen RW. The Peptic Ulcer Perforation (PULP) score: a predictor of mortality following peptic ulcer perforation. A cohort study. Acta Anaesthesiol Scand 2012; 56:655–662. doi: 10.1111/j. 1399-6576.2011.02609.x

12 Muller MK, Wrann S, Widmer J, Klasen J, Weber M, Hahnloser D. Perforated peptic ulcer repair: factors predicting conversion in laparoscopy and postoperative septic complications. World J Surg 2016; 40:2186–2193. doi: 10.1007/s00268-016-3516-z

13 Odisho T, Shahait AA, Sharza J, Ali AA. Outcomes of laparoscopic modified Cellan-Jones repair versus open repair for perforated peptic ulcer at a community hospital. Surg Endosc 2023; 37:715–722. doi: 10.1007/s00464-022- 09306-7.

14 Davenport DL, Ueland WR, Kumar S, Plymale M, Bernard AC, Roth JS. A comparison of short-term outcomes between laparoscopic and open emergent repair of perforated peptic ulcers. Surg Endosc 2019; 33:764–772. doi: 10.1007/s00464-018- 6341-7.

15 Søreide K, Thorsen K, Harrison EM, Bingener J, Møller MH, Ohene-Yeboah M, Søreide JA. Perforated peptic ulcer. Lancet 2015; 386:1288–1298. doi: 10.1016/S0140-6736(15) 00276-7.

16 Roberts DJ, Bobrovitz N, Zygun DA, Ball CG, Kirkpatrick AW, Faris PD, *et al.* Indications for use of damage control surgery in civilian trauma patients: a content analysis and expert appropriateness rating study. Ann Surg 2016; 263:1018–1027. doi: 10.1097/SLA.0000000000001347

17 Navez B, Navez J. Laparoscopy in the acute abdomen. Best Pract Res Clin Gastroenterol 2014; 28:3–17. doi: 10.1016/j.bpg.2013.11.006

18 Tan S, Yu W, Lin Z, Chen Q, Shi J, Dong Y, *et al.* Peritoneal air exposure elicits an intestinal inflammation resulting in postoperative ileus. Mediators Inflamm 2014; 2014:924296. doi: 10.1155/2014/924296

19 Venkat R, Edil BH, Schulick RD, Lidor AO, Makary MA, Wolfgang CL. Laparoscopic distal pancreatectomy is associated with significantly less overall morbidity compared to the open technique: a systematic review and meta-analysis. Ann Surg 2012; 255:1048–1059. doi: 10.1097/SLA.0b013e318251ee09

20 Kim MG. Laparoscopic surgery for perforated duodenal ulcer disease: analysis of 70 consecutive cases from a single surgeon. Surg Laparosc Endosc Percutan Tech 2015; 25:331–336. doi: 10.1097/SLE.0000000000000146

21 Guadagni S, Cengeli I, Galatioto C, Furbetta N, Piero VL, Zocco G, Seccia M. Laparoscopic repair of perforated peptic ulcer: single-center results. Surg Endosc 2014; 28:2302–2308. doi: 10.1007/s00464-014-3481-2.

22 Buck DL, Vester-Andersen M, Møller MH; Danish Clinical Register of Emergency Surgery. Surgical delay is a critical determinant of survival in perforated peptic ulcer. Br J Surg 2013; 100:1045–1049. doi: 10.1002/bjs.9175

23 Surapaneni S S R, Reddy A VB. The perforation-operation time interval; an important mortality indicator in peptic ulcer perforation. J Clin Diagn Res 2013; 7:880–882. doi: 10.7860/JCDR/2013/4925.2965

24 Siu WT, Leong HT, Law BK, Chau CH, Li AC, Fung KH, *et al.* Laparoscopic repair for perforated peptic ulcer: a randomized controlled trial. Ann Surg 2002; 235:313–319. doi: 10.1097/00000658- 200203000-00001.

25 Thorsen K, Søreide JA, Søreide K. Scoring systems for outcome prediction in patients with perforated peptic ulcer. Scand J Trauma Resusc Emerg Med 2013; 21:25. doi: 10.1186/1757-7241- 21-25.

26 Wang YH, Wu YT, Fu CY, Liao CH, Cheng CT, Hsieh CH. Potential use of peptic ulcer perforation (PULP) score as a conversion index of laparoscopic-perforated peptic ulcer (PPU) repair. Eur J Trauma Emerg Surg 2022; 48:61–69. doi: 10.1007/s00068-020- 01552-5.

27 Taasconi A, Coccolini F, Biffl WL, Tomasoni M, Ansaloni L, Picetti E, *et al.* Perforated and bleeding peptic ulcer: WSES guidelines. World J Emerg Surg 2020; 15:3. doi: 10.1186/s13017-019- 0283-9.

28 Zimmermann M, Hoffmann M, Laubert T, Jung C, Bruch HP, Schloericke E. Conversion of laparoscopic surgery for perforated peptic ulcer: a single-center study. Surg Today 2015; 45:1421–1428. doi: 10.1007/s00595-015-1112-8.

29 Kim JH, Chin HM, Bae YJ, Jun KH. Risk factors associated with the conversion of laparoscopic simple closure in perforated duodenal ulcer. Int J Surg 2015; 15:40–44. doi: 10.1016/j.ijsu.2015.01.028

30 Pereira A, Santos Sousa H, Gonçalves D, Lima da Costa E, Costa Pinho A, Barbosa E, Barbosa J. Surgery for Perforated Peptic Ulcer: Is Laparoscopy a New Paradigm? Minim Invasive Surg 2021; 2021:8828091. doi: 10.1155/2021/8828091

31 Wright GP, Davis AT, Koehler TJ, Scheeres DE. Cost-efficiency and outcomes in the treatment of perforated peptic ulcer disease: laparoscopic versus open approach. Surgery 2014; 156:1003–1007. doi: 10.1016/j.surg.2014.06.047

32 Wilhelmsen M, Møller MH, Rosenstock S. Surgical complications after open and laparoscopic surgery for perforated peptic ulcer in a nationwide cohort. Br J Surg 2015; 102:382–387. doi: 10.1002/bjs.9753. Epub 2015 Jan 21

33 Pan CW, Liou LR, Mong FY, Tsao MJ, Liao GS. Simple laparoscopic repair of perforated peptic ulcer without omental patch. Asian J Surg 2020; 43:311–314. doi: 10.1016/j.asjsur.2019.08.007

34 Siow SL, Mahendran HA, Wong CM, Hardin M, Luk TL. Laparoscopic versus open repair of perforated peptic ulcer: Improving outcomes utilizing a standardized technique. Asian J Surg 2018; 41:136–142. doi: 10.1016/j.asjsur.2016.11.004

35 Kim CW, Kim JW, Yoon SN, Oh BY, Kang BM. Laparoscopic repair of perforated peptic ulcer: a multicenter, propensity score matching analysis. BMC Surg 2022; 22:230. doi: 10.1186/s12893-022- 01681-1.

36 Cirocchi R, Soreide K, Di Saverio S, Rossi E, Arezzo A, Zago M, *et al.* Meta-analysis of perioperative outcomes of acute laparoscopic versus open repair of perforated gastroduodenal ulcers. J Trauma Acute Care Surg 2018; 85:417–425. doi: 10.1097/TA.0000000000001925