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REVIEW

Laparoscopic correction of perforated peptic ulcer: first choice? A review of literature

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Abstract
Background Perforated peptic ulcer (PPU), despite anti-ulcer medication and *Helicobacter* eradication, is still the most common indication for emergency gastric surgery associated with high morbidity and mortality. Outcome might be improved by performing this procedure laparoscopically, but there is no consensus on whether the benefits of laparoscopic closure of perforated peptic ulcer outweigh the disadvantages such as prolonged surgery time and greater expense.
Methods An electronic literature search was done by using PubMed and EMBASE databases. Relevant papers written between January 1989 and May 2009 were selected and scored according to Effective Public Health Practice Project guidelines.
Results Data were extracted from 56 papers, as summarized in Tables 1–7. The overall conversion rate for laparoscopic correction of perforated peptic ulcer was 12.4%, with main reason for conversion being the diameter of perforation. Patients presenting with PPU were predominantly men (79%), with an average age of 48 years. One-third had a history of peptic ulcer disease, and one-fifth took nonsteroidal anti-inflammatory drugs (NSAIDs). Only 7% presented with shock at admission. There seems to be no consensus on the perfect setup for surgery and/or operating technique. In the laparoscopic groups, operating time was significant longer and incidence of recurrent leakage at the repair site was higher. Nonetheless there was significant less postoperative pain, lower morbidity, less mortality, and shorter hospital stay.
Conclusion There are good arguments that laparoscopic correction of PPU should be first treatment of choice. A Boey score of 3, age over 70 years, and symptoms persisting longer than 24 h are associated with higher morbidity and mortality and should be considered contraindications for laparoscopic intervention.

Keywords Laparoscopic surgery · Perforated peptic ulcer · Omentoplasty · Review

Since the late 1980s, laparoscopy has become increasingly popular. In the beginning laparoscopy was mainly used for elective surgery since it was not clear what the influence was of the pneumoperitoneum on the acute abdomen with peritonitis. However the benefits of laparoscopy with regard to the acute abdomen as a diagnostic tool have been established since, and also its therapeutic possibilities seem to be advantageous [1–3]. The rapid development of laparoscopic surgery has further complicated the issue of the best approach for the management of perforated peptic ulcer (PPU) [4]. PPU is a condition in which laparoscopic repair is an attractive option. Not only is it possible to identify the site and pathology of the perforation, but the procedure also allows closure of the perforation and peritoneal lavage, just like in open repair but without a large upper abdominal incision [5, 6]. Nonetheless, not all patients are suitable for laparoscopic repair [5]. Despite many trials (mostly nonrandomized or retrospective), the routine treatment for perforated peptic ulcer still seems to be by upper laparotomy, representing the main motive for

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reviewing the literature and summarizing all (significant) results.

Materials and methods

An extensive electronic literature search was done by using PubMed and EMBASE databases. Keywords used for searching were "laparoscopic," "correction," "repair," and "peptic ulcer." All papers in English or German language published between January 1989 and May 2009 were included. Papers were scored according to Effective Public Health Practice Project (EPHPP) guidelines as advised in Jackson's guidelines for systematic reviews [7]. Using this rating system each paper was classified as weak, moderate or strong.

Results

Fifty-six relevant articles were found by PubMed and EMBASE search. Of these, 36 were prospective or retrospective trials, 5 were review articles, 3 articles described new techniques making laparoscopic correction of PPU more accessible, and 12 were general, of which 1 was the European Association for Endoscopic Surgery (EAES) guideline [1–6, 8–57]. Study details are listed in Table 1. Based on patient details and selection criteria as reported in these papers a general overview could be made of the average symptoms of a patient presenting with acute abdominal pain suspected for PPU, and of the results of additional diagnostic tools such as X-ray and blood sample (Table 2). Three papers published results of randomized controlled trials (RCTs) [29, 46, 57]. Since these were the only RCTs comparing laparoscopic repair with open repair for PPU, their results have been listed separately in Table 3. All three showed significant reduction in postoperative pain in the laparoscopic group, and Siu et al. concluded that morbidity was significant lower in the laparoscopic group [29]. Two of these RCT's concluded that operating time was significant longer, though the other group showed a significant shorter operating time. In 29 studies the surgical technique used for laparoscopic correction of PPU was mentioned in the "Material and Methods" section. These details are summarized in Table 4. Table 5 gives an overview of the total amount of complications observed after surgery for PPU by either laparoscopic technique or open closure. It is noticeable that the incidence of scar problems after surgery for PPU was as high as 9.9%. Also, mortality after surgery for peptic ulcer disease, despite all technical and medical improvement, was still 5.8%. The average conversion rate was 12.4% (Table 1). Reasons for conversion are listed in Table 6. The three most common reasons for conversion were size of perforation (often >10 mm), inadequate ulcer localization, and difficulties placing reliable sutures due to friable edges. Table 7 compares results between laparoscopic and open repair with regard to most important parameters such as postoperative pain, bowel action, hospital stay, morbidity, and mortality. Finally, Table 8 gives an overview of the conclusions drawn by 40 papers.

Discussion

In 2002, Lagoo et al. added the sixth decision for a surgeon to be make regarding PPU to the existing five therapeutic decisions proposed by Feliciano in 1992 [4]. The first decisions were about the need for surgical or conservative treatment, to use omentoplasty or not, the condition of the patient to undergo surgery, and which medication should be given. The sixth decision was: "Are we going to perform this procedure laparoscopically or open?" Is there really a sixth decision to be made, or are there enough proven benefits of laparoscopic correction that this should not be a question anymore? Reviewing literature showed that much research has been done, although not many prospective randomized trials have been performed ($n = 3$). Still, data extracted from these papers are interesting.

Patient characteristics

Often it was mentioned that age of patients presenting with PPU is increasing, due to better medical antiulcer treatment and also because of more NSAID and aspirin usage in the elderly population [4, 17, 56]. The results in Table 2 show that the average age of patients with PPU was 48 years and that only 20% of these patients had used NSAIDs. One-third of patients had a history of peptic ulcer. Although *Helicobacter pylori* is known to be present in about 80% of patients with PPU, this might indicate that there are more factors related to PPU for which the pathology is not yet clear [4]. Sixty-seven percent of perforations were located in the duodenum and only 17% were gastric ulcers (Table 2), according to findings in literature [58]. In 85% there was free air visible on X-ray (Table 2), which supports the diagnosis, but free air could be caused by other perforations as well and, although the diagnosis of PPU is not difficult to make, sometimes there is a good indication for diagnostic laparoscopic to exclude other pathology [2]. In 93–98%, definitive diagnosis could be made by performing diagnostic laparoscopy in the patient with an abdominal emergency, of which 86–100% could be treated laparoscopically during the same session [1, 2].

Table 1 Overview studies

Study	EPHPP	Study design	Number patients	Procedure	Conversion rate (%)
Vaidya 2009	Weak	NRP	31	Lap	6.5
Ates 2008	Moderate	NRP	17	Lap	17.6
Song 2008	Weak	NRP	35	Lap	5.7
Bhogal 2008	Moderate	NRP	19	Lap	0.0
			14	Open	
Ates 2007	Weak	NRP	17	Lap	17.6
			18	Open	
Malkov 2004	Moderate	NRP	42	Lap	0.0
			40	Open	
Siu 2004	Moderate	NRP	172	Lap	21.5
Arnaud 2002	Weak	NRP	30	Lap	16.6
Lee 2001	Weak	NRP	155	Lap	28.5
			219	Open	
Khourseed 2000	Weak	NRP	21	Lap	4.7
Kathkouda 1999	Weak	NRP	30	Lap	17.0
			16	Open	
Bergamaschi 1999	Weak	NRP	17	Lap	23.5
		N	62	Open	
Matsuda 1995	Weak	NRP	11	Lap	21.4
			55	Open	
Lee 2004	Weak	NRP	30	Lap	3.3
Druart	Moderate	NRP	100	Lap	8.0
Siu 2002	Strong	PR	63	Lap	14.2
			58	Open	
Lau 1996	Moderate	PR	52	Lap	23.0
			51	Open	
Bertleff 2009	Strong	PR	52	Lap	7.7
			49	Open	
Palanivelu 2007	Weak	R	120	Lap	0.0
Lunevicius 2005	Moderate	R	60	Lap	23.3
			162	Open	
Lunevicius IV	Weak	R	60	Lap	23.3
Kirshtein 2005	Weak	R	68	Lap	4.4
			66	Open	
Tsumura 2004	Weak	R	58	Lap	12.0
			13	Open	
Seelig 2003	Weak	R	24	Lap	12.5
			31	Open	
Al Aali 2002	Weak	R	60	Lap	6.6
			38	Open	
Lee 2001 I	Weak	R	209	Lap	26.8
			227	Open	
Robertson	Weak	R	20	Lap	10.0
			16	Open	
So 1996	Weak	R	15	Lap	6.6
			38	Open	
Johansson 1996	Weak	R	10	Lap	0.0
			17	Open	
Total			**2788**		**12.4**

NRP nonrandomized prospective, *PR* prospective randomized, *R* retrospective, *EPHPP* Effective Public Health Practice Project

Table 2 Demographics of patients with perforated peptic ulcer disease

	Total ($n = 2,784$)	
Age (years)	48	$n = 2,328$
Male (%)	79	$n = 2,678$
History of ulcer (%)	29	$n = 1,140$
History of NSAID use (%)	20	$n = 1,109$
Smokers (%)	62	$n = 472$
Alcohol use (%)	29	$n = 198$
ASA I (%)	35	$n = 1,120$
ASA II (%)	37	$n = 1,060$
ASA III (%)	20	$n = 1,060$
ASA IV (%)	9	$n = 1,030$
Boey 0	59	$n = 513$
Boey 1	23	$n = 513$
Boey 2	16	$n = 513$
Boey 3	2	$n = 513$
Shock at admission (%)	7	$n = 1,107$
Duration of symptoms (h)	13.6	$n = 837$
Free air on X-ray (%)	85	$n = 510$
Symptoms >24 h (%)	11	$n = 723$
Size perforation (mm)	5.5	$n = 691$
Manheim peritonitis index	15.1	$n = 220$
WBC	12.3	$n = 147$
Localization ulcer		
Duodenal (%)	67	$n = 1,355$
Juxtapyloric (%)	23	$n = 1,355$
Gastric (%)	17	$n = 1,355$

WBC white blood cells

Surgical technique

There seems to be no consensus on how to perform the surgical procedure, which probably means that the perfect setup has not yet been found. Forty-four percent of surgeons preferred to stand between the patient's legs, while 33% performed the procedure at the patient's left side. Also, the number, position, and size of trocars differed between surgeons. Placing and tying sutures was more demanding laparoscopically, and two techniques were used (Table 4). Theoretically there is a preference for intracorporeal knotting over extracorporeal suturing, because the latter is likely to cut through the friable edge of the perforation [12]. One of the disadvantages of laparoscopic correction of PPU often mentioned was the significant longer operating time, which causes more costs and may be nonpreferable in a hemodynamically unstable patient [5, 16, 18, 35, 42, 43, 45, 46]. Ates et al. presented results with simple suture repair of PPU without using pedicled omentoplasty [11]. This significantly shortened operating time, but the question remains of whether it is safe to abandon omentoplasty completely. Cellan-Jones emphasized the necessity for omentoplasty [59]. His advised technique, to prevent tearing out of sutures and prevent enlargement of the size of perforation by damaging the friable edges, is to place a plug of pedicled omentum into the "hole" and secure this with three tie-over sutures. His technique is often called the Graham patch, but Graham describes in his article the use of a free omental plug, a technique that hardly any surgeon uses nowadays [60]. It might be less confusion to use the term "pedicled omentoplasty." The usefulness of pedicled omentoplasty has been emphasized by others, and Schein even stated: "first suturing the hole and then sticking omentum over the repair is wrong, if you cannot patch it, then you must resect" [59, 61]. Avoiding omentoplasty might shorten operating time but might be the reason for a higher incidence of leakage at the repaired ulcer side [5, 24]. Another reason for longer operating time during the laparoscopic procedure might be the irrigation procedure. Peritoneal lavage is one of the key interventions in the management of PPU [4]. Lavage was performed with 2–6 L warm saline, but even up to 10 L has been described (Table 3) [4]. By using a 5-mm or even 10-mm suction device, this part of surgery took even up to 58 min [30]. Whether generous irrigation is really necessary has not yet been proven.

Patient selection

Not all patients are suitable for laparoscopic repair, and it is important to preselect patients who are good candidates for laparoscopic surgery [5]. Boey's classification appears to be a helpful tool in decision-making [4, 56]. The Boey score is a count of risk factors, which are: shock on admission, American Society of Anesthesiologists (ASA) grade III–V, and duration of symptoms [52]. The maximum score is 3, which indicates high surgical risk. Laparoscopic repair is reported only to be safe with Boey score 0 and 1 [16, 42]. Since the incidence of patients with Boey score 2 and 3 is low (according to Table 2, only 2% of patients were admitted with Boey score 3, 7% were in shock at admission, and 11% had prolonged symptoms for more than 24 h) and Boey 2 and 3 is associated with high morbidity and mortality rate anyway, independent of type of surgery, it is difficult to find significant foundation for this statement. Other reported contraindications are age >70 years and perforation larger than 10 mm in diameter [16, 17, 32, 33].

Reasons for conversion

Overall conversion rate was 12.4%, with a range of 0–28.5% (Table 1). The most common reason for conversion was the size of perforation, but by using an omental

Table 3 Results of prospective randomized trials

Laparoscopic correction	Siu 2002	Lau 1996	Bertleff 2009	Average
Operating time (min)	42	94	75	70.3
Nasogastric tube (days)	3.0	2.5	2.0	2.5
Normal diet (days)		4.0		4.0
Postoperative opiate use	0 injections	1.5 days	1 day	
Hospital stay (days)		5.5	6.5	6.0
Morbidity (%)	25	23	18	22.0
Normal daily activities (days)	10.4			10.4
Mortality (%)	1.6	2	3.8	2.5
Ileus (days)			0	0.0
Wound infection (%)			0	0.0
Leakage (%)		2.1	3.8	3.0
VAS day 1	3.5	4.0	3.8	3.8
VAS day 3	1.6		2.1	1.9
Open correction PPU	Siu 2002	Lau 1996	Bertleff 2009	Average
Operating time (min)	52.3	54	50	52.1
Nasogastric tube (days)	3.0	2.5	3.0	2.8
Normal diet (days)		4.0		4.0
Postoperative opiate use	6 injections	3.5 days	1 day	
Hospital stay (days)		5	8	6.5
Morbidity (%)	50	22	36	36.0
Normal daily activities (days)	26.1			26.1
Mortality (%)	5.2	4.0	8.1	5.8
Ileus (days)			2.0	2.0
Wound infection (%)			6.1	6.1
Leakage (%)		2.2	0	1.1
VAS day 1	6.4	5.0	5.2	5.5
VAS day 3	3.3		3.0	3.2

VAS visual analog scale

Table 4 Surgical technique (29 studies)

Closure of perforation	66% omental patch	24% mixed techniques	10% sutures only	
Pneumoperitoneum	26% Hassan trocar	47% Veress needle	26% mixed	
Pneumoperitoneum	75% 12 mmHg	25% 11 or 14 mmHg		
Camera position	35% supraumbilical	35% umbilical	30% infraumbilical	
Number of trocars used	60% four trocars	40% three trocars		
Surgeon position	44% between legs	33% left side patient	16% between or left side	6% right side
Irrigation fluid	45% generous	55% between 2 and 6 L		
Camera	80% 30°	10% 40°	10% 0°	
Nasogastric tubing	94% yes	6% no		
Abdominal drains	79% yes	21% no		
Suture material	64% resorbable	38% nonresorbable		
Knotting technique	64% intracorporeal	14% extracorporeal	14% mix	

patch this might not necessarily have to be a reason anymore to convert. From literature it was already known that other common reasons for conversion include failure to locate the perforation [17]. Shock at admission was associated with a significant higher conversion rate (50% versus 8%) [4]. Furthermore, time lapse between perforation

Table 5 Overview of complications (17 studies, $n = 1{,}802$)

Scar problems	9.9%
Mortality	5.8%
Intra abdominal collection	5.7%
Wound infection	4.9%
MODS	4.7%
Sepsis	4.6%
Reoperation	4.5%
Prolonged ileus	4.1%
Suture leakage	3.8%
Pneumonia	3.4%
Respiratory complications	3.3%
Ulcer recurrence	3.1%
Intra-abdominal abscess	2.7%
Heart failure	2.3%
Hemorrhage	2.0%
Incisional hernia	1.8%
Atrial fibrillation	1.7%
Fistula	1.7%
Pneumothorax	1.7%
Urine retention	1.7%
Urinary tract infection	1.6%
Cerebral vascular accident	1.0%
Wound dehiscence	0.8%

MODS multiple organ dysfunction syndrome

Table 6 Conversion reasons (21 studies, $n = 2{,}346$)

Perforation size	9.4%
Inadequate ulcer localization	6.6%
Friable edges	6.4%
Adhesions	5.9%
Perforation gallbladder	5.0%
Cardiovascular instability	4.4%
Suspected tumor	4.2%
Severe peritonitis	4.2%
Posterior localization	3.9%
Definitive ulcer surgery	3.2%
Technical difficulties	2.2%
Pancreatic infiltration	1.0%

and presentation negatively influenced conversion rate (33% versus 0%) [4].

Complications

The best parameters to compare two different surgical techniques are morbidity and mortality. PPU is still associated with high morbidity and mortality, with main problems caused by wound infection, sepsis, leakage at the repair site, and pulmonary problems (Table 4) [56]. Comparing results shows a remarkable difference in morbidity (14.3% in the laparoscopic group versus 26.9% in the open group) and mortality (3.6% versus 6.4%) (Table 6). Many trials measured the amount of postoperative opiate usage, but since this was scored in different ways (days used, number of injections, amount of opiates in mg) these data were not comparable. However, overall, many studies showed significant reduction in pain, mortality, morbidity, wound infection, resuming normal diet, and hospital stay (Tables 6 and 7). Of course there are some negative results which cannot be ignored (Table 7). Three papers reported a significant higher incidence of suture leakage, associated in one with a higher incidence of reoperations, but leakage mainly occurred in the sutureless repair group or in the group in which (pedicled) omentoplasty was not routinely used [18, 24, 32].

Overall there seems to be significant proof of the benefits of laparoscopic repair, but it is technical demanding surgery which needs a surgeon experienced with laparoscopy [4, 17]. CO_2 insufflation of the peritoneal cavity in the presence of peritonitis has been shown in rat models to cause an increase in bacterial translocation [4]. This led to the assumption that laparoscopic surgery might be dangerous in patients with prolonged peritonitis. Vaidya et al. performed laparoscopic repair in patients with symptoms of PPU for more than 24 h and concluded that it was safe even in patients with prolonged peritonitis, which has been confirmed by others [4, 8, 39, 44].

Alternative techniques

Closing the perforation site using suture repair is challenging, which is why alternative methods have been described [5, 15, 21, 24, 25, 31]. Examples are represented by the sutureless repair of PPU, in which the perforation is closed by a gelatin sponge glued into the perforation or the perforation is closed by fibrin glue. Song et al. proposed the simple "one-stitch" repair with omental patch [9]. The automatic stapler has been used for perforation site closure, use of running suture was suggested to avoid intracorporeal or extracorporeal knotting, and combined laparoscopic–endoscopic repair has been described as well [21].

Definitive ulcer surgery

The need for definitive surgical management of peptic ulcer disease has markedly decreased, but 0–35% of patients admitted for PPU received definitive ulcer surgery [8, 16, 20, 56]. Definitive ulcer surgery can be performed safely with laparoscopic techniques [4, 12, 36]. Palanivelu et al. performed definitive surgery in 10% of cases admitted for PPU. All procedures (posterior truncal vagotomy and anterior highly selective vagotomy) were

Table 7 Laparoscopic versus open repair

$n = 1,874$	Laparoscopic ($n = 843$)	Open ($n = 1,031$)
Operating time (min)	70.8	59.3
Nasogastric tube (days)	23	3.0
Intravenous fluids (days)	2.8	3.1
Abdominal drains (days)	2.2	3.8
Urinary catheter (days)	2.3	3.7
Normal diet (days)	3.5	5.7
Prolonged ileus (days)	2.7	3.6
Hospital stay (days)	6.3	10.3
Wound infection (%)	0.0	5.0
Suture leakage (%)	6.3	2.6
Mobilization (days)	1.9	3.3
Normal daily activity (days)	12.7	16.6
Morbidity (%)	14.3	26.9
Mortality (%)	3.6	7.2
VAS day 1	3.8	6.4
VAS day 3	1.9	3.3

VAS visual analog scale

Table 8 Conclusions of 40 studies with regards to laparoscopic repair PPU

The procedure is safe	16
Significantly less pain	19
Significantly less mortality	1
Significantly lower morbidity	4
Significantly shorter operation time	2
Significantly shorter hospital stay	5
Significantly faster resumption of normal diet	3
Significantly less wound infection	2
No difference between laparoscopic repair or open	2
Significantly longer operating time	8
Significantly more suture leakage	3
Significantly more reoperations	1

performed laparoscopically without conversion or mortality [12].

Research

A few aspects regarding laparoscopic repair of PPU are still unclear, and further research on these topics would be interesting. One of the remaining questions is whether there is less formation of intra-abdominal adhesions after laparoscopic repair [4]. If this is the case, it would be another convincing reason to perform this procedure laparoscopically. Often mentioned as one of the major disadvantages of laparoscopic surgery are the high costs, caused by the need for more surgical staff and laparoscopic equipment. However no specified calculation of per- and postoperative costs have been made so far, and also the costs saved by possible earlier return to work have to be taken into account.

To conclude, the results of this review support the statement of the EAES already made in 2006 that, in case of suspected perforated peptic ulcer, laparoscopy should be advocated as diagnostic and therapeutic tool [14].

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