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Management Strategies, Early Results, Benefits, and Risk Factors of Laparoscopic Repair of Perforated Peptic Ulcer

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Abstract. The primary goal of this study was to describe epidemiology and management strategies of the perforated duodenal ulcer, as well as the most common methods of laparoscopic perforated duodenal ulcer repair. The secondary goal was to demonstrate the value of prospective and retrospective studies regarding the early results of surgery and the risk factors. The tertiary goal was to emphasize the benefits of this operation, and the fourth goal was to clarify the possible risk factors associated with laparoscopic repair of the duodenal ulcer. The Medline/Pubmed database was used. Review was done after evaluation of 96 retrieved full-text articles. Thirteen prospective and twelve retrospective studies were selected, grouped, and summarized. The spectrum of the retrospective studies' results are as follows: median overall morbidity rate 10.5 %, median conversion rate 7%, median hospital stay 7 days, and median postoperative mortality rate 0%. The following is the spectrum of results of the prospective studies: median overall morbidity rate was slightly less (6%); the median conversion rate was higher (15%); the median hospital stay was shorter (5 days) and the postoperative mortality was higher (3%). The risk factors identified were the same. Shock, delayed presentation (> 24 hours), confounding medical condition, age > 70 years, poor laparoscopic expertise, ASA III-IV, and Boey score should be considered preoperative laparoscopic repair risk factors. Each of these factors independently should qualify as a criterion for open repair due to higher intraoperative risks as well as postoperative morbidity. Inadequate ulcer localization, large perforation size (defined by some as > 6 mm diameter, and by others as > 10 mm), and ulcers with friable edges are also considered as conversion risk factors.

As early as 1992, Feliciano proposed five therapeutic decisions that may have to be made in the management of perforated duodenal ulcer patients: (1) whether an operation is needed; (2) whether an omental patch repair or definitive operation is necessary; (3) whether the patient is stable enough to undergo a definitive operation; (4) which definitive operation is indicated; and (5) whether the availability of newer antacid agents should influence the choice of operation [1]. Ten years later, Lagoo et al. suggested a sixth decision: Should the procedure be performed laparoscopically or by laparotomy [2]? All these decisions are still important, and they all have to be considered when evaluating each patient individually. In the era of minimally invasive surgery, we draw particular attention to the sixth decision.

Laparoscopic repair of the perforated duodenal ulcer is, obviously, an example of minimal access surgery. There is wide agreement regarding the benefits of this approach. On the other hand, like any other invasive procedure, laparoscopic repair carries risks itself. The risks can be defined either by early (postoperative morbidity and mortality rates) or late (ulcer recurrence, functional results, classic or modified Visick scores) follow-up criteria. Open repair has its benefits and risks as well. Keeping this in mind, the surgeon's most important task should be to choose and perform the safest method of perforated duodenal ulcer repair. At first, it might seem easy when the classic surgery techniques are mastered, but in reality it is not.

The primary goal of this article is to describe epidemiology and management strategies of the perforated duodenal ulcer as well as the most common methods of laparoscopic perforated duodenal ulcer repair. The secondary goal is to emphasize the benefits of this operation. The tertiary goal is to clarify the possible risk factors in laparoscopic repair of the duodenal ulcer, and the fourth is to demonstrate the value of prospective and retrospective studies regarding the early results of surgery and the risk factors.

Materials and Methods

The articles were found on the MEDLINE/PubMed database using the MESH Browser function. The search terms "perforated duodenal ulcer" (MESH)" "laparoscopy" (MESH) were employed using the following limits: English language, human. A total of 97 articles were found published between April 1990 and October 2004. After analyzing the abstracts, 61 articles were drawn from the list for full text analysis. Using the references of these articles, 35 extra papers were chosen and the reprints received and analyzed. So the literature review employs the analysis and evaluation of 96 articles. Extra attention was paid to the 25 clinical trials: 12 retrospective and 13 prospective analyses.

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Terms

Repair that is initiated laparoscopically with the intention to treat perforated duodenal ulcer is considered laparoscopic. The term "increased risk" means increased likelihood of conversion, morbidity, or mortality risk. Laparoscopic repair is considered unsuccessful if the patient undergoes conversion to open repair, or if there is severe postoperative morbidity or a fatal outcome after laparoscopic repair.

Clinical Epidemiology

Duodenal ulcer perforation is a serious complication of peptic ulcer disease that occurs in 5% to 10% of duodenal ulcer patients and accounts for more than 70% of deaths associated with peptic ulcer disease [3]. A history of peptic ulcer disease is present in 60% to 75% of patients with perforated peptic ulcer [1]. The incidence of this complication is 7 to 10 cases/100,000 adults per year [4].

The current peak age for perforated duodenal ulcer is 40 to 60 years [2], but the age of perforated peptic ulcer patients is increasing, especially the number of patients over 60 years old [5, 6]. Thus patients admitted today tend to be older and sicker [7]. Nonsteroidal antiinflammatory drugs (NSAIDs) are the most important risk factor for peptic ulcer perforation [8, 9]. The patients are at increased risk if using several NSAIDs at a time or a single NSAID at an increased dosage. Cocaine and psychostimulants were also noted for destructive effects on gastric and duodenal mucosa [10, 11]. They are therefore considered risk factors for peptic ulcer perforation. Iatrogenically induced ulcers were also described and may result from performing endoscopy [12].

The major role of *Helicobacter pylori* infection in the pathogenesis of ulcer perforation cannot be confirmed [5, 13]. *H. pylori* seropositivity rates are similar in peptic ulcer patients who required surgical treatment and those requiring only medical treatment. This indicates that *H. pylori* is not significantly associated with peptic ulcer complications such as hemorrhage and perforation [13]. Nonetheless, some authors still emphasize the role of *H. pylori* in peptic ulcer perforation [14].

The era of H_2 receptor blockers and proton pump inhibitors treatment for peptic ulcer disease has led to a decline in peptic ulcer prevalence. At the same time, the role of definitive ulcer surgery has declined. Yet during this era there did not appear to be any fall in the rates of peptic ulcer perforation [15] but, rather, an increase [16]. The fact is that NSAID-induced ulcers are on the increase [17], and elective surgery for peptic ulcer is disappearing in many areas of the world. Both of these factors may have led to this increase in perforated peptic ulcers [8, 17].

Management Strategies

The role of definitive duodenal ulcer surgery (pyloroplasty with vagotomy, resection) and its complications has declined radically over the last decades, essentially because of the efficacy of gastric antisecretory drugs and *H. pylori* eradication [17–20]. Current indications for surgical treatment are complications of duodenal ulcer disease but not the ulcer disease itself [17, 21], which means that the primary and most important goal of perforated duodenal ulcer repair is just to close the perforation. The ulcer recurrence rate and outcome is reasonable if postoperatively patients receive proton pump inhibitors or H_2 receptor blockers and *H. pylori* eradication therapy according to the recommendations of gastroenterologists [7, 17, 22–25]. That is one of the most important reasons the minimally invasive approach is an attractive alternative to open repair. On the other hand, definitive surgery still has its indications. First is the fact that medical treatment fails sometimes. Second is the cost of treatment; especially when the treatment relies mostly on antisecretory drugs. Lastly, NSAID-induced ulcers are on the increase, and the role of antisecretory drug treatment and laparoscopic repair has not yet been assessed [17, 26]. Stenosis, malignancy, and bleeding are other indications for definitive surgery [17]. Even in this case, however, few surgeons would perform definitive surgery in the emergency setting. Because of the effectiveness of H_2 blockers and proton pomp inhibitors, definitive repair can be delayed until a patient recovers after simple closure of the perforated ulcer. Elective definitive surgery can be performed by the open or laparoscopic approach [2, 27–31]. It appears that the results of late follow-up after both types of surgery are similar. The ulcer recurrence rate is 4% to 11% and the postoperative complication rate is 1% to 2% after definitive elective procedure; whereas medical treatment with antisecretory drugs can result in recurrence rates of up to 30% [27].

Conservative treatment was developed even earlier than laparoscopic repair owing unacceptable postoperative mortality after emergency open repair in poor surgical risk patients [32]. Berne and Donovan developed the conservative treatment by using contrast studies to confirm sealed perforated duodenal ulcers [33]. Crofts et al. carried out a randomized prospective trial comparing conservative (noninvasive) and surgical treatment [34]. They revealed that morbidity and mortality were comparable in the two groups, denying any influence of the method. Two differences were noted, however. First, the hospital stay was longer for the conservative treatment group. Second, the conservative treatment failed in 67% of elderly patients (> 70 years old), whereas it was successful in 100% of patients < 40 years. According to the current perforated peptic ulcer treatment guidelines, conservative treatment is indicated only for patients with end-stage sepsis [2].

In our opinion, a good example of current perforated duodenal ulcer management guidelines is the algorithm presented by Lagoo et al. in 2002 [2]. There are three indications for the conservative approach: (1) end-stage septic patients; (2) patients with prohibitive surgical risks; (3) poor surgical candidates with confirmed sealed perforations. When none of the above-mentioned criteria are satisfied, open or laparoscopic repair should be considered. Open repair is chosen for (1) patients with a hostile or frozen abdomen that would prevent safe access, (2) if there is simultaneous bleeding and perforation in the unstable patient, or (3) in the presence of co-morbid cardiovascular or respiratory factors that compromise a patient's ability to tolerate pneumoperitoneum. The surgeon's experience in laparoscopic surgery is definitely one of the most important factors affecting the surgeon's choice between open and laparoscopic repair [35]. Another consideration is the availability of trained operating room personnel and equipment. The choice between laparoscopic repair methods is determined by the properties of the ulcer's edges. If the edges are infiltrated, friable, and nonmobile, repair is accomplished with a sutured omental patch only. For viable opposable ulcer edges,

suture repair with reinforcement of an omental patch is the procedure of choice.

A recently published meta-analysis summarized the results of 13 trials that were comparing treatment outcomes for open and laparoscopic repairs [36] and specified the indications for laparoscopic repair. It concluded that the minimally invasive approach should be the procedure of choice for patients with no Boey risk factors. Additionally, it is worth emphasizing that a previous abdominal operation was considered to be a relative contraindication of laparoscopic surgery for peptic ulcer perforation [36].

Techniques of Laparoscopic Repair

For laparoscopic surgical treatment, it is recommended that the patient be placed in a 15° to 20° reverse Trendelenburg position. The operating surgeon stands between the legs or on the patient's left. The assistants stand on each side of the patient. Through a supraumbilical or infraumbilical incision (incision length depends on the diameter of the trocar one plans to use) a carbon dioxide pneumoperitoneum (up to 12 mmHg) is established with a Veress needle. (Hassan's cannula is an alternative to the Verres needle.) After establishing the pneumoperitoneum, the laparoscope is introduced through a 10 mm or 12 mm diameter trocar. Laparoscopy itself is a valuable diagnostic tool, so the whole abdominal cavity should be thoroughly investigated [37]. The other trocars are placed under laparoscopic control, including a trocar in the epigastrium used for liver and gallblader retraction and the two most important working trocars on the left side: one in the upper left quadrant in the subcostal region on the left midclavicular line or a little lateral to that and the second where the left midclavicular line meets with the inferior border of the left upper quadrant or a little lower. On the other hand, working trocars can be placed in the middle or upper portion of the right side [2]. Other positioning can also be used.

Previous studies show that the perforation site can be easily identificatied by laparoscopy [37]. On the other hand, failure to locate the perforation site is one of the most common reasons for conversion to open repair [3, 20, 38–41]. If the ulcer is localized on the lateral wall of the descending portion of the duodenum, the duodenum must be mobilized [42]. The adhesions can be divided with electrocautery or blunt or ultrasonic dissection [2]. An alternative approach (i.e., minilaparoscopy for perforated peptic ulcer) was first described by Siu et al. [43] and is potentially the future of laparoscopic repair.

Several methods of laparoscopic repair are described. One is the Walsh et al method [44]. After a sealed perforation is confirmed, it is left untouched; peritoneal lavage and drainage are than performed. In case the perforation site is not sealed by the omentum, the patient undergoes conversion to open repair, and simple omentopexy is performed. This method was later accepted by other surgeons [45, 46]. For example, Urbano et al. [45] succesfully treated five of six patients. Three of five patients had delayed presentation (>12 hours before surgery). All of the patients underwent uneventful recovery and were discharged in 7 days.

Omentopexy alone [18, 20, 22, 47–49] or suture repair with omentopexy [3, 40, 50–52] are examples of other methods. When performing suture closure with reinforcement of omental patch, three sutures are placed through the viable duodenum on either side of the perforation and tied to close the perforation. Laparoscopic suturing of a pedicle of omentum placed across the perforation completes the closure. When the omentum is small, the falciform ligament can be used instead [53, 54]. The use of the round hepatic ligament has also been described [55]. Use of ulcer perforation closure alone was reported by several surgery centers as well [56].

Closing the perforation site using suture repair is challenging for the surgeon, which is why alternative methods were described. Examples of sutureless techniques are the gelatin sponge fibrin glue repair [38, 57–59] and application of omentum using fibrin glue alone to close the perforation [60, 61]. Automated stapler use for perforation site closure was reported as well [62]. Running suture closure as an alternative approach was proposed to avoid any intracorporeal or extracorporeal knotting [63]. Essential details of that operation are as follows: When the suture is fixed with a reabsorbable clip, a piece of omentum is fixed with one or two more stitches of the same suture over the defect, and another clip is applied. Combined laparoscopic-endoscopic repair has been described as well. After confirming the diagnosis by laparoscopy, gastroduodenoscopy is performed [64, 65]. An omental patch is then inserted into the duodenum through the perforation site, and the omentum is fixed within the duodenum with the help of an endoscope, and suture repair is performed by laparoscopy.

Irrigation of the peritoneal cavity is one of the most important parts of the surgery, consuming a Substantial part of the Surgery. Although 6 to 10 liters of warm saline are often recommended [2, 18, 22, 66–68], others recommend using at least 30 liters [69, 70]. Extra attention has to be paid to irrigating the suprahepatic and subhepatic spaces, the lateral channel, and the left subdiaphragmatic and minor pelvic cavities. The peritoneal cavity is usually drained [3, 71]. On the other hand, some authors do not advocate drainage of the peritoneal cavity [49, 72]. In addition, the duration of nasogastric probing is at least 48 hours. Proton pump inhibitors or H_2-receptor blockers are started right after the surgery [18]. Antibiotics are used for up to 5 days or until the fever subsides [45].

Early Results of Laparoscopic Repair

The early results of laparoscopic perforated duodenal ulcer repair in 12 retrospective studies are presented in Table 1. The main points are as follows.

1. The groups of patients are small: 6 patients [45, 53, 73] to 25 patients [40]; only Lee et al. observed 209 patients [74].
2. Suture repair alone, suture repair with omentopexy or omentopexy only were the most commonly used procedures; Lee's experience using fibrin glue is unique [74].
3. The reported median of operating time is 90 minutes.
4. The median overall morbidity rate is 10.5%.
5. The median conversion rate is 7%.
6. The median postoperative mortality is zero.
7. The median hospital stay is 7 days.
8. Laparoscopic repair is effective and feasible; further studies are needed to determine the risk factors and clear indications for laparoscopic repair.

The early results of the 13 prospective studies are presented in Table 2. The main points are as follows.

1. The samples are larger: 20 patients [20] to 63 patients [39], including two even larger studies with 100 cases [3] and 201

Table 1. Laparoscopic perforated duodenal ulcer repair: summary of 12 retrospective studies.

Authors, year, country	Laparoscopic technique[a] Technique	No.	Duration of operation (min)	Morbidity[b]	Conversion[b]	Mortality[b]	Mean hospital stay (days)	Conclusion/ comparison with open repair
Seelig et al. [68], 2003, Germany	Suture repair	24	65 (58–94)	3 (13%)	3 (13%)	0	9 (8–11)	Laparoscopic repair is a safe and effective option in case of peritonitis; previous abdominal surgery is a risk factor; less analgesic requirement
Lee et al. [74], 2001, Hong Kong	Sutureless fibrin glue	153	—	26 (17%)	46 (30%)	4 (3%)	6 (2–77)	APACHE II helps to predict morbidity and mortality; Boey score predicts mortality and conversion rate; conversion did not affect the outcome
	Suture repair	56		11 (20%)	10 (18%)	2 (4%)		
Agresta et al. [50, 51], 2000, Italy	Suture repair	5[c]	90 (60–130)	3 (19%)	1 (6%)	1 (6%)	11 (7–28)	Laparoscopic repair is safe; operation time L > O; risk factors: old age, shock, prolonged peritonitis, concurrent medical illness
	Suture repair with omentopexy	3						
	Peritoneal lavage	6						
	Peritoneal lavage and omentoplasty	1						
Naesgaard et al. [40], 1999, Norway	Suture repair with omentopexy	24	100 (48–160)	7 (28%)	5 (20%)	5 (20%)	8 (3–23)	safe; increased mortality after prologed perforation; operating time L > O
	Suture repair with ligamentopexy (lig. falciforme)	1						
Bergamaschi et al. [41], 1999, Norway	Suture repair with omentopexy	10	92 ± 9	2 (12%)	4 (24%)	2 (12%)	7.0 ± 0.9	Laparoscopic repair has no advantages; conversion predicted by ulcer location rather than size
	Stapled	7						
So et al. [18], 1996, Singapore	Omentopexy	15	80 (70–95)	1 (7%)	1 (7%)	0	7 (5–13)	Safe; less postoperative pain; operation time L > O; morbidity L = O
Munro et al. [53], 1996, the UK	Suture repair + falciform ligament patch	2	—	0	0	0	3–5	Falciform ligament is an excellent, simple alternative to omental patch repair
	Falciform ligament patch	4						
Matsuda et al. [67], 1995, Japan	Omentopexy	14	135 (102–160)	1 (9%)	3 (21%)	0	17 (13–23)	Laparoscopic omentopexy is reliable
Urbano et al. [45], 1994, Italy	Peritoneal lavage/drainage	5	52	—	0	0	7 (6–15)	Peritoneal lavage and drainage is most important; leave sealed ulcers untouched
	Omentopexy	1						
Isaac et al. [42], 1994, Singapore	Suture repair with omentopexy	7	80 (70–90)	0	0	0	6 (5–7)	Laparoscopic repair is feasible
Benoit et al. [61], 1993, France	Fibrin glue omental patch	10	97 (70–130)	0	0	0	8 (6–11)	Omental patch fibrin glue repair is simple, quick, and safe
Sunderland et al. [73], 1992, Hong Kong	Omentopexy	6	108 (85–160)	0	0	0	6.5 (5–10)	An alternative to open repair; performed easily by surgeons familiar with laparoscopic cholecystectomy

APACHE: Acute Physiology, Age, and Chronic Health Evaluation; L: laparoscopic repair; O: open repair
[a]Including converted and dead patients.
[b]Proportion counted including converted and dead patients.
[c]One converted patient is not included.

Table 2. Laparoscopic perforated duodenal ulcer repair: summary of 11 prospective studies.

Author, year, country	Laparoscopic technique[a] Technique	No.	Duration of operation (min)	Morbidity[b]	Conversion[b]	Mortality[b]	Mean hospital stay (days)	Conclusion/ comparison with open repair
Lee et al. [66], 2004, Taiwan	Endoscopic evaluation + suture closure with omentopexy	29	58.1 ± 13.5	3 (10%)	0	0	4.7 ± 1.1	Endoscopy assisted laparoscopic repair is safe and feasible. Preoperative endoscopy reduces failure rate
Siu et al. [81], 2004, Hong Kong	Suture closure with omental patch	172	64.8 (14–180)	28 (16.3%)	37 (22%)	14 (8%)	6 (4–43)	L is safe for most patients with small pyloroduodenal perforations irrespective of physical health status
Mehendale et al. [56], 2002, India	Suture repair or suture repair with omentopexy	34	50 (25–120)	0	6 (18%)	0	4 (4–6)	Safe and effective; less morbidity; shorter hospital stay; faster return to usual activities with L
Siu et al. [39], 2002, Hong Kong	Suture repair with omentopexy	63	42 ± 25	4 (6%)	9 (14%)	1 (2%)	6 (4–35)	Operating time L < O, less pain, pulmonary morbidity with L; shorter hospital stay, faster return to usual activities with L; shock does not influence outcome
Lee et al. [38] 2001, Hong Kong	Sutureless fibrin glue	149	60 (30–180)	(16%)[c]	40 (27%)	4 (3%)	5	Sutureless fibrin glue operation time is shorter, APACHE II predicts suture leak in sutureless fibrin glue repair; conversion does not influence outcome
	Omentopexy	52	90 (35–135)	(6)[c]	8 (15%)	2 (4%)	5	
Robertson et al. [20], 2000, Australia	Omentopexy	20	77 ± 20	1 (5%)	2 (10%)	2 (10%)	5.0 (3–65)	Hospital stay and operating time O = L
Khoursheed et al. [22], Kuwait	Omentopexy	21	72 (40–120)	2 (10%)	0	0	5.2 (3–9)	Safe and effective; less postoperative pain with L; surgeon's experience is important; L is the procedure of choice
Katkhouda et al. [49], 1999, USA	Suture repair with omentopexy	30	106 (76–122)	7 (23%)	5 (17%)	1 (3%)	Shock on admission: 3 (3–4) No shock: 10 (8–11)	Safe; risk factors: shock and prolonged perforation > 24 hr; morbidity rate L = O; operating time L > O; less analgestics, shorter hospital stay, faster return to usual life with L
Druart et al. [3], 1997, Belgium	Suture repair	14[d]	80 (40–135)	4 (4%)	8 (8%)	5 (5%)	9.3 (2–40)	Morbidity and mortality L = O; risk factors: age > 70 years, septic shock, prolonged peritonitis; underlying medical illness
	Suture repair with omentopexy	67[d]						
	Sutureless fibrin glue	7[d]						
Siu et al. [47], 1997, Hong Kong	Suture repair with omentopexy	33	50 (18–150)	1 (3%)[c]	5 (15.2%)	0	6	L is the procedure of choice; safe for ulcers < 10 mm
Lau et al. [57], 1996, Hong Kong	Sutureless fibrin glue	24	75 ± 24	6 (25%)	3 (13%)	2 (8%)	6 (3–11)	Less analgesics with L; hospital stay, morbidity and mortality rates L = O
	Omentopexy	24	113 ± 44	5 (21%)	6 (25%)	0	5 (3–20)	
Lau et al. [58], 1995, HongKong	Sutureless fibrin glue	21	61 ± 17	1 (5%)[c]	1 (5%)	1 (5%)	5 (3–11)	Safe and feasible; sutureless fibrin glue—faster and simpler; less analgesics with L
	Omentopexy	35	101 ± 34	1 (3%)[C]	6 (17%)	0	5 (3–20)	
Thompson et al. [75], 1995, USA	Omentopexy	5	96 (85–106)[d]	0	3 (60%)	0	6.5 (5–8)[d]	Laparoscopic repair is safe and effective

[a]Including converted and dead patients.
[b]Proportion counted including converted and dead patients.
[c]Only suture leak is included.
[d]Converted patients are excluded.

Table 3. Risk factors for postoperative morbidity after laparoscopic perforated duodenal ulcer repair: data of retrospective studies.

Risk factor	Author, year	Country	No. of patients[a]
Shock	Seelig et al., 2003 [68]	Germany	24
	Naesgaard et al., 1999 [40]	Norway	25
	Bergamaschi et al., 1999 [41]	Norway	17
	So et al., 1996 [18]	Singapore	15
	Matsuda et al., 1995 [67]	Japan	14
Underlying medical illness	Agresta et al., 2000 [50, 51]	Italy	16
	Bergamaschi et al., 1999 [51]	Norway	17
	So et al., 1996 [18]	Singapore	15
Duration of perforation >24 hours	Agresta et al., 2000 [50, 51]	Italy	16
	Bergamaschi et al., 1999 [41]	Norway	17
	So et al., 1996 [18]	Singapore	15
	Matsuda et al., 1995 [67]	Japan	14
Age > 70 years	Agresta et al., 2000 [50, 51]	Italy	16
APACHE II score[b]	Lee et al., 2001 [74]	Hong Kong	209
	Bergamaschi et al., 1999 [41]	Norway	17
ASA III–IV			
	Seelig et al., 2003 [68]	Germany	24
	Bergamaschi et al., 1999 [41]	Norway	17
	So et al., 1996 [18]	Singapore	15
Boey score[c]	Lee et al., 2001 [74]	Hong Kong	209
Corticosteroid use	Agresta et al., 2000 [50, 51]	Italy	16

ASA: american anesthesiologists association score.
[a]Including converted and dead patients.
[b]APACHE II scores among survivors and nonsurvivors were 4 (0–21) and 15 (6–24), respectively [65].
[c]Prognostic factor proposed by Boey [65, 77]. Counted as the sum of Boey risk factors the patient meets: shock on admission, ASA III-IV° score, prolonged perforation time >24 hours. Boey score predicts the outcome. Patients with no risk factors (score 0) result in 17.4% morbidity and 1.5% mortality rates; score 1, 30.1% morbidity and 14.4% mortality rates; score 2, 42.1% morbidity and 32.1% mortality rates: score 3, mortality rate 100%.

patients [38]. However, one was small with only 5 patients [75].
2. Identical operations were performed, but omentopexy and sutureless fibrin glue repair were more common (three studies).
3. The operating time is shorter (i.e., 72 minutes).
4. The overall morbidity rate is marginally lower (i.e., 6%).
5. The median conversion rate is higher (i.e., 15%).
6. The median postoperative mortality rate is higher (i.e., 3%).
7. The hospital stay is shorter: median 5 days.
8. Laparoscopic repair is safe and effective; sutureless fibrin glue repair is advocated; the importance of further studies to define the risk factors and more exact indications for laparoscopic perforated duodenal ulcer repair is emphasized.

To summarize, the early results of retrospective and prospective studies differ somewhat. The better results in prospective studies most likely reflect better preparation. On the other hand, the conclusions are the same.

Benefits of Laparoscopic Repair

Mouret et al. first performed laparoscopic sutureless fibrin glue omental patch for perforated duodenal ulcer repair in 1990 [60]. In 1990, Nanthanson et al. first described a successful laparoscopic perforated peptic ulcer suture repair [76, 77]. Soon after that the laparoscopic approach came into widespread use.

There are many publications showing the feasibility and efficacy of laparoscopic perforated duodenal ulcer repair [3, 18, 22, 40, 45, 49–51, 56, 67, 78–83]. The following conclusions were made after a recently published meta-analysis by Lau [36] comparing open and laparoscopic repair: Laparoscopic repair resulted in lower postoperative analgesic use, lower wound infection and mortality, but higher reoperation rates [36]. Other benefits, such as better cosmesis due to the nature of minimal access, were noted. It is also believed that there were fewer postoperative adhesions and incisional hernias after laparoscopic repair [2]. Most trials reported longer operating time's in the laparoscopic repair group[39, 49, 56]. However, a randomized prospective study performed by Siu et al. revealed that the operating time for laparoscopic repair is statistically significantly shorter than for open repair [39], pointing to the development of modern irrigation systems and the increase in surgeons' experience in laparoscopic surgery that has led to a shorter operating time for laparoscopic repair versus open repair. Other authors supported these findings as well [49, 56]. All studies showed that the length of hospital stay following laparoscopic repair was either shorter or equal to that after conventional repair [36]. The difference was statistically significant in three studies [39, 49, 56]. The time of return to work favored laparoscopic repair as well [39, 49, 56]. Most studies also reported that the patient's subjective well-being was better after laparoscopic repair [2]. However, the advantages of laparoscopic repair here are not as obvious as for laparoscopic cholecystectomy because the surgery is performed in the presence of peritonitis.

Preoperative Risk Factors for Laparoscopic Repair

A number of risk factors are associated with unsuccessful laparoscopic repair. Both retrospective (Table 3) and prospective (Table 4) studies report similar findings. Eight factors are accentuated.

1. Shock on admission (defined as arterial systolic blood pressure < 80 to 100 mmHg)
2. Delayed presentation (>24 hours)
3. Underlying severe medical illness
4. Older age: > 70 (75) years
5. American Society of Anesthesiologists (ASA) III to IV
6. Acute Physiology, Age and Chronic Health Evaluation (APACHE) II = 5

Table 4. Risk factors for postoperative morbidity after laparoscopic perforated duodenal ulcer repair: data of prospective studies.

Risk factor	Author, year	Country	No. of patients[a]
Duration of perforation >24 hours	Siu et al., 2004 [81]	Hong Kong	172
	Siu et al., 2002 [39]	Hong Kong	63
	Katkhouda et al., 1999 [49]	USA	30
	Druart et al., 1997 [3]	Belgium	100
	Lau et al., 1996 [57]	Hong Kong	48
	Lau et al., 1995 [58]	Hong Kong	56
Shock	Siu et al., 2004 [81]	Hong Kong	172
	Mehendale et al., 2002 [56]	India	34
	Katkhouda et al., 1999 [49]	USA	30
	Druart et al., 1997 [3]	Belgium	100
	Lau et al., 1996 [57]	Hong Kong	48
	Lau et al., 1995 [58]	Hong Kong	56
Underlying medical illness	Mehendale et al., 2002 [56]	India	34
	Druart et al., 1997 [3]	Belgium	100
	Lau et al., 1996 [57]	Hong Kong	48
	Lau et al., 1995 [58]	Hong Kong	56
Ulcer size >10 mm	Siu et al., 2004 [81]	Hong Kong	172
	Siu et al., 1997 [47]	Hong Kong	33
Age > 75 years	Siu et al., 2002 [39]	Hong Kong	63
> 70 years	Druart et al., 1997 [3]	Belgium	100
APACHE II score ≥5 points	Lee et al., 2001 [38]	Hong Kong	201[b]
	Robertson et al., 2000 [20]	Australia	20
	Lau et al., 1996 [57]	Hong Kong	48
	Lau et al., 1995 [58]	Hong Kong	56
Boey score	Siu et al., 2002 [39]	Hong Kong	63
ASA III-IV	Siu et al., 2004 [81]	Hong Kong	172
	Siu et al., 2002 [39]	Hong Kong	63
	Robertson et al., 2000 [20]	Australia	20
	Druart et al., 1997 [3]	Belgium	100
Cocaine use	Katkhouda et al., 1999 [49]	USA	30
Corticosteroid use	Druart et al., 1997 [3]	Belgium	100

[a]Including converted and dead patients.
[b]Suture leak risk.

7. Boey score
8. Expertise in laparoscopic surgery

Up to 20% of patients presenting with perforated duodenal ulcer are in shock on admission [2, 3, 49]. Kathouda et al. [49] demonstrated that patients with shock had worse outcomes if compared to those without shock. About 2% to 33% of patients have ASA III or IV evaluation on admission [40, 41]. Underlying medical illness (e.g., respiratory or cardiovascular insufficiency, liver cirrhosis, morbid obesity) is considered a risk factor for laparoscopic repair. Although the Boey score was originally proposed for risk stratification in patients undergoing open repair for perforated duodenal ulcer [84], the Boey score and its variables are proposed to be valid for risk stratification in patients undergoing laparoscopic repair as well [74]. Boey evaluation can have four distinct degrees: 0, 1, 2, or 3. The Boey score is counted as the sum of Boey risk factors: shock on admission (defined as systolic blood pressure < 90 mmHg), severe medical illness (defined as ASA III–IV), and delayed presentation (defined as duration of symptoms > 24 hours). Postoperative mortality rates of patients with various Boey scores undergoing laparoscopic perforated duodenal ulcer repair are as follows: 0 to 1.5%, 1.0% to 14.4%, 2.0% to 32.1%, 3.0 to 100% [74]. Few studies have been conducted regarding the potential of APACHE II in predicting the outcome in patients undergoing laparoscopic peptic ulcer repair [85]. However, APACHE II is difficult to apply in practice because of the multitude of factors and the difficulty calculating the score [86]. The surgeon's laparoscopic expertise (which unfortunately is difficult to measure in figures) is also one of the most important factors influencing the outcome. That is why it should also be taken into account when choosing the method of approach [2, 58].

On the other hand, the above-mentioned risk factors would also predict an unfavorable outcome in patients undergoing open repair [87, 88]. However, so far there is not sufficient information regarding the outcome following laparoscopic repair in high risk surgical patients. The proposed risk factors (e.g., Boey score, APACHE II) for perforated peptic ulcer affect the outcome after both open and laparoscopic repair. However, the outcome might still be improved by taking (or avoiding) one of the alternative interventions (laparoscopic or open). This question remains to be answered. In the mean time, surgical centers [49] suggest choosing the better mastered open repair for high risk patients, although there is no evidence that it is a better option in this category of patients. Keeping this statement in mind, the Boey score is employed to select patients for laparoscopic repair. Thus, for patients having no Boey risk factors (prolonged perforation >24 hours, shock on admission, and confounding medical condition defined as ASA III–V), laparoscopic repair should be the procedure of choice [36].

Conversion

Surgeons fail to complete the laparoscopic repair for perforated duodenal ulcers rather often. In these cases, patients undergo conversion from laparoscopic to open repair. As mentioned previously, the conversion rate in retrospective studies varies

Table 5. Predictive factors of increased rate of conversion (failure of laparoscopic repair): data from retrospective studies.

Risk factor	Authors, year	Conversion	Conversion due to risk factor	Rate (%)
Inadequate ulcer localization	Lee et al., 2001 [74]	56	20	35
	Agresta et al., 2000 [50, 51]	1	1	100
	Naesgaard et al., 1999 [40]	5	4	80
	Bergamaschi et al., 1999 [41]	4	3	75
	So et al., 1996 [18]	1	1	100
Large perforation size	Lee et al., 2001 [74]	56	26	47.0
	Matsuda et al., 1995 [67]	3	1	33.3
Posterior ulcer location	Bergamaschi et al., 1999 [41]	4	1	25.0
	Matsuda et al., 1995 [67]	3	1	33.3%
Postoperative adhesions	Seelig et al., 2003 [68]	3	1	33.3
	Matsuda et al., 1995 [67]	3	1	33.3
Boey score	Lee et al., 2001 [74]	56		
0 Point		—	—	21.4
1 Point		—	—	30.2
2 Points		—	—	81.8

Table 6. Predictive factors of increased rate of conversion (failure of laparoscopy): data from prospective studies.

Risk factors	Authors, year	Conversion	Conversion due to risk factor	Rate (%)
Perforation size				
> 10 mm	Siu et al., 2004 [81]	37	29	78
> 10 mm	Siu et al., 2002 [39]	9	2	22
> 10 mm	Lee et al., 2001 [38]	48	22	46
> 10 mm	Siu et al., 1997 [49]	5	2	40
> 6 mm	Katkhouda et al., 1999 [49]	5	3	60
	Lau et al., 1996 [57]	6	4	66
	Lau et al., 1996 [57]	3	2	66
	Lau et al., 1995 [58]	6	3	50
Inadequate ulcer localization	Siu et al., 2004 [81]	37	3	8
	Siu et al., 2002 [39]	9	3	33
	Lee et al., 2001 [38]	48	15	31
	Robertson et al., 2000 [20]	2	1	50
	Druart et al., 1997 [3]	8	4	50
Shock	Siu et al., 2004 [81]	37	1	3
	Katkhouda et al., 1999 [49]	5	2	40
	Lau et al., 1996 [57]	3	1	33
	Lau et al., 1995 [58]	1	1	100
Bleeding	Siu WT et al., 2002 [39]	9	1	11
	Siu WT et al., 1997 [47]	5	1	20
Prolonged perforation > 24 hours	Katkhouda et al., 1999 [49]	5	5	100
Posterior ulcer localization	Druart et al., 1997 [3]	8	1	12.5
Inadequate, instruments	Druart et al., 1997 [3]	8	1	12.5
Abscess	Druart et al., 1997 [3]	8	1	12.5
Peripancreatic infiltration	Druart et al., 1997 [3]	8	1	12.5

[a]Suture closure.
[b]Sutureless fibrin glue repair.

from 0% up to 30% [22, 74], and in prospective studies up to 60% [75]. The results are presented in Tables 5 and 6, which summarize the most common risk factors for conversion. Prospective studies revealed more conversion predicting factors [3, 20, 38, 47, 49, 57, 58]. Conversion per se did not affect the morbidity or mortality [74]. However, Siu et al. [81] reported significantly worse outcome in the converted patients group. They explained that the high morbidity and mortality rates in the converted group were related to the large ulcer perforations and associated technical difficulties. Moreover, conversion leaves additional scars from trocar incisions, leads to increased cost of the operation, takes extra efforts, and potentially increases the operating time. That is why efforts should be made to predict the conversion and choose open repair instead of laparoscopy.

Inadequate ulcer localization is the most commonly reported reason for conversion [3, 18, 38–41, 50, 51], accounting for 31%–100% of all conversions [18, 38]. Large ulcer size is another commonly reported reason for conversion, resulting in 20% to 60% of all conversions [38, 39, 57, 58, 81]. This is reported in the prospective studies. However, there is no generally accepted opinion on what ulcer size should be considered critical for laparoscopic repair. Some authors advocate a perforation of > 10 mm [38, 39] as a critical ulcer size, whereas others place it at 6 mm diameter [49]. Other reported reasons for the remaining 4% to 11% of conversions are the following: infiltration and fragility of ulcer edges [2], perforation associated with bleeding [39, 72], and cardiovascular instability induced by pneumoperitoneum [2, 49, 72]. The first two factors are also related to progressing peritonitis, with a delay between the onset of symptoms and surgery being the

Table 7. Postoperative morbidity rate after laparoscopic perforated duodenal ulcer repair: data from retrospective studies.

Complication	Author	Patients	Complications	Complication rate (%)
Intraabdominal abscess	Lee et al., 2001 [74]	149 (109)[c]	2[a]	2[b]
	Lee et al., 2001 [74]	52 (46)[d]	4[a]	8[b]
	Naesgaard et al., 1999 [40]	25	1	4
	So et al., 1996 [18]	15	1	7
Suture leak	Seelig et al., 2003 [68]	24	1	4
	Lee et al., 2001 [74]	149 (109)[c]	17[a]	16[b]
	Lee et al., 2001 [74]	52 (46)[d]	3[a]	7[b]
	Naesgaard et al., 1999 [40]	25	1	4
Pulmonary/pleural	Seelig et al., 2003 [68]	24	1	4
	Agresta et al., 2000 [50, 51]	16	1	6
	Begamaschi et al., 1999 [41]	17	1	6
	Naesgaard et al., 1999 [40]	25	4	16
Prolonged ileus	Lee et al., 2001 [74]	149 (109)[c]	3[a]	3[b]
	Lee et al., 2001[74]	52 (46)[d]	3[a]	6[b]
	Bergamaschi et al., 1999 [41]	17	1	6
Fistula	Agresta et al., 2000 [50, 51]	16	1	6
Bleeding	Agresta et al., 2000 [50, 51]	16	1	6

[a]Only successful laparoscopic repair cases included.
[b]Only successful laparoscopic repair and survived cases included.
[c]Sutureless fibrin glue repair.
[d]Suture repair.

main reason [49]. Posterior duodenal ulcer perforation is reported to be the cause of conversion in 12.5% to 33.0% of cases by both retrospective and prospective studies [3, 67]. Failure of laparoscopic repair and increased risk of conversion are predicted by shock on admission (conversion rate of 50% in patients with shock versus 8% in those without shock on admission), delayed presentation for > 24 hours (conversion rate of 33% in patients with delayed presentation versus 0% in those without it) [49]. Conversion can also be predicted by the Boey score. The conversion rate increases with increasing Boey scores: 1, 2, and 3 points result in 21.4%, 30.2%, and 81.8% conversion rates, respectively [74].

As one might have noted, some information regarding the proposed risk factors (especially inadequate ulcer localization, large ulcer size, infiltration and fragility of ulcer edges, concomitant ulcer bleeding) is not available during the preoperative period, so these factors are not as helpful in preventing the conversion by choosing the open repair from the beginning. On the other hand, an arbitrarily chosen cutoff value for the ulcer size (as described by Siu et al. [39]) might potentially save time and efforts while trying to close the ulcer laparoscopically before the decision is made to convert. On the other hand, if the surgical skills are mastered and one is able to close the perforation laparoscopically, no matter how large it is, the knowledge that the ulcer size does not influence morbidity/mortality would justify the laparoscopic closure of huge ulcers. Two recently published articles [66, 89] proposed routine preoperative use of endoscopy prior to performing laparoscopy to identify the localization and the size and properties of the perforated ulcer, rather than invoking extensive exploration through the laparoscope when omentum and other structures may be adherent to the site of perforation in an abdomen affected by peritonitis. This potentially might reduce the conversion rate, although it still needs to be proved.

Postoperative Complication Rate

The outcome results of retrospective (Table 7) and prospective (Table 8) studies are similar. The same complications are reported, and the differences in the rates are minor.

Postoperative suture leak is one of the most common complications (i.e., 1.5–16%); actually, however, the suture leak rate of 16% is reported only in laparoscopic sutureless fibrin glue repair patients [38, 74]. In other groups, the suture leak rates are much smaller, averaging around 5%. Lee et al. clarified that APACHE II (5 points) and ulcer size (> 10 mm) were independent risk factors predicting increased risk for postoperative leak for laparoscopic sutureless fibrin glue repair [38].

Other commonly reported complications are as follows: pneumonia, which is most likely related to pneumoperitoneum; intraabdominal abscess formation; prolonged dynamic ileus; external fistula, and bleeding. In Naesgard's study, infectious complications of the lung and pleura were diagnosed in 4 of 25 patients (i.e., 16% of all patients) [40]. Intraabdominal abscess complicates 0% to 9% of patient's recovery [58]. Abscess could be related not only to the extent of infectious abdominal contamination but also to postoperative duodenal suture leak. Trials on animals proved that carbon dioxide pneumoperitoneum increases the risk of bacteremia and sepsis by increasing intraperitoneal pressure. The mechanism is still not clear, although it is considered to be related to increased bacterial translocation from the peritoneal cavity into the bloodstream [90–92]. This is substantiated by the following conclusions of experimental studies. First, trials on rabbits revealed that bacteremia, endotoxemia, and the risk of sepsis are the same in both laparoscopic and open surgery groups if the duration of preoperative peritonitis was 1 hour [91]. Second, trials on mice revealed that pneumoperitoneum increases the risk of infections in case of prolonged peritonitis (> 12 hours) [91]. However, evidence-based clinical data are lacking regarding the relation between pneumoperitoneum and infectious complications [20]. Navez et al. conducted a study comparing outcomes in patients with peritonitis who underwent laparotomy or laparoscopy [93]. Their study evaluated 231 patients (69 of whom had peritonitis due to perforated peptic ulcer) and concluded that laparoscopy is safe and feasible in cases of peritonitis. Although the Naesgaard et al. trial reported that the rate of pneumonia was increased in the laparoscopic repair group compared to the open repair group [40], the duration of symptoms could not affect the

Table 8. Postoperative morbidity rate after laparoscopic perforated duodenal ulcer repair: data from prospective studies.

Complication and author	Patients[a]	Complications (no.)	Complication rate[a] (%)
Suture leak			
Siu et al., 2004 [81]	172	6	3
Siu et al., 2002 [39]	63	1	1.5
Lee et al., 2001 [38]	149 (109)[C]	17[a]	16[b]
Lee et al., 2001 [38]	52 (46)[d]	3[a]	6[b]
Robertson et al., 2000 [20]	20	1	5
Khoursheed et al., 2000 [22]	21	1	5
Druart et al., 1997 [3]	100	2	2
Siu et al., 1997 [47]	33	1	3
Lau et al., 1996 [57]	24[c]	1	4
Lau et al., 1995 [58]	21[c]	1	5
Lau et al., 1995 [58]	35[d]	1	3
Intraabdominal abscess			
Siu et al., 2002 [39]	63	2	3
Lee et al., 2001 [38]	149 (109)[c]	—	—
Lee et al., 2001 [38]	52 (46)[d]	—	—
Kathouda et al., 1999 [49]	30	2	7
Druart et al., 1997 [3]	100	3	3
Lau et al., 1996 [57]	24[d]	2	8
Lau et al., 1995 [58]	21[c]	0	0
Lau et al., 1995 [38]	35[d]	3	9
Pulmonary/pleural			
Siu et al., 2004 [81]	172	1	1
Lee et al., 2004 [66]	29	1	3
Lee et al., 2001 [38]	149 (109)[c]	—	—
Lee et al., 2001 [22]	52 (46)[d]	—	—
Khoursheed et al., 2000[22]	21	2	7
Kathouda et al., 1999[22]	30	1	3
Druart et al., 1997 [3]	100	4	4
Lau et al., 1996 [57]	24[c]	2	8
Lau et al., 1996 [57]	24[d]	1	4
Lau et al., 1995 [58]	21[c]	0	0
Lau et al., 1995 [58]	35[d]	1	3
Prolonged ileus			
Lee et al., 2004 [81]	29	2	7
Siu et al., 2002 [39]	63	1	1.5
LeeFYJ et al., 2001 [38]	149 (109)[d]	—	—
LeeFYJ et al., 2001 [38]	52 (46)[d]	—	—
Kathouda et al. 1999 [49]	30	2	7
Lau et al., 1996 [57]	24[c]	2	8
Lau et al., 1996 [57]	24[d]	1	4
Lau et al., 1995 [58]	21[c]	1	5
Lau et al., 1995 [58]	35[d]	2	6
Bleeding			
Druart et al., 1997 [3]	100	2	2
Lau et al., 1995 [58]	21[a]	1	5

[a]Only successful laparoscopic repair cases included.
[b]Only successful laparoscopic repair and survived cases included.
[c]Sutureless fibrin glue repair.
[d]Suture repair.

results because it was comparable in the two groups. Despite the empiric data that laparoscopy is safe even in the case of bacterial peritonitis [20, 93, 94], further randomized comparative studies are needed to evaluate the true benefits and risks of laparoscopic perforated duodenal ulcer repair in patients with bacterial peritonitis [40, 41, 95]. It is worth recalling that increased intraabdominal pressure induced by pneumoperitoneum can be avoided by the abdominal wall-lifting method, although this technique [96] is not widely accepted so far [97].

Conclusions

1. Laparoscopic repair is the procedure of choice in patients with no Boey risk factors; open repair might be a safer alternative in high risk patients, at least until more data state that the reverse is true.
2. Boey risk factors—shock, delayed presentation > 24 hours, underlying medical illness, elderly age (> 70 years)—must be considered preoperative risk factors for laparoscopic perforated duodenal ulcer repair.
3. Derived risk factors, such as the APACHE II and Boey scores, should be considered preoperative risk factors having the potential to predict the outcome of laparoscopic repair [97].
4. Inadequate ulcer localization, large perforation size (some authors state > 6 mm and others >10 mm), and fragile ulcer edges should be considered risk factors for laparoscopic repair; if the patient has any of the above-mentioned risks, a laparoscopic operation should be converted to open repair.
5. Suture leak, infectious lung and pleura complications, intraabdominal abscesses, and prolonged dynamic ileus are the most commonly reported complications of laparoscopic repair. Thus meticulous irrigation of the peritoneal cavity is necessary.
6. Laparoscopic sutureless fibrin glue repair should have strict patient selection criteria; otherwise morbidity approaches high rates (6–25%), although the mortality remains the same (3–8%).

7. It must be noted that patients are more likely to benefit from laparoscopic repair only after sufficient laparoscopic expertise is gained by their surgeons.

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