Duodenal ulcer perforation: A systematic literature review and narrative description of surgical techniques used to treat large duodenal defects

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BACKGROUND: There is no consensus on optimal surgical treatment of large duodenal defects arising from perforated ulcers, even though such defects are challenging to repair and inadequate repair is associated with high morbidity and mortality. The aim of this study was to carry out a systematic literature review of different surgical techniques used to treat large duodenal perforations, provide a narrative description of these techniques, and propose a framework for approaching this pathology.

METHODS: PubMed/MEDLINE database was searched for articles published in English between January 1, 1970, and December 1, 2020. Studies describing surgical techniques used to treat giant duodenal ulcer perforation and their outcomes in adult patients were included. No quantitative analysis was planned because of the heterogeneity across studies.

RESULTS: Out of 960 identified records, 25 studies were eligible for inclusion. Two randomized controlled trials, one case-control trial, three cohort studies, 14 case series, and 5 case reports were included. Eight main surgical approaches are described, ranging from simple damage-control operations, such as the omental plug and triple-tube techniques, all the way to complex resections, such as gastrectomy.

CONCLUSION: Evidence on surgical treatment of large duodenal defects is of poor quality, with the majority of studies corresponding to Oxford levels 3b-4. Current evidence does not support any single surgical technique as superior in terms of morbidity or mortality, but choice of technique should be guided by several factors including location of the perforation, degree of duodenal tissue loss, hemodynamic stability of the patient, as well as expertise of the operating surgeon. (*J Trauma Acute Care Surg.* 2021;91: 748–758. Copyright © 2021 Wolters Kluwer Health, Inc. All rights reserved.)

LEVEL OF EVIDENCE: SR with more than two negative criteria, Level IV.

KEY WORDS: Giant duodenal ulcer perforation; omental plug; triple tube technique; pancreas-preserving duodenal resection.

Giant perforated duodenal ulcers are an important cause of large duodenal defects and pose a particular surgical challenge, because they are unlikely to be successfully fixed by primary suture repair or omental patch repair, and outcomes are particularly poor if such a repair fails.[1,2] Compared with their regular counterpart, perforated giant duodenal ulcers are associated with higher morbidity and mortality, higher leak rates, and longer hospital stay.[3]

Some controversy exists with regard to the definition of "giant" duodenal ulcer, with most authors quoting an ulcer size larger than 2 cm, while Gupta et al.[3] suggest a size larger than 3 cm. For the purposes of this review, we define a giant duodenal ulcer perforation as any duodenal perforation which cannot be managed by conventional methods of repair because of the size of the perforation and extent of native tissue loss. These perforations constitute a distinct entity, which requires a different operative approach.[1] While most duodenal perforations are small and, therefore, can and should easily be addressed by suture closure or omental patch repair, the premise of this review is to address management of giant duodenal defects, which cannot be managed by these conventional repair methods.

Repair of large duodenal defects is challenging for several anatomical and pathological reasons.[4,5] Giant duodenal ulcer perforation is rare, and its incidence has been further reduced in recent decades through widespread use of proton-pump inhibitors, H2-receptor antagonists and *Helicobacter pylori* eradication.[6] Because this is a rare pathology, most surgeons will have very limited experience of managing such cases. The repair of giant duodenal perforations is technically demanding. This complexity paired with a lack of experience and the devastating consequences of inadequate repair makes this an important topic to review to familiarize oneself with available surgical solutions to this problem.

The aim of this study was to carry out a systematic review of the available literature on different surgical techniques used to treat giant perforations of the duodenum and their outcomes, as well as to provide a detailed narrative description of these techniques. We included all studies of surgical techniques used to treat large duodenal defects of peptic etiology in adult patients, which reported outcomes of the techniques in terms of morbidity, mortality, or length of stay. This review aims to set out the described techniques in order of ascending surgical complexity.

We propose a framework for dealing with large duodenal defects in terms of four aspects: First is the question of how to best close, repair, or resect the perforated or damaged duodenum; second, whether diversion of gastric and duodenal contents away from this repair is necessary and how this could be achieved; third, how and when to reconstruct gastrointestinal continuity if this has been disrupted; and finally, consideration of access to enteral feeding distally to the perforation in these complex patients. The final aim of this review is to assess each technique in terms of this framework.

METHODS

This systematic review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement.

A systematic literature search was performed by a single author (D.C.) on December 1, 2020. PubMed/MEDLINE database was searched using the following search terms: [(giant OR large OR major) AND duodenal perforation] OR [(giant OR large OR major) AND peptic perforation]. Articles published in English between January 1, 1970, and the search date were included.

Titles and abstracts were screened for inclusion based on the following criteria: we included all articles describing surgical techniques used to treat giant duodenal ulcer perforation and their outcome in patients older than 18 years. Studies on large duodenal

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defects arising from other etiologies, such as trauma or iatrogenic perforation, following endoscopic procedures were excluded, as were articles on gastric ulcers. Reoperations following failed suture or omental patch repair of giant duodenal ulcers were included but studies reporting results of simple suture repair or omental patching were excluded. Animal studies were excluded. Following screening, potentially relevant articles were obtained in full text and assessed for eligibility. Only articles published in full were included, with conference abstracts excluded. References of eligible articles were hand searched for missed studies.

One author (D.C.) extracted data from each article. Baseline characteristics extracted were author, year of publication, number of patients, patient age, patient sex, American Society of Anesthesiologists (ASA) grade/comorbidities, length of symptoms at presentation, and ulcer size. A description of each surgical technique was obtained, as were outcome variables, including operative time, length of stay, morbidity, mortality, and length of follow-up.

No quantitative synthesis or meta-analysis was planned as we expected to find studies with small numbers of patients and a high degree of heterogeneity. Risk of bias was assessed at study level.

RESULTS

Study Selection

Our study selection process is outlined in the flow diagram (Fig. 1). The search strategy identified 960 studies, which were screened for relevance based on their title and abstract. At this stage, 890 studies were excluded. Seventy articles were obtained in full text and assessed for eligibility. Forty-five full-text articles were excluded for the following reasons: eight articles were excluded because they did not state ulcer size, while in 16 studies the ulcers were not large. Two articles described surgical techniques for bleeding ulcers and two articles were case series for patients operated on for bleeding or perforation, which did not report outcomes separately. The giant ulcer was not perforated in one study and one study described perforation following endoscopic retrograde cholangiopancreatography. Three studies described suture repair or omental patching. Two studies did not report any outcome. Two studies were commentaries on original articles, one was an article describing a hypothetical technique and five were review articles on general management techniques of peptic ulcers. Two studies could not be obtained in full text. This left a total of 25 eligible studies which were included in our systematic review. Table 1 provides the extracted outcome variables for each of the 25 included studies. Table 2 provides an overview over how each of the described techniques addresses the four guiding principles of our framework as outlined in *Introduction*. Figures 2 and 3 provide an illustration of some of the described techniques.

Techniques

The Omental Plug

Four articles describe the use of an omental plug to close large perforated duodenal ulcers (Table 1). This technique was originally described by Karanjia et al.[7] in 1993. It involves insertion of a nasogastric tube (NG), the tip of which is guided through the

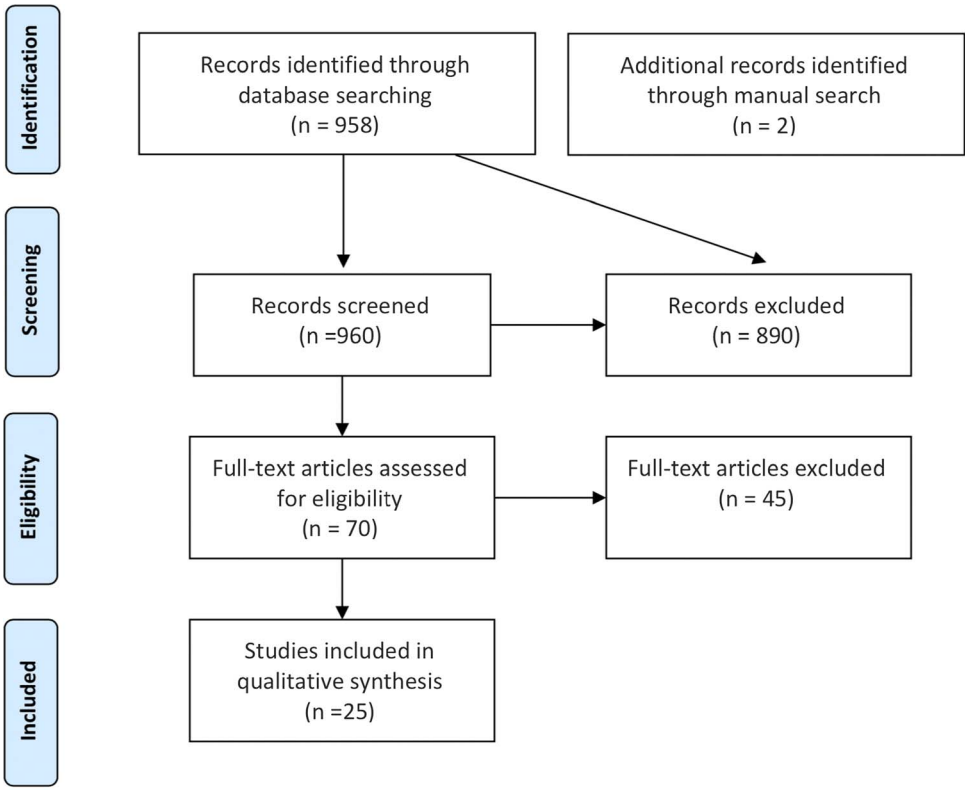

Figure 1. PRISMA flowchart of study selection. PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

perforation. The free edge of the greater omentum is subsequently sutured to the tip of the NG using absorbable sutures, and the tube is drawn proximally, pulling a plug of omentum into the duodenum sufficiently to occlude the perforation. Subsequently, interrupted sutures are taken between the omentum and healthy duodenum to secure the plug in place. The NG is removed 1 week later after dissolution of the sutures. The authors propose that the main advantage of this technique over a classic omental patch repair,[30,31] is that while a patch placed on the outside of the defect could be disturbed by a rise in intraluminal pressure, an omental plug is more likely to remain in continuous contact with duodenal mucosa.

In terms of outcomes of this technique, Jani et al.[2] published results of a prospective randomized-controlled trial of 100 patients with large (2–3 cm) perforated duodenal ulcers treated with classic omentopexy versus omental plugging and concluded that omental plugging had lower short- and long-term morbidities compared with standard omentopexy. The incidence of postoperative leak was significantly higher following omentopexy than following omental plugging (6 of 50 patients vs. none). All patients with postoperative leak required reoperation and subsequently died due to sepsis. While there was no statistically significant difference in mortality—eight patients (16%) following omentopexy and four patients (8%) following omental plug—the authors noted that all patients who died in the study group had presented following a delay of over 48 hours, while 6 of 8 mortalities in the control group had presented early. In a smaller, nonrandomized study, Mukhopadhyay et al.[8] noted a significant reduction in the rate of duodenal fistula formation following omental plug compared with omentopexy. The mean operating time was 108 minutes, with a mean postoperative length-of-stay of 8 days to 13 days.

Jani et al.[2] noted a higher rate of postoperative hemorrhage—most likely due to presence of an NG tube—in the omental plug group compared with controls. This complication may be avoided altogether by using the "free omental plug" as described by Sharma et al.[9] The authors suggest harvesting a piece of omentum and forming this into a mushroom shape by tying two sutures around its waist to create a "stalk," which is then pushed through the perforation and loosely tied in place. In their case series of seven patients with either giant duodenal ulcer perforations or failed patch repairs, they report one death. Although not specifically mentioning ulcer size, Sakamoto et al.[32] report the combined use of endoscopy and laparoscopy to fill a large perforated duodenal ulcer with omentum. The obvious disadvantage of this technique is that it requires the presence of an additional endoscopist, so may be difficult to perform out of hours and in resource-poor settings.

The main advantages of the omental plug technique are that it is simple, quick and should be accessible to any trainee or general surgeon who finds himself or herself in an emergency situation with a seriously ill patient.[2] While the abnormal duodenal segment is left *in situ*, omental plugs have been shown to eventually provide a near-normal duodenal mucosal surface.[33] This type of repair does not involve diversion or gastric or duodenal contents away from the repair and does not require restoration of gastrointestinal continuity at a later date.

Triple Tube Technique

Three articles[10–12] describe the use of the triple tube technique in the treatment of perforated giant duodenal ulcers, and several articles[13–15] describe modifications of this technique (Table 1). The triple tube technique involves Kocherisation of the duodenum, excision of the ulcer margins and primary closure of the duodenal perforation. Subsequently, three tubes are placed: First, an antimesenteric enterotomy is made in the jejunum approximately 15 cm distal to the duodenojejunal flexure and a retrograde duodenostomy tube is placed, allowing decompression of the duodenum and takes the tension off the primary repair. A second tube—an anterograde jejunostomy for feeding purposes—is passed via a second enterotomy 5 cm distal to the first. Finally, a gastrostomy tube is placed to reduce the secretion load passing into the duodenum. This technique does not require restoration of gastrointestinal continuity at a later stage.

Lal et al.[10] compared the outcomes of the triple tube technique in a prospective case-control study of 40 patients with giant duodenal ulcer perforations, half of which were managed by the triple tube technique (study group), while the other half underwent conventional omentopexy. At 30 days, there were 13 deaths (65%) in the control group, but only 1 death (5%) in the study group, and the groups were well-matched in terms of patient characteristics. The very high mortality rate in the control group was mainly attributed to the fact that 14 patients (70%) in the control group suffered leakage following repair requiring reoperation in eight patients, while there were no leaks following treatment with the triple-tube technique. Morbidity of this procedure was reported at 100% in both groups. Hospital stay was 12 days to 20 days for 19 of 20 patients in the study group, while all control group patients had hospital stays in excess of 25 days. However, any comparisons between these two groups should be made with caution, given the nonrandomized design and the use of nonconsecutive patients.

Ali et al.[11] report results of a retrospective case series of 34 patients treated with the triple-tube technique for giant perforated ulcers over a 10-year period and quote similar results, with a mortality rate of 5.8% and mean hospital stay of 18 days. Agarwal et al.[12] report a mortality rate of 20% (4 of 20 patients) and a mean hospital stay of 22 days in their prospective observational study of 20 patients treated with the triple tube technique.

Modifications to the triple tube technique have been cited in several articles: Katariya et al.[13] published a case report of a patient managed with a gastrostomy and duodenostomy. Kutlu et al.[14] successfully managed a patient with a giant duodenal defect following failed repair by placement of a duodenostomy and feeding jejunostomy, but diversion of contents away from the defect was achieved by means of pyloric exclusion—a method commonly used in the context of trauma.[4] Finally, Cranford et al.[15] described the technique of "gastric disconnection," which consists of truncal vagotomy, antrectomy, tube gastrostomy, duodenostomy, and jejunostomy.

Similar to the omental plug, the triple tube technique seems to be quick and simple and can be undertaken by any general surgeon treating an unwell patient in an emergency setting. However, it depends on the duodenal defect being amenable to primary closure. It also does not address concurrent problems, such as hemorrhage or gastric outlet obstruction, due to chronic scarring.

Gastric Body Partition

Two case series by Shyu et al.[16,17] describe the technique of gastric body partitioning for treatment of giant perforated peptic ulcer (Table 1). This technique involves simple closure

TABLE 1. Studies Included in Systematic Review of Different Surgical Techniques Used to Treat Giant Perforations of the Duodenum and Their Outcomes

Author (Year) (Reference Citation)	Study Type	Surgical Technique Described	No. of Patient (in Study Group)	Mean Age, y	Sex	Co-Morbidities	Ulcer Size (cm)	Length of Symptoms	Operative Time (Min)	Mortality	Complications	Length of Stay, d	Length of Follow-Up
Karanjia et al. (1993)[7]	Case series	Omental plug	3	—	—	—	>1	—	—	None (0%)	No leaks	8	6 wk
Jani et al. (2006)[2]	Prospective randomized controlled trial	Omental plug (vs. omentopexy)	50	39.2	88% male	20/50 (40%)	2–3	—	—	4/50 (8%)	No leaks 4/50 (8%) hemorrhage, no GOO* at 6 wk, 5/50 (10%) GOO* at 6 mo	8	5 y
Mukhopadhyay et al. (2011)[8]	Prospective nonrandomized controlled trial	Omental plug (vs. omentopexy)	10	52.5	100% male	4/10 (40%)	>2	24–48 h in 7/10 (70%) >48 h in 3/10 (30%)	108	1/10 (10%)	No fistula, no evidence of GOO* at 12 weeks, 2/10 (20%) wound infection 2/10 (20%) intra-abdominal abscess, 2/10 (20%) respiratory complications	12.6	12 wk
Sharma et al. (2000)[9]	Case series	Free omental plug	7 (3 of which redo after failed omental patch)	—	—	—	>2.5	48–72 h in 2/7 (29%) >7 d in 1/7 (14%)	—	1/7 (14%)	2/7 (29%) wound infection	—	—
Lal et al. (2009)[10]	Prospective case-control study	Triple tube (vs. omentopexy)	20	80% 30–50	80% male	100% had at least 1 comorbidity	60% 2–3, 40% >3	<48 h in 4/20, >48 h in 16/20	—	1/20 (5%)	No leaks, 4/20 (20%) Intra-abdominal sepsis, 8/20 (40%) wound infection, 8/20 (40%) pneumonia, 2/20 (10%) wound dehiscence	12–20 d in 19/20 patients, >20 ds in 1/20	—
Ali et al. (2018)[11]	Case series	Triple tube	34	51.5	71% male	100% had at least 1 comorbidity	≥2	>3 d in 26/34, >5 d in 7/34, >7 d in 1/34	—	2/34 (5.8%)	19/34 (56%) wound infection, 13/34 (38%) burst abdomen. 4/34 (12%) leak	18	—
Agarwal et al. (2017)[12]	Prospective observational cohort study	Triple tube	20	44.6	85% male	—	1.83	—	—	4/20 (20%)	9/20 (45%) wound infection, 4/20 (20%) respiratory complications, 6/20 (30%) peritubal leak or excoriation, 1/20 (5%) leak, 5/20 (25%) burst abdomen	22	—
Katariya et al. (1976)[13]	Case report	Duodenostomy + gastrostomy	1	70	100% male	—	2.5	7 d	—	None (0%)	—	—	—
Kutlu et al. (2013)[14]	Case series	Tube duodenostomy + feeding jejunostomy + pyloric exclusion	1	39	100% male	Hashimoto's encephalitis	>3	Redo operation after failed omental patch repair	—	None (0%)	None (0%) Patient transferred to long-term care facility due to neurological condition	—	—
Cranford et al. (1988)[15]	Case series	Gastric disconnection in 4/6 Antrectomy, vagotomy + Bilroth II in 2/6	6	55.2	50% male	—	2–6	1/4 gastric disconnection procedures was redo after failed repair	—	2/6 (33.3%), all patients following gastric disconnection survived	—	16.3	12–29 mo
Shyu et al. (2006)[16]	Case series	Gastric body partition	10	78.2	90% male	100% had at least 1 comorbidity	2.5–5	Mean 95.6 hours	123	1/10 (10%)	4/10 (40%) minor leakage, 2/10 (20%) wound infection, 1/10 (10%) recurrent anastomotic ulcer	—	3 y
Shyu et al. (2006)[17]	Case series	Gastric body partition	8	73.9	—	100% had at least 1 comorbidity	≥5	Mean 129 hours	—	None (0%)	3/8 (37.5%) minor leakage, 1/8 (12.5%) recurrent anastomotic ulcer	—	2 y
Gan et al. (2020)[18]	Case series	Duodenojejunostomy	4	67	50% male	Average Charlson Comorbidity Index of 3 (moderately severe)	2–3	—	—	None (0%)	1/4 (25%) pneumonia	10.75 d	—
Wong et al. (2004)[19]	Case series (of posterior perforations)	Billroth II gastrectomy in 1 patient Duodenojejunostomy in 1 patient	2 (of 9 patients with posterior perforation met inclusion criteria)	83 69	—	—	2.5 2	72 h < 24 h	—	1/1 (100%) 1/1 (100%)	—	—	—

Chaudhary et al. (1981)[1]	Case series	Serosal patch in 5/8 Catheter duodenostomy 2/8 Partial gastrectomy 1/8	8	45–70	86% male	—	1.2–1.7	—	—	3/8 (37.5%)	5/8 (62.5%) wound infection, 4/8 (50%) intra-abdominal abscess requiring reoperation in two cases, 1/8 (12.5%) bleeding duodenal ulcer	—	5 wk
Gupta et al. (2005)[3]	Retrospective cohort study	Serosal patch 5/10 Antrectomy 5/10	5 5	—	—	—	—	—	—	—	1/5 (20%) leak 1/5 (20%) leak	—	—
McIlrath et al. (1971)[20]	Case report	Pedicled graft	1	67	100% male	—	—	Several days	—	None (0%)	No major complications, readmitted 15 mo later with perforated ulcer at site of gastrojejunostomy	15	2.5 y
Di Saverio et al. (2018)[21]	Case series	Pancreas-preserving duodenal resection (D1 and D2)	10 (7 with peptic ulcers, 3 with other etiologies)	78	70% male	All ASA III or higher	D1/D2 only, >2	—	264	2/10 (20%)	5/10 (50%) cardiorespiratory complications (2 major, 3 minor) 1/10 (10%) anastomotic bleeding, 1/10 (10%) pancreatitis, 1/10 (10%) intra-abdominal collection 1/10 (10%) biliary leak around T-tube	17.8	—
Ntlhe et al. (2004)[22]	Case report	Antrectomy + truncal vagotomy + pancreaticoduodenostomy + gastrojejunosotmy	1	48	100% male	Heavy smoker and drinker	>2	—	—	None (0%)	—	—	7 mo
Di Saverio et al. (2020)[23]	Case report	Pancreas-preserving duodenal resection (total), reconstruction of neoduodenum with jejunal limb	1	60	100% male	—	Giant defect involving D2-D4	—	—	1/1 (100%)	1/1 (100%) necrotizing pancreatitis	—	21 d
Chan et al. (2019)[24]	Retrospective cohort study	Gastrectomy (vs. omental patch repair)	58	70	36.2% male	38/58 (65.5%) were ASA III or higher	>2	<24 hours in 23/58, >24 hours in 35/58	172.5	12/58 (20.7%)	10/58 (17.2%) intra-abdominal collection, 8/58 (13.8%) leak, 4/58 (6.9%) reoperation	13.5	
Kujath et al. (2002)[25]	Case series	Billroth II in 22/29, Billroth I in 4/29, atypical resection in 3/29	29	—	—	—	"Complicated perforated ulcer with destruction of proximal duodenum and penetration into adjacent organs"	—	—	5/29 (17.2%)	1/29 leak (3.4%), 2/29 (6.9%) pancreatitis, 2/29 (6.9%) pulmonary embolus, 2/29 (6.9%) pneumonia, 3/29 (10.3%) myocardial infarction	—	—
Kim et al. (2012)[26]	Case series	Laparoscopic distal gastrectomy + Roux-en-Y gastrojejunostomy + truncal vagotomy	5	59	60% male	3/5 heavy smokers, 2/5 hypertension, 1/5 diabetes	2–3	<24 hours in 2/5, 24–48 h in 2/5, >10 d in 1/5	202	None (0%)	1/5 (20%) wound infection	12.2	—
Nobori et al. (2016)[27]	Case report	Antrectomy + Billroth II with Braun anastomosis	1	25	100% male	Postoperative brainstem tumor resection	3.5	—	—	None (0%)	1/1 (100%)—leakage from gastrojejunostomy and jejunojejunostomy requiring reoperation for gastric disconnection D10, subsequent multiorgan failure (recovered in ITU)	—	8 mo
Nussbaum and Schusterman (1985)[28]	Case series	Truncal vagotomy + pyloroplasty 7/10 Truncal vagotomy + antrectomy + Billroth II 2/10 Truncal vagotomy + gastroenterostomy 1/10	10	59**	75% male**		>2	—	—	3/10 (30%)	41% morbidity**	—	41 mo

*Gastric outlet obstruction.
**Outcome given for whole case series not broken down by individual procedure.

TABLE 2. Review of Techniques to Treat Large Duodenal Defects With Respect to Proposed Framework

	Factor to Consider			
Surgical Techniques	**Treatment of Duodenal Defect**	**Diversion of Gastric/Duodenal Content**	**Reconstruction of Gastrointestinal Continuity**	**Enteral Feeding Access**
Omental plug	Plugging of defect with omentum	None	Not required	None
Triple tube technique	Primary closure	Gastrostomy and retrograde duodenostomy	Not required	Feeding jejunostomy
Gastric body partition	Primary closure	Gastric body partition with stapler	Gastrojejunal anastomosis at index operation	None
Duodenojejunostomy	Closure of defect with side-to-side anastomosis with jejunal loop	None	Not required	None
Serosal patch	Serosa-to-serosa closure of defect using loop of jejunum	Jejunojejunostomy	Jejunojejunostomy at index operation	None
Pedicled graft	Defect closed using pedicled jejunal graft	Gastrojejunostomy to partially bypass duodenum	Jejunojejunostomy at graft harvest site	None
Pancreas-sparing duodenal resection	Resection of damaged duodenal segment	Normal bile flow preserved	Roux-en-Y gastrojejunal anastomosis at index operation	Nasojejunal tube
Gastric resection	Resection of damaged duodenal segment	Normal bile flow preserved	Billroth II at time of index operation in majority of cases	None

of the perforation followed by partition of the gastric body with a linear stapler 2 cm proximal to the angular incisura. To restore gastrointestinal continuity, gastrojejunostomy is performed, and a duodenostomy tube was inserted for biliary drainage. The authors stress that dividing the stomach in the gastric body as opposed to the antrum will avoid the occurrence of hypergastrinemia. In two case series of elderly patients with a good length of follow-up (2–3 years), they report a combined mortality of one in 18 patients (5.6%) as well as no major short-term complications. While minor leakage occurred in seven out of 18 (38.9%) of patients, this was managed conservatively in all cases.

Gastric body partition is similar to the triple tube technique in that it is reliant on the primary defect being amenable to simple closure, but the diversion of gastrointestinal content is permanent and achieved by simple stapling, which is much more straightforward than any form of resection but more complex than placing a gastrostomy tube. This technique requires formation of a gastrojejunal anastomosis at time of initial surgery so that oral intake can be resumed.

Duodenojejunostomy

Two articles[18,19] describe the use of a duodenojejunostomy in the repair of giant duodenal perforations. In this technique, the perforation site is identified and extended into the pylorus to minimize risk of subsequent gastric outlet obstruction. Subsequently, a loop of jejunum is brought up in retrocolic fashion and a hand-sewn side-to-side duodenojejunostomy performed. In a small case series of four patients, Gan et al.[18] report no mortalities and one case of postoperative pneumonia, with an average length of stay of 11 days. The main appeal of this technique is its relative simplicity and in theory use of a single anastomosis.

Serosal Patches

Two[1,3] articles present cases of giant duodenal ulcer perforation managed by jejunal serosal patches. This technique—originally described in animal models[34–36]—involves bringing a loop of jejunum approximately 40–60 cm distal to the ligament of Treitz over the colon and using this to close the perforation site serosa-to-serosa. A diverting jejunojejunostomy is fashioned.

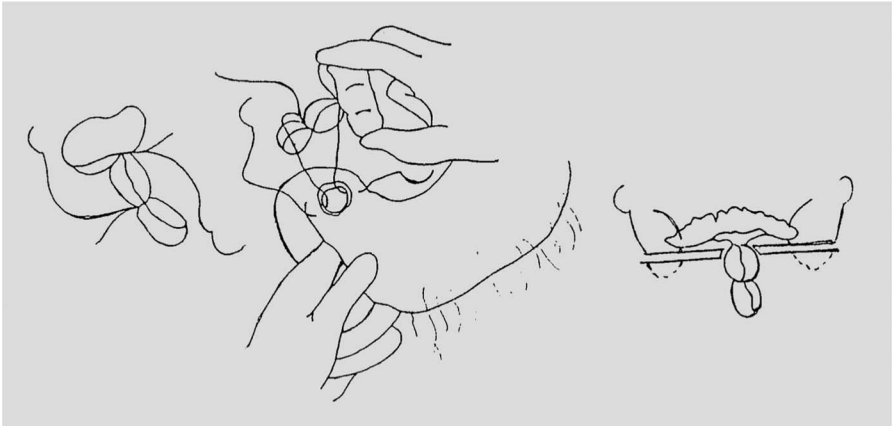

Figure 2. Free omental plug technique described by Sharma et al.[9] Copyright © 2000, S. Karger AG, Basel. Reproduced with permission from the publisher. This is a modification of the omental plug technique used to treat giant duodenal defects. A piece of omentum is harvested and a stalk created by tying two sutures around its base, which is then pushed through the perforation and loosely tied in place.

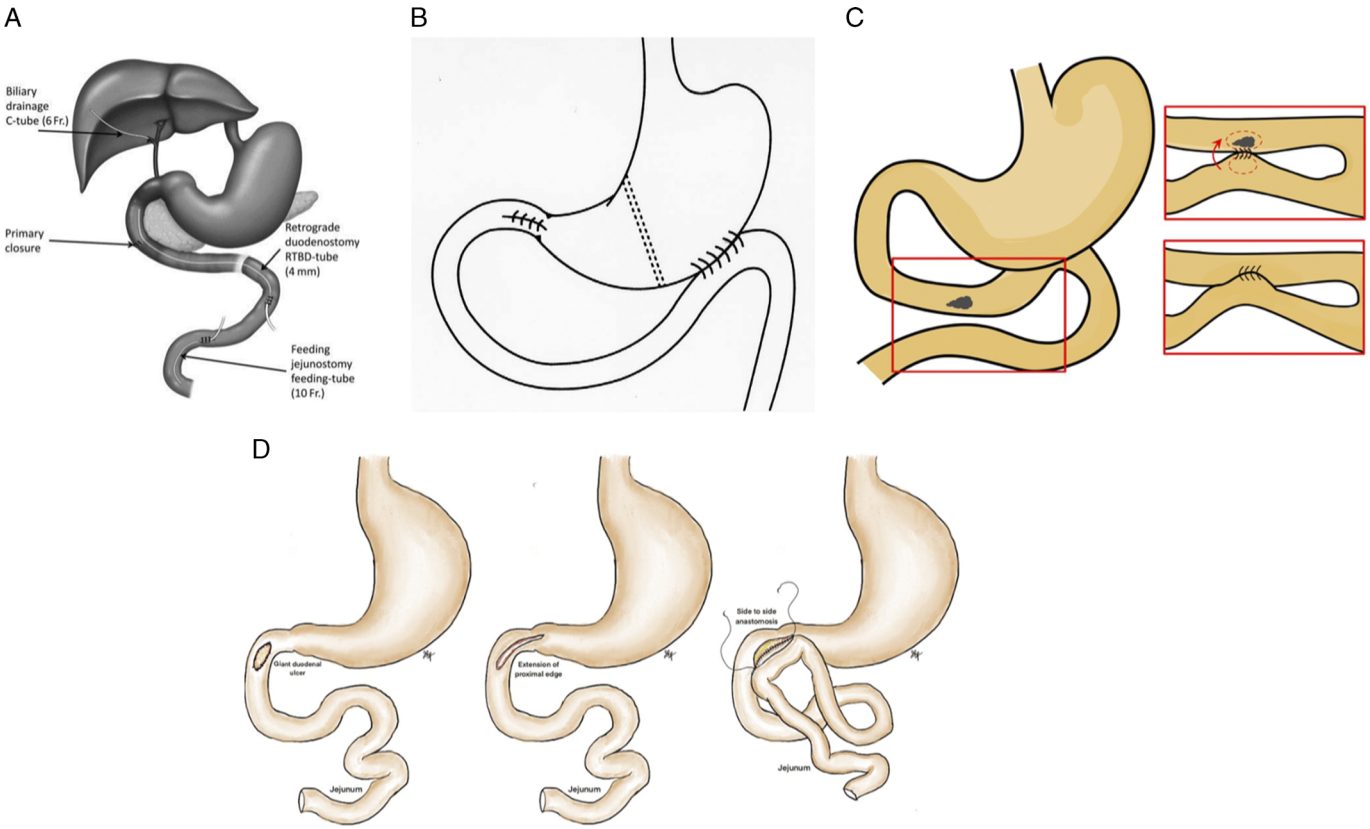

Figure 3. This figure illustrates four of the techniques used to close large duodenal defects. (*A*) In the triple tube technique,[18] the duodenal defect is closed primarily and three tubes are placed. A gastrostomy to reduce secretion load passing into the duodenum, a retrograde duodenostomy to take tension off the repair, and a jejunostomy for feeding purposes. (*B*) During gastric body partition,[17] the duodenal defect is closed primarily and gastric content diverted by partition of the gastric body with a stapler. Gastrointestinal continuity is restored via gastrojejunostomy. (C) The serosal patch technique describes closure of the duodenal defect serosa-to-serosa using a loop of jejunum. (*D*) Duodenojejunostomy[29] can be used to close large duodenal defects by fashioning a side-to-side duodenojejunal anastomosis encompassing the perforation site.

A case series by Chaudhary et al.[1] on eight patients with large duodenal ulcer perforations, five of whom were treated by a jejunal serosal patches, cites a total 30-day mortality of three in eight patients (37.5%) and a four in eight (50%) incidence of intra-abdominal abscess requiring reoperation in half of cases. Unfortunately, the outcomes in this case series were not broken down by type of procedure, so it is difficult to make a direct comparison with other techniques.

In terms of our framework, this technique aims at closing the duodenal defect by covering it with a serosal patch and over time, duodenal mucosa has been shown to spread over the serosal surface.[37] Serosal patching may produce duodenal stenosis or obstruction if used for larger defects and its use is only recommended if half to two thirds of the duodenal wall remain intact. A jejunojejunostomy is used for diversion, and therefore, restoration of gastrointestinal continuity at a later date is not required.

Pedicled Grafts

The use of a pedicled jejunal graft to repair a large duodenal defect from perforated ulcer is described in a case report by McIlrath et al.[20] The authors carried out resection of a short segment of jejunum including its mesentery approximately 20 cm distal to the ligament of Treitz. This pedicled graft was brought through the transverse mesocolon, opened longitudinally along the antimesenteric border and trimmed to cover the duodenal defect, prior to anastomosis. This technique required a distal end-to-end jejunojejunostomy at the site from which the graft was taken and additionally, the authors completed a gastrojejunostomy to partially bypass the duodenum. The patient recovered without any major complications and was discharged on post-operative day 15, but represented 15 months later with peptic perforation from the gastrojejunostomy.

The use of pedicled grafts may be beneficial in situations where there is little healthy duodenal tissue left, as a pedicled graft can allow for transfer of more healthy tissue to the damaged duodenum, for example, where use of a serosal patch may produce significant narrowing. However, this technique is complex, requires several anastomoses, and there are very few case reports describing its outcomes.

Pancreas-Preserving Duodenal Resection

Di Saverio et al.[21] recently presented a case series of 10 consecutive patients (seven of whom had perforated giant duodenal ulcers) treated with pancreas-sparing, ampulla preserving

duodenectomy for injuries to D1/D2 proximal to the ampulla of Vater. This technique involves Kocherisation of the duodenum, cholecystectomy, and placement of a transcystic tube, which is progressed down the common bile duct and into the duodenum to allow anatomical correlation of the perforation to the location of the ampulla. Distal gastrectomy is carried out, which allows flipping of the specimen and dissection of the proximal duodenum off the pancreas. An articulated endostapler is used tangentially across healthy duodenum proximal to the ampulla. Gastrointestinal continuity is restored with a Roux-en-Y gastrojejunostomy, and external biliary drainage is achieved with the transcystic tube. This technique bears similarity to a case report by Ntlhe et al.[22]

In terms of intraoperative outcomes, the authors report a mean operative time of 4 hours, with one resection undertaken laparoscopically. Mean hospital stay was 17.8 days, and this technique had a 20% (two of 10 patients) mortality, with 90% morbidity.

In a further case report,[23] the authors describe a technique for performing a pancreas-sparing total duodenectomy in a patient with a giant duodenal defect involving D2, D3, and D4 secondary to duodenal ulcer perforation. Following initial damage-control surgery, the patient was taken for a pancreas-sparing total duodenectomy with distal gastrectomy the following day. Transcystic cannulation was used to identify and protect the ampulla. Biliary reconstruction was undertaken with an ampullary-jejunal anastomosis in which a free jejunal loop was interposed around the pancreas, thus creating a neoduodenum. Intestinal continuity was restored with a Roux-en-Y gastrojejunal anastomosis and enteroenteral anastomosis between the biliary and alimentary limbs. The patient died on the 21st post-operative day from necrotizing pancreatitis.

The advantages of these techniques include resection of the damaged segment of duodenum with preservation of normal flow of bile into the remaining duodenum or neoduodenum. Resection—as opposed to simple closure—of the duodenal defect has been associated with reduction in ulcer recurrence at 5 years.[38] While complex compared with the previous techniques described, they allow for definitive management and may be used in extensive injuries otherwise requiring pancreaticoduodenectomy—a procedure that should be avoided in the emergency setting at all costs.[39]

Gastric Resection

Several articles[1,3,15,19,24–28] present outcomes following gastric resections for large perforated duodenal ulcers, with the most common resection being Billroth II, but Billroth I and atypical resections also cited in the literature.

In a retrospective cohort study of 58 patients undergoing gastrectomy for large peptic perforations, Chan et al.[24] note a mortality rate of 20.7% (12 of 58 patients), with 10 of 58 patients (17.2%) suffering from a postoperative intra-abdominal collection, eight out of 58 patients (13.8%) found to have a leak and four out of 58 (6.9%) requiring reoperation. The mean operation time for this procedure was found to be approximately 3 hours, with a mean hospital stay of 13.5 days. Kujath et al.[25] report a case series of 29 patients, the majority of which underwent Billroth II resection for complicated duodenal ulcer perforation and cite a similar mortality rate of 17.2% (five out of 29 patients), but only one patient (3.4%) suffering from a leak.

Kim et al.[26] describe successful laparoscopic management of perforated giant duodenal ulcers in a series of five patients, but it must be noted that the operating surgeon in this case series had extensive experience with laparoscopic gastric resection in the context of malignancy prior to attempting the procedure in the context of perforated giant duodenal ulcer, so this is unlikely to be applicable in the out-of-hours emergency setting in less experienced hands.

DISCUSSION

In summary, we carried out a systematic review and narrative description of surgical techniques used to treat giant perforated duodenal ulcers. Database searching identified 960 records which were potentially eligible for inclusion, and 25 articles were included in the final review. The described techniques range from simple options, such as omental plugging or triple tube-ostomy all the way to the most complex resections. It is important to note that the techniques presented in this review have also been used in combination with each other and that the list presented here is not exhaustive, as some techniques described in the trauma literature could be transferable to the management of giant ulcers.

Overall, the main limitation of this review at study and outcome level is that the evidence-base surrounding surgical management of giant duodenal ulcer perforations is of poor quality. With only one prospective randomized controlled trial,[2] the vast majority of evidence comes from case reports or series as well as cohort studies, which represent levels of evidence 3b-4 according to the Oxford Centre for Evidence-based Medicine. Inherently, there is likely to be a high degree of selection bias confounding the results. No quantitative analysis can be carried out, as there is a large amount of heterogeneity across studies in terms of the patient groups studied and reported outcomes. Moreover, there is lack of data on long-term follow-up. Six articles included in this systematic review were case reports of individual patients and an additional four studies reported outcomes for five or fewer patients, making up 40% of studies in this systematic review. Because of the rarity of this pathology, cases from single institutions are often collected over many years to obtain sufficient numbers, which is problematic as any technique is unlikely to be applied consistently and there will be developments in peri-operative care over time which may have a larger impact on outcomes than the surgical technique itself. Studies included in this review were relatively old, with 10 of 24 studies published before 2005. While medical therapies for peptic ulcer disease have rendered acid-reducing surgery largely obsolete and there has been an advent of minimally invasive surgery, it should be noted that many of the techniques in this systematic review were successfully used and remained almost unchanged many decades after their original description. As giant duodenal defects remain more common in the developing world, the focus should not lie exclusively on newer or laparoscopic techniques.

At review level, while there may have been incomplete retrieval of identified research, we hope that our search strategy was broad and inclusive enough to identify most relevant studies.

Factor	Triple tube technique	Omental plug	Duodeno-jejunostomy	Gastric body partition	Serosal patch	Pedicled graft	Gastrectomy	Pancreas-sparing duodenal resection
Inexperienced surgeon	+++	+++	++	++	+	+	-	-
Large degree of duodenal tissue loss	-	+	+	-	+	++	+++	++
Haemodynamically unstable patient	+++	+++	++	++	++	+	-	-

Legend	
Most favourable	+++
	++
	+
Least favourable	-

Figure 4. Decision aid for selecting appropriate technique in surgery for perforated giant duodenal ulcers based on operative and situational factors. Eight surgical techniques identified from the systematic review are rated according to favorability in the following three circumstances: presence of an inexperienced surgeon, large degree of duodenal tissue loss, and hemodynamic instability of the patient.

Currently, there is no consensus on optimal surgical treatment of giant duodenal ulcer perforations. The World Society of Emergency Surgery guidelines[40] suggest using pancreas-sparing duodenectomy for ulcers in D1/D2. In perforations involving the ampulla, a definitive resectional approach is not recommended. Instead, the guideline favors damage-control options, such as pyloric exclusion (even though this technique is most widely described in the trauma literature and only one case report[14] describes its use in the context of ulcer perforation), gastric decompression, and external biliary drainage.

We suggest approaching the problem down into four distinct steps which require consideration: First is the question of how to best close, repair or resect the perforated or damaged duodenum; second, whether diversion of gastric and duodenal contents away from this repair is necessary and how this could best be achieved, third, how and when to reconstruct gastrointestinal continuity if this has been disrupted; and finally, consideration of access to enteral feeding distally to the perforation in these complex patients. Table 2 provides an overview over the extent to which the reviewed techniques address these four guiding principles and illustrates how the answer to each of the above questions will influence the next steps. Two of the techniques—the triple tube technique and gastric body partition—rely on the duodenal defect being amenable to primary closure, which may not be the case in some patients. Similarly, serosal patching and omental plugging require some of the duodenal wall to remain intact to be used, while resectional techniques, such as gastrectomy and pancreas-preserving duodenal resection, can deal with the largest degree of native tissue loss and inflammation. Therefore, the degree of native tissue loss and inflammation will preclude certain techniques from being used successfully. It is noteworthy that of all the reviewed techniques, only the triple tube technique and pancreas-sparing duodenal resection explicitly describe distal enteral feeding access. However, we would advise consideration of distal enteral access ideally in the form of a nasojejunal tube in all cases, as these patients are usually high risk and have often not been optimized preoperatively due to the emergency nature of their procedure.

This review presents an array of options and we present a decision aid on the situational and operative factors which may inform a choice between these techniques in Figure 4. Which technique to choose from this armamentarium will ultimately depend on several factors including location of the perforation (especially with respect to the ampulla), the degree of duodenal tissue loss, the degree of contamination, the hemodynamic stability of the patient at the time of surgery as well as the expertise of the operating surgeon. While current evidence does not support any single surgical technique as superior in terms of morbidity or mortality, what may matter more is good situational awareness allowing the general surgeon faced with a hemodynamically unstable patient to select one of the less complex techniques, while more complex resections can be undertaken by specialist surgeons in better circumstances. This article adds to the current literature by systematically and comprehensively reviewing all described techniques regarding the management of giant duodenal ulcer perforations and their outcomes so that clinicians have a reference framework if faced with this rare pathology. While there are severe limitations to the literature at study level, our proposed framework and decision aid can guide making an informed choice as to the best approach in any given situation.

AUTHORSHIP

D.C. carried out a systematic literature search. All authors contributed significantly to and were actively involved in the drafting, writing, and critical revision of the article and the final version was approved by all authors prior to submission.

DISCLOSURE

The authors declare no funding or conflicts of interest.

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