Complex penetrating duodenal injuries: Less is better

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BACKGROUND: The traditional management of complex penetrating duodenal trauma (PDT) has been the use of elaborate temporizing and complex procedures such as the pyloric exclusion and duodenal diverticulization. We sought to determine whether a simplified surgical approach to the management of complex PDT injuries improves clinical outcome.

METHODS: A retrospective review of all consecutive PDT from 2003 to 2012 was conducted. Patients were divided into three groups according to a simplified surgical algorithm devised following the local experience at a regional Level I trauma center. Postoperative duodenal leaks were drained externally either via traditional anterior drainage or via posterior “retroperitoneal laparostomy” as an alternate option.

RESULTS: There were 44 consecutive patients with PDT, and 41 of them (93.2%) were from gunshot wounds. Seven patients were excluded owing to early intraoperative death secondary to associated devastating traumatic injuries. Of the remaining 36 patients, 7 (19.4%) were managed with single-stage primary duodenal repair with definitive abdominal wall fascial closure (PDR + NoDC group). Damage-control laparotomy was performed in 29 patients, (80.5%) in which primary repair was performed in 15 (51.7%) (PDR + DC group), and the duodenum was oversewn and left in discontinuity in 14 (48.3%). Duodenal reconstruction was performed after primary repair in 2 of 15 cases and after left in discontinuity in 13 of 14 cases (DR + DC group). The most common complication was the development of a duodenal fistula in 12 (33%) of 36 cases. These leaks were managed by traditional anterior drainage in 9 (75%) of 12 cases and posterior drainage by retroperitoneal laparostomy in 3 (25%) of 12 cases. The duodenal fistula closed spontaneously in 7 (58.3%) of 12 cases. The duodenum-related mortality rate was 2.8%, and the overall mortality rate was 11.1%.

CONCLUSION: An application of basic damage-control techniques for PDT leads to improved survival and an acceptable incidence of complications. (J Trauma Acute Care Surg, 2014;76: 1177–1183. Copyright © 2014 by Lippincott Williams & Wilkins)

LEVEL OF EVIDENCE: Therapeutic study, level IV.

KEY WORDS: Duodenal injuries; penetrating injuries; pyloric exclusion; retroperitoneal laparostomy; damage-control laparotomy.


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using the Revised Trauma Score (RTS), Injury Severity Score (ISS), and the New Injury Severity Score (NISS). Initial resuscitation followed advanced trauma life support guidelines. Duodenal injury severity was scored using the American Association for Surgery of Trauma Organ Injury Scaling (AAST-OIS). Patients with an AAST-OIS Grade I and those that required a Whipple procedure were excluded. Data elements selected for analysis included age, sex, mechanism of injury (gunshot/stabbing), hypotension on admission (systolic blood pressure < 90 mm Hg), associated injuries, operative procedures, hospital length of stay, intensive care unit (ICU) length of stay, ventilator days, duodenal related morbidity (fistula formation), duodenal-related mortality, and survival outcomes.

Injuries were diagnosed and graded during laparotomy. Operative repair was dictated by surgeon preference. The underlying surgical principle was management of the duodenal injuries as simple as possible aiming at obtaining debridement and primary duodenal repair when feasible. If extensive destruction occurred, the duodenal ends were oversewn and left in discontinuity. Subsequent reconstruction was performed according to the location and size of the lesion: duodenojejunostomy, gastrojejunostomy in Roux en Y, and a duo denodudenostomy were performed. Complex drainage procedures (“duodenal diverticulization” and “triple tube ostomy”) were not performed. Pyloric exclusion was avoided, but when performed, a modified technique as described by Ferrada was implemented.

Patients were divided into three groups according to the surgical management used to address their duodenal injury: primary duodenal repair without damage-control laparotomy (PDR + NoDC group), primary duodenal repair with damage-control laparotomy (PDR + DC group), and duodenal reconstruction with damage-control laparotomy (DR + DC group). Discrete variables are presented as counts and percentages. Continuous variables are presented as age, median, and interquartile range (IQR). Categorical variables were compared by the Fisher’s exact test. Continuous variables were compared by the two-sided Kruskal-Wallis equality-of-populations rank test. Calculations were made by Stata 12.1 for Mac (StataCorp, College Station, TX). A \( p < 0.05 \) was considered statistically significant.

All duodenal leaks, defined as a breakdown in the duodenal repair, were drained externally either by the traditional anterior approach (closed suction drain[s]) or via a posterior retroperitoneal laparostomy according to the surgeon’s preference. For the posterior approach, a retroperitoneal laparostomy was conducted through a 15-cm right flank transverse subcostal incision starting from midaxillary line and extending it just beyond the posterior axillary line. After splitting the muscles, the duodenal region was reached by gentle finger dissection of the exposed retroperitoneal space just above the renal fossa. The whole cavity was packed with gauze. The gauze pack was removed daily at the bedside.² ⁶

RESULTS

During the study period, 44 consecutive patients with penetrating duodenal injuries were identified. Seven patients were excluded because of early operative death, secondary to devastating associated injuries. Another patient was excluded because a pancreatoduodenectomy was required for a destructive and catastrophic injury of the pancreatoduodenal complex. This type of injury was not the focus of our study. We then analyzed 36 patients with penetrating duodenal trauma, of whom 33 (91.7%) of 36 experienced gunshot wounds and 3 (8.3%) were stabbed. Thirty-four (94.4%) were male. Median age was 26 years (IQR, 23–33 years), ISS of 25 (16–25), NISS of 28 (27–48), abdominal Abbreviated Injury Scale (AIS) score of 4 (4–5), and RTS of 7.11 (5.44–7.84). Twenty-two patients (61.1%) presented in hypovolemic shock defined as systolic blood pressure of less than 90 mm Hg. The diagnosis of duodenal injury was made at laparotomy in all patients. During laparotomy, 12 patients (33%) had an AAST-OIS Grade II duodenal lesion, 16 (44%) Grade III, and 8 (22%) Grade IV. None of these wounds involved the ampulla complex. All patients in this study experienced injuries to the abdominal organs other than the duodenum. In total, 113 associated injuries were identified in these 36 patients (median associated injuries per patient, 4; IQR, 4–5). The colon was the most frequently injured associated organ (18 of 36, 50%) followed by the small bowel (17 of 36, 47.2%), liver (16 of 36, 44.4%), and major vascular structures (14 of 36, 38.9%) (Table 1). Of the major vascular structures, the vena cava was wounded in six cases (42.9%), portal and/or inferior mesenteric vein in six (42.9%), and the aorta in two (14.3%).

Seven patients (19.4%) were managed with single-stage primary duodenal repair, followed by definitive abdominal wall fascial closure at the end of the initial laparotomy (PDR + NoDC group). Staged damage-control laparotomy was performed in 29 patients (80.5%), in which primary repair of the duodenum was performed in 15 (51.7%) (PDR + DC group) and the duodenum was kept under and left in discontinuity in 14 (48.3%). Duodenal reconstruction was performed after primary repair in 2 of 15 and after left in discontinuity in 13 of 14 cases (DR + DC group). Reconstruction consisted of lateral duodenojejunostomy in 8 (53.3%) of 15, duodenal resection with gastrojejunostomy in 3 (20%), duodenoduodenostomy in 2 (13.3%), and a Ferrada modified pyloric exclusion in 2 patients (13.3%).

<table>
<thead>
<tr>
<th>Organ</th>
<th>Total Patients (n = 36), n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colon</td>
<td>18 (50.0)</td>
</tr>
<tr>
<td>Small bowel</td>
<td>17 (47.2)</td>
</tr>
<tr>
<td>Liver</td>
<td>16 (44.4)</td>
</tr>
<tr>
<td>Major vascular</td>
<td>14 (38.9)</td>
</tr>
<tr>
<td>Stomach</td>
<td>12 (33.3)</td>
</tr>
<tr>
<td>Kidney</td>
<td>12 (33.3)</td>
</tr>
<tr>
<td>Pancreas</td>
<td>10 (27.8)</td>
</tr>
<tr>
<td>Diaphragm</td>
<td>4 (11.1)</td>
</tr>
<tr>
<td>Gallbladder</td>
<td>4 (11.1)</td>
</tr>
<tr>
<td>Ureter</td>
<td>3 (8.3)</td>
</tr>
<tr>
<td>Spleen</td>
<td>3 (8.3)</td>
</tr>
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jejunostomy was used as an adjunctive procedure only in the Ferrada modified pyloric excluded patients.

The DR + DC, PDR + DC, and the PDR + NoDC groups were all similar according to demographics and mechanism of injury. The DR + DC group had a significant higher NISS (48 [34–59]) as compared with the PDR + DC group (37 [27–43]) and the PDR + NoDC group (24.5 [9–27]). This correlates with the noticeable higher incidence of AAST-OIS Grade III and IV injuries seen in the DR + DC group. Eighty percent of the DR + DC patients presented hypotensive (systolic blood pressure < 90 mm Hg) at admission as compared with 64.9% in the PDR + DC group and none in the PDR + NoDC group. The median number of associated organ injuries was 3 for the PDR + NoDC group, 4 for the PDR + DC group, and 5 for the DR + DC group. The percentage of associated vascular injuries was 0 in the PDR + NoDC group, 42.8% in the PDR + DC group, and 53.3% in the DR + DC group. Although not statistically significant, the probability of survival decreased gradually among the three groups: (0.97 [0.96–0.98]) in the PDR + NoDC group, 0.96 [0.8–0.97] in the PDR + DC group, and 0.82 [0.7–0.96] for the DR + DC group (Table 2).

The mean ICU stay for all patients was 7.5 days (IQR, 3.25–19.5 days), and the mean hospital stay was 19 days (IQR, 13–46.5 days). The mean ventilator days was 6 (IQR, 3–7). The overall mortality rate was 11.1% (four patients). Two of them (5.6%) had an AAST-OIS Grade III injury, and the other two (5.6%) had a Grade IV injury. The cause of death was multiorgan failure in three (75%) of the four mortalities. The duodenal-related mortality rate was 2.8% (one case) and involved duodenal suture line dehiscence. The predominant intra-abdominal complication was the development of a duodenal fistula in 12 patients (33%). These leaks were managed by traditional anterior drainage in nine cases (75%) and retroperitoneal laparostomy in three cases (25%). The duodenal fistula closed spontaneously in 7 (58.3%) of the 12 cases. Two patients (16.7%) required a subsequent surgical intervention to close the fistula. Two patients died with an active fistula, and one patient had not sealed yet (Fig. 1).

**DISCUSSION**

The incidence of duodenal injuries varies from 3% to 5% of all trauma laparotomies. Most (80%) of these injuries are caused by penetrating trauma, with gunshot, stab, and shotgun injuries responsible for 75%, 20%, and 5%, respectively. Duodenal injuries cause morbidity in up to 65%, and an overall mortality rate was between 5.3% and 30%, but injuries to the duodenum itself are responsible for a mortality rate of approximately 10%.

Throughout the years, surgeons have developed several innovative and temporizing procedures to both repair the wounded duodenum and prevent fistulization from repair breakdown. The first method of suture line protection was the “triple tube ostomy” described by Stone and Fabian. Despite its technical simplicity and encouraging initial results, reports from others have failed to show improved outcomes with this technique. Ivatury et al. found an increased incidence of duodenal fistula and complications when duodenal decompression was used (Stone and Fabian’s “triple ostomy”), and their current preference was to avoid them. Procedures for complete diversion of the gastrointestinal stream were soon developed. Berne et al. excluded repairs by “diverticulizing” the duodenum. Although effective in

![TABLE 2. Complex Penetrating Duodenal Injuries Demographics and Clinical Characteristics](image)

<table>
<thead>
<tr>
<th>Demographics</th>
<th>PDR + NoDC Group (n = 7)</th>
<th>PDR + DC Group (n = 14)</th>
<th>DR + DC Group (n = 15)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male, n (%)</td>
<td>5 (71.4) 13 (92.9) 15 (100)</td>
<td>0.05**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trauma mechanism, n (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gunshot wounds</td>
<td>6 (85.7) 13 (92.9) 14 (93.3)</td>
<td>NS**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Duodenal injury grade, n (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>5 (71.4) 7 (50.0) 0</td>
<td>0.002**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>1 (14.3) 6 (42.9) 8 (53.3)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td>1 (14.3) 1 (7.1) 7 (46.7)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Trauma severity, median [IQR]</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>RTS</td>
<td>7.55 [5.44–7.84] 7.11[5.64–7.84] 5.81[5.43–7.55]</td>
<td>NS*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NISS</td>
<td>24.5 [9–27] 37 [27–43] 48 [34–59]</td>
<td>0.002*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PS†</td>
<td>0.97 [0.96-0.98] 0.96 [0.8–0.97] 0.82 [0.7–0.96]</td>
<td>NS*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shock, n (%)</td>
<td>0 9 (64.3) 12 (80.0)</td>
<td>0.001**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Associated vascular injury, n (%)</td>
<td>0 6 (42.8) 8 (53.3)</td>
<td>0.06**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Duodenal specific mortality, n</td>
<td>0 0 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall mortality, n</td>
<td>0 1 3</td>
<td></td>
<td></td>
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</table>

*Kruskal-Wallis equality-of-populations rank test.
**Fisher’s exact test.
†Probability of survival.
Significant controversy exists regarding the best surgical treatment for complex penetrating duodenal injuries. Debridement and primary repair or resection and anastomosis are suitable for the majority of duodenal injuries, especially for penetrating injuries. The physiologic presentation of the patient is the most important factor in predicting mortality in patients with traumatic duodenal injuries. Ivatury et al. classified treatment according to the hemodynamic status of the patient and pointed out that in the hemodynamically unstable patient, a damage-control approach consisting of hemorrhage control, rapid sealing or resection of gastrointestinal perforations without establishing continuity, temporary abdominal closure, and ICU resuscitation should initially be performed and gastrointestinal tract integrity restoration should be accomplished in a second operation. In hemodynamically stable patients, lower-grade lesions of the duodenum, low-velocity penetrating wounds with no delay in diagnosis and treatment, simple primary repair is an adequate treatment for the majority of duodenal injuries. As seen in our study, 80% of the DR + DC patients presented hypotensive at admission as compared with 64.3% in the PDR + DC group and none in the PDR + NoDC group. Optimal management and better outcome of duodenal injuries seem to be associated with shorter operative time and with simple and fast damage-control surgery, in contrast to definitive surgical procedures. The surgeon should be aware that treatment with a minimalistic approach, with only primary repair, may be ideal.

Duodenal injuries are often associated with multiple major intra-abdominal vascular and solid organ injuries as shown in our series (Table 1). The median number of associated organ injuries was 3 for the PDR + NoDC group, 4 for the PDR + DC group, and 5 for the DR + DC group. These associated injuries compromise the patient’s hemodynamic status and quickly descend them into the triad of acidosis, hypothermia, and coagulopathy. Lengthy, complex procedures in these cases inevitably lead to poor outcomes. For these reasons, the principles of damage-control surgery come into play to manage organ-specific injuries. It is our experience that a staged approach to high-grade duodenal injuries preserves tissue and allows more frequent use of nonresection alternatives. The management philosophy is the avoidance of complex reconstructive procedures but at the same time advocating necessary debridement and adequate drainage.

In a meta-analysis, Asensio et al. reviewed 15 clinical series containing 1,408 patients with duodenal injuries who underwent various surgical repairs and found an overall duodenal fistula rate of 6.6%. In our study, we found that the predominant intra-abdominal complication was also the development of a duodenal fistula in 12 (33%) of 36 patients. Although our duodenal fistula rate is higher than the previously stated average of 6.6%, it is also important to note that our study has a distinctive cohort of patients of exclusively penetrating trauma with significant elevated injury scores, high prevalence of hemodynamic instability, median number of four associated organ injuries per patient, and an overall incidence of associated vascular injury of 39%. Any one of these factors would incline the treating trauma surgeon to perform a damage-control procedure for any one of the significant associated injuries besides applying it simultaneously to manage the duodenal injury. This emphasizes our initial premise that “less is better,” knowing that our duodenum-related mortality was 2.8% and our overall mortality was 11.1%, both of which are significantly better than those reported by Asensio et al..

The traditional treatment of a postoperative duodenal fistula is adequate drainage and control via an anterior laparotomy with or without drain placement and with or without an open abdomen/temporary abdominal closure system. The
repeated debridement of the retroperitoneal cavity. Van Vyve et al. coined retroperitoneal laparostomy and provides a safe and efficient route for drainage. It also avoids dissection through the dependent part of the abdominal cavity and thus achieving the wound dehiscence by creating a wide opening at the most significant drawback with the previously published experience of Fang et al. with this technique is that it took them between three to four re-laparotomies before implementing the retroperitoneal laparostomy. We avoided this delay, and in the three cases in which we performed this technique, it was instituted as soon as the diagnosis of a duodenal fistula was made. So, it is our experience that the duodenal fistula can be managed with the same philosophy of simplicity with acceptable outcomes, which is reflected in our overall mortality of 11.1%. These results compare favorably with previous reported overall mortality rates of 13% to 25% for acute mortality and 18.5% to 56% for delayed mortality. Moreover, our duodenum-related mortality was 2.8%, which is considerably less than the reported 10% in the literature. 

**CONCLUSION**

Application of basic damage-control techniques for PDT leads to improve survival and an acceptable incidence of complications. Furthermore, the management of possible subsequent complications of initial damage-control management can be managed with the same philosophy of simplicity with acceptable outcomes. Retroperitoneal laparostomy is an effective means for treating a duodenal leak and associated extensive retroperitoneal abscess and should be performed sooner than later. On the basis of our findings, we believe that the general rule that “less is better” should be adopted for the management of all penetrating duodenal injuries.

**REFERENCES**


**DISCUSSION**

Dr. David V. Feliciano (Indianapolis, Indiana): I first had the privilege of working with Drs. Ordoñez, Garcia and Ferrada in 1991 at the Hospital Universitario in Cali, Colombia. During my subsequent ten visits to Colombia in Cali, Medellin, and Bogota have taught me much and I recommend that all of you go to visit them.

And today they are trying to convince me that a “simple” approach to primarily penetrating duodenal wounds is best. Upfront I must say that the definition of what is a simple repair is another whole debate beyond today’s discussion.

In the authors’ discussion in the manuscript they emphasize the negative aspects of the Harlan Stone triple tube approach, the Berne-Donovan duodenal diverticulization, and the Baylor pyloric exclusion with gastro-jejunostomy, all of which are occasional replacements of primary repair but more often adjuncts to a primary repair. I have one comment and several questions.

The comment is that the authors reference several review papers in their discussion which document that the duodenal fistula rate in primarily American series is 6.5% while the authors’ fistula rate is 33%, which is five times greater. Let me repeat: five times greater.

My first question, in your damage control group of 29 patients, Carlos, you just told us on a slide that you had a 28% leak rate on your 14 primary repairs and a leak rate of 53% on your complex duodenal reconstructions. Were these two-layer or one-layer repairs? Did you buttress them with viable omental pedicles? Did you do anything special to lower the leak rate? Did you drain them at all? There is very little in the manuscript about your technical approach and I’m concerned about your fistula rate.

Second, how did you feed these patients while waiting for the duodenum to heal? Again, there was very little in the manuscript in these very sick patients about how you maintained their nutritional status. Were they all on TPN post-op because you were trying to protect the repaired duodenum? Or did this depend on your postoperative prealbumin level? Third, why do you think your leak rate is so high? You’re going to have a hard time selling these primary repairs without adjuncts to anybody when you have to spend so much time dealing with postoperative fistulas. I know you are going to tell me your patients are sicker in Colombia than in the United States, but I’d like you to prove that to me.

Fourth, have you analyzed the patients who developed fistulas to see if there were some common factors? How bad was their massive transfusion? Did they all have low prealbumin levels in the postoperative period? Did you do premature GI feeding? Did you see any factors that might have contributed to your fistula rate and can be addressed in the future?

Let me be honest with the audience. I just don’t see any evidence that the authors’ “less is better” approach is an improvement over a highly selective use of the adjunct of pyloric exclusion with gastro-jejunostomy or Ricardo Ferrada’s modified pyloric exclusion.

I love all my friends in Cali, Colombia, and I’m sure they will never invite me back again. But, this paper is more about treating duodenal fistulas than in preventing them with any operative technique.

I’d like to thank the Cali group for their continuing contributions to the care of injured patients and the AAST for the privilege of discussing this interesting manuscript. Thank you.

Dr. David P. Blake (Norfolk, Virginia): I, too, enjoyed this paper. And I appreciate all the comments by Dr. Feliciano. I want to focus for a moment, if I could, on the subsequent retroperitoneal abscesses that presumably represent these duodenal fistulas.

Were these patients truly septic? And if so, how were they identified? And how were they managed in that septic phase?

Then, secondly, did you have the availability for using image-guided drainage versus, say, this retroperitoneal laparostomy? If so, was that considered for any of these patients?

Again, I enjoyed your paper. Thank you very much.

Dr. William P. Schecter (San Francisco, California): When I approach duodenal injuries, I’m not sure that the pyloric exclusion prevents the fistula; but what it does, it turns a very complex management problem for the side duodenal fistula that’s high output with difficulty with enteral feeding into a rather simple end fistula that’s low output and that allows you to feed the patient through the gastro-jejunostomy.

So if we accept the fact that you’re dealing with very complex injuries and you see something that you’re worried might break down, do you think in retrospect had you added a pyloric exclusion at the time of the injury the postoperative management might have been much easier?

Dr. Carlos A. Ordoñez (Cali, Colombia): Dr. Feliciano, in our study we found that the predominant intra-abdominal complication was the development of a duodenal fistula in 12 of 36 (33%) patients. Although our duodenal fistula rate is higher than the previously stated average of 6.6%, it is also important to note that our study has a distinctive cohort of patients of exclusively penetrating trauma with significant elevated injury scores, high prevalence of hemodynamic instability (80%), median number of four associated organ injuries per patient and an overall incidence of associated vascular injury of 39%. Another compounding factor is that in Colombia only 30% of these kinds of patients arrive by ambulance and within the pre-hospital “golden hour”. Any one of these factors...
would incline the treating Trauma Surgeon to perform a damage control procedure for any one of the significant associated injuries besides applying it simultaneously to manage the duodenal injury. This emphasizes our initial premise that “less is better,” knowing that our duodenum-related mortality was 2.8% and our overall mortality was 11.1%—both of which are significantly better than those reported previously in the trauma literature.

To answer your questions related to our surgical technique: the repair is performed in a single running layer, we do not buttress our repair with omentum, nor do we primarily drain the area. Nutritional support is parental in those that we opted for reconstruction as opposed to early enteral feeding in those that were primarily repaired.

I appreciate Dr. Feliciano’s comments and reiterate our deep admiration towards him; you will always be welcomed in Colombia.

To answer Dr. Blake’s question, although we do have the ability of using image-guided drainage it is not our protocol in patients status post damage control surgery with an open abdomen. Our first approach is the traditional anterior drainage and in those cases in which this is not possible than the retroperitoneal laparostomy is preferred.

Thank you.