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 over sewn 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.

Up to modern times, duodenal injuries have presented in many ways a puzzle to the trauma surgeon. Although penetrating mechanisms account for the majority of duodenal injuries (80%), previous reports estimate that duodenal injuries constitute less than 5% of all abdominal injuries.[1] Their rarity precludes anyone from gaining a vast experience in their management. Over the years, the principles of managing duodenal injuries have evolved into certain widely accepted paradigms that emphasize high index of suspicion, thorough operative exposure, and measured surgical interventions tailored to the severity of the injury. Innovative procedures such as duodenal "diverticulization," pyloric exclusion, and "triple tube ostomy" drainage have been developed to both repair duodenal wounds and divert gastrointestinal secretions to prevent the most serious complication related to the surgical repair of duodenal injuries, which is the development of a duodenal fistula.[1] There is no single method of duodenal repair that completely eliminates the possibility of dehiscence of the duodenal suture line, and although these aggressive surgical procedures are still advocated by some for complex injuries, their true benefits are not well documented.[2,3] As a result, the surgeon is confronted with the dilemma of choosing from several complex surgical procedures for the same problem.[3] The aim of the present study was to evaluate a simplified approach to the management of complex penetrating duodenal injuries, which emphasizes the current trend of organ-specific damage-control surgery.

PATIENTS AND METHODS

We performed a retrospective chart review of all patients admitted to a regional level I urban trauma center between January 2003 and December 2012, which revealed 44 consecutive adult (age > 18 years) patients with penetrating duodenal injuries, surviving greater than 24 hours, not undergoing pancreaticoduodenectomy, and having operative intervention within 24 hours of presentation. Injury severity was categorized

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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), duodenum-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 over sewn 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 denoduodenostomy 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[4] 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 amounts and percentages. Continuous variables are presented as range, 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.[5,6]

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 ampullary 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 over sewn 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%). Feeding

TABLE 1. Complex Penetrating Duodenal Injuries Associated Abdominal Injuries

Organ	Total Patients (n = 36), n (%)
Colon	18 (50.0)
Small bowel	17 (47.2)
Liver	16 (44.4)
Major vascular	14 (38.9)
Stomach	12 (33.3)
Kidney	12 (33.3)
Pancreas	10 (27.8)
Diaphragm	4 (11.1)
Gallbladder	4 (11.1)
Ureter	3 (8.3)
Spleen	3 (8.3)

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 duodenum-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%.[7–9] 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.[10] Despite its technical simplicity and encouraging initial results, reports from others have failed to show improved outcomes with this technique. Ivatury et al.[11,12] 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.[7] Procedures for complete diversion of the gastrointestinal stream were soon developed. Berne et al.[13] excluded repairs by "diverticulizing" the duodenum. Although effective in

TABLE 2. Complex Penetrating Duodenal Injuries Demographics and Clinical Characteristics

	PDR + NoDC Group (n = 7)	PDR + DC Group (n = 14)	DR + DC Group (n = 15)	*p*
Demographics				
Age, median [IQR], y	25 [21–43]	26 [22–32]	27 [25–37]	NS*
Male, n (%)	5 (71.4)	13 (92.9)	15 (100)	0.05**
Trauma mechanism, n (%)				
Gunshot wounds	6 (85.7)	13 (92.9)	14 (93.3)	NS**
Duodenal injury grade, n (%)				0.002**
II	5 (71.4)	7 (50.0)	0	
III	1 (14.3)	6 (42.9)	8 (53.3)	
IV	1 (14.3)	1 (7.1)	7 (46.7)	
Trauma severity, median [IQR]				
RTS	7.55 [5.44–7.84]	7.11[5.64–7.84]	5.81[5.43–7.55]	NS*
ISS	16 [16–25]	16 [16–25]	25 [25–32]	NS*
NISS	24.5 [9–27]	37 [27–43]	48 [34–59]	0.002*
PS†	0.97 [0.96–0.98]	0.96 [0.8–0.97]	0.82 [0.7–0.96]	NS*
Shock, n (%)	0	9 (64.3)	12 (80.0)	0.001**
Associated organ injuries, median [IQR]	3 [3–3]	4 [3–5]	5 [4–6]	0.006*
Associated vascular injury, n (%)	0	6 (42.8)	8 (53.3)	0.06**
Duodenal specific mortality, n	0	0	1	
Overall mortality, n	0	1	3	

*Kruskal-Wallis equality-of-populations rank test.
**Fisher's exact test.
†Probability of survival.

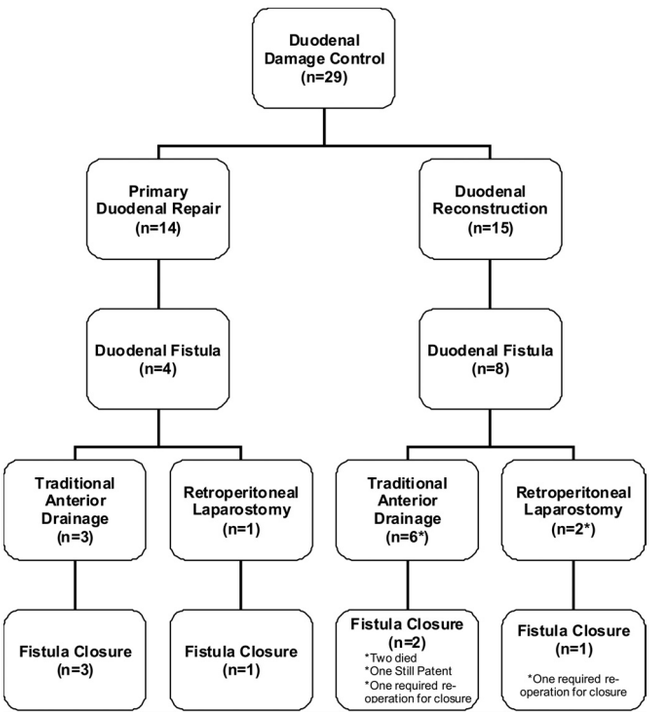

Figure 1. Penetrating duodenal injuries: duodenal fistula.

diverting enzymatic secretions, the procedure is complex, is time consuming, and resects normal tissue in young, often healthy patients. Today, diverticulization is seldom performed.[12] Vaughan et al.[14] in 1977 described the first pyloric exclusion, but despite its technical simplicity and swiftness, the procedure entails a permanent alteration of the gastrointestinal tract with the construction of the gastrojejunostomy. Pyloric exclusion offers minimal advantage over adequate nasogastric drainage when primary duodenal repair is performed and is associated with increased operative time, an extra intestinal anastomosis, and gastric suture line ulcers.[7,15–17] Postpyloric exclusion marginal ulceration occurred in approximately 10% of patients who underwent postoperative surveillance endoscopy.[3] Seamon et al.[1] reported a trend toward a higher overall complication rate in the pyloric exclusion group (71% vs. 33%) and concluded that simple repair without pyloric exclusion was both adequate and safe for most penetrating duodenal injuries.[8] For these reasons, the use of pyloric exclusion in our surgical armamentarium in this study was avoided, and only a modified version of this technique was used in a limited number of cases (n = 2), which minimized the inherent potential drawbacks of increased procedural time, the presence of an extra intestinal anastomosis, and gastric suture line ulcers.[4]

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.[7] The physiologic presentation of the patient is the most important factor in predicting mortality in patients with traumatic duodenal injuries.[18,19] Ivatury et al. classified treatment according to the hemodynamic status of the patients 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.[7,11,12] 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.[20] The surgeon should be aware that treatment with a minimalistic approach, with only primary repair, may be ideal.[8]

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 descends 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.[21]

In a meta-analysis, Asensio et al.[22,23] 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.[22,23]

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

retroperitoneal approach that has been previously described by Van Vyve et al.[5] coined *retroperitoneal laparostomy* has also been used as an alternative drainage method for the management of postoperative blunt duodenal trauma complications by Fang et al.[6] This approach allows a total exploration and drainage of the duodenum and permits reexploration and removal of necrotic retroperitoneal secretions without the risk of intra-peritoneal cross-contamination. Fang et al. reported their experience of a total of six retroperitoneal laparostomies, in which four of their patients underwent this procedure after their third laparotomy and the remaining two patients after their fourth. Moreover, the duodenal wound dehiscence was not repaired during retroperitoneal laparostomies, and a total of five of the six patients had spontaneous healing of their duodenal wounds.[6] The duodenal fistulas in our study were managed by traditional anterior drainage in nine (75%) and retroperitoneal laparostomy in three (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). The arguments in favor of the retroperitoneal laparostomy is the benefit it offers of taking advantage of the inherent natural tendency of a duodenal fistula to drain toward the back following gravitational pull instead of requiring an antigravity-directed flow via a temporary abdominal closure device and/or sump drains. The procedure has also the advantage of rapid restoration of peristalsis and allows for early enteral feeding. For these reasons, retroperitoneal laparostomy is an ideal procedure for the management of penetrating duodenal injury complications of duodenal wound dehiscence by creating a wide opening at the most dependent part of the abdominal cavity and thus achieving the best route for drainage. It also avoids dissection through the peritoneal cavity and provides a safe and efficient route for repeated debridement of the retroperitoneal cavity.[6] The 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.[21] Moreover, our duodenum-related mortality was 2.8%, which is considerably less than the reported 10% in the literature.[7–9]

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.

AUTHORSHIP

C.O., A.G., M.W.P., and J.C.P. contributed to the study conception and design. C.O., A.G., M.M., D.S., and M.B. were responsible for the collection, assembly, and quality of data. M.M., D.S., and F.R. performed the acquisition of data. A.G. and J.S. performed the statistical analysis. C.O., A.G., M.W.P., M.B., and J.C.P. performed the analysis and interpretation of data. C.O., A.G., M.W.P., M.B., J.C.P., L.F.P., and R.F. drafted the manuscript. C.O., A.G., M.W.P., M.B., J.C.P., L.F.P., and R.F. provided critical revision of the manuscript for important intellectual content. C.O. and M.B. provided study supervision and administrative, technical, or logistic support. C.O. and M.B. obtained funding.

DISCLOSURE

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REFERENCES

1. Seamon MJ, Pieri PG, Fisher CA, Gaughan J, Santora TA, Pathak AS, Bradley KM, Goldberg AJ. A ten year retrospective review: does pyloric exclusion improve clinical outcome after penetrating duodenal and combined pancreaticoduodenal injuries? *J Trauma*. 2007;62(4):829–833.
2. Leppaniemi A. Focus on pancreatic and duodenal injuries. *Eur J Trauma Emerg Surg*. 2007;33:219–220.
3. Degiannis E, Boffard K. Duodenal injuries. *Br J Surg*. 2000;87(11): 1473–1479.
4. Ferrada R. Chapter 33: commentary. The duodenum and pancreas. In: Mattox KL, Feliciano DV, Moore EE, eds. *Trauma*. 4th ed. 2000:735–762.
5. Van Vyve EL, Reynaert MS, Lengele BG, Pringot JT, Otte JB, Kestens PJ. Retroperitoneal laparostomy: a surgical treatment of pancreatic abscesses after an acute necrotizing pancreatitis. *Surgery.* 1992;111(4):369–375.
6. Fang JF, Chen RJ, Lin BC, Hsu YB, Kao JL, Kao YC, Chen MF. Retroperitoneal laparostomy: an effective treatment of extensive intractable retroperitoneal abscess after blunt duodenal trauma. *J Trauma*. 1999;46(4): 652–655.
7. Girgin S, Gedik E, Yagmur Y, Uysal E, Bac B. Management of duodenal injury: our experience and the value of tube duodenostomy. *Ulus Travma Acil Cerrahi Derg*. 2009;15(5):467–472.
8. Fraga GP, Biazotto G, Bortoto JB, Andreollo NA, Mantovani M. The use of pyloric exclusion for treating duodenal trauma: case series. *Sao Paulo Med J.* 2008;126(6):337–341.
9. Talving P, Nicol AJ, Navsaria PH. Civilian duodenal gunshot wounds: surgical management made simpler. *World J Surg*. 2006;30(4):488–494.
10. Stone HH, Fabian TC. Management of duodenal wounds. *J Trauma*. 1979; 19:334–339.
11. Ivatury RR, Nassoura ZE, Simon RJ, Rodríguez A. Complex duodenal injuries. *Surg Clin North Am*. 1996;76(4):797–812.
12. Ivatury RR, Malhotra AK, Aboutanos MB, Duane TM. Duodenal injuries: a review. *Eur J Trauma Emerg Surg*. 2007;3:231–237.
13. Berne CJ, Donovan AJ, White EJ. Duodenal "diverticulization" for duodenal and pancreatic injury. *Am J Surg*. 1974;127:503–507.
14. Vaughan GD III, Frazier OH, Graham DY. The use of pyloric exclusion in the management of severe duodenal injuries. *Am J Surg*. 1977;134: 785–790.
15. Yilmaz TH, Ndofor BC, Smith MD, Degiannis E. A heuristic approach and heretic view on the technical issues and pitfalls in the management of penetrating abdominal injuries. *Scand J Trauma Resusc Emerg Med*. 2010;18:40.
16. Subramanian A, Dente CJ, Feliciano DV. The management of pancreatic trauma in the modern era. *Surg Clin North Am*. 2007;87(6):1515–1532.
17. Velmahos GC, Constantinou C, Kasotakis G. Safety of repair for severe duodenal injuries. *World J Surg*. 2008;32(1):7–12.

18. Dubose JJ, Inaba K, Teixeira PG, Shiflett A, Putty B, Green DJ, Plurad D, Demetriades D. Pyloric exclusion in the treatment of severe duodenal injuries: results from the national trauma data bank. *Am Surg*. 2008; 74(10):925–929.
19. Huerta S, Bui T, Porral D, Lush S, Cinat M. Predictors of morbidity and mortality in patients with traumatic duodenal injuries. *Am Surg*. 2005; 71(9):763–767.
20. Antonacci N, Di Saverio S, Ciaroni V, Biscardi A, Giugni A, Cancellieri F, Coniglio C, Cavallo P, Giogini E, Baldoni F, Gordini G, Tugnoli G. Prognosis and treatment of pancreaticoduodenal traumatic injuries: which factors are predictors of outcome? *J Hepatobiliary Pancreat Sci*. 2011;18(2): 195–201.
21. Rickard MJ, Brohi K, Bautz PC. Pancreatic and duodenal injuries: keep it simple. *ANZ J Surg*. 2005;75(7):581–586.
22. Asensio JA, Petrone P, Roldan G, Pak-art R, Salim A. Pancreatic and duodenal injuries: complex and lethal. *Scand J Surg*. 2002;91(1):81–86.
23. Asensio JA, Stewart BM, Demetriades D. Chapter 49. Penetrating injuries to the duodenum. In: Ivatury RR, Cayten CG, eds. *Textbook of Penetrating Trauma*. Philadelphia, PA: Lea & Febiger; 1995:610–630.

DISCUSSION

Dr. David V. Feliciano (Indianapolis, Indiana): I first had the privilege of working with Drs. Ordoþez, Garcia and Ferrada in 1991 at the Hospital Universitario in Cali, Colombia. During my subsequent ten visits to Colombia, the surgeons in Cali, Medellín, 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 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.