



Modified Finney enteroplasty: a bowel sparing damage control stapled technique for penetrating jejunal and ileal injuries

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Abstract

The rise in gun violence and other penetrating trauma constitutes one of the main challenges in the modern practice of Acute Care Surgery. Expertise in the emergency management of this type of injuries is needed if one is to avoid preventable complications, such as short bowel syndrome. Revisiting and sometimes repurposing old surgical techniques may facilitate this task. The use of a modified Finney enteroplasty as a bowel sparing damage control technique for penetrating jejunal and ileal injuries was studied on 87 gunshot wound victims. The results show this to be a safe and efficient bowel sparing approach to the management of these injuries.

Introduction

Damage control surgery is one of the most significant advances in Trauma Surgical care in the past 25 years [1]. The principles of abbreviated surgical time to allow for continued resuscitation in the SICU, bleeding arrest, restoration of perfusion and contamination source control instead of complex, time-consuming, definitive repairs based on traditional techniques have saved countless lives and significantly boost survival rates [2] for this complex patient population. Improvements in damage control approaches to common injuries are, therefore, desirable.

One of the most common injuries found in busy urban trauma surgery practice is jejunoileal enterotomies secondary to penetrating trauma [3]. The incidence and number of said lesions are greatly associated with the mechanism of injury (gunshot wounds or GSW versus stab wounds), and the preferred management strategy includes consideration to the hemodynamic status of the patient and the presence and type of associated injuries (i.e. solid organs, colon, stomach, etc) [4]. With patients in extremis, damage control principles mandate leaving these segments of intestine in discontinuity, to allow for warming of the patient and ongoing resuscitation while achieving source control of the enteral spillage [5]. The downside of this approach is the inevitable swelling

of the intestine that will occur with the resuscitation [5, 6] and will make the bowel reconstruction much more challenging and perhaps less safe [6]. In addition, extensive jejunoileal resections that include many enterotomies (as recommended currently) [2, 7] may increase the risk for short bowel syndrome in the current hospital stay or in a future one (given the somber fact that many of these patients will experience additional interventions for recurrent trauma in their lifetime) [8–10]. Thus, the use of a bowel sparing technique that achieves adequate source control and minimizes the need for second look procedures, while not compromising damage control principles (i.e. fast) is imperative. In this article, I present the surgical technique of the Modified Finney Enteroplasty, which is optimal in addressing these specific situations.

Methods

The members of the study population were identified by mining the author's American College of Surgeons' Surgeon Specific Registry from May 2011 until December 2016, using the following CPT codes: 44120, 44121, 44602 and 44603. Additional information was then cross-referenced from the Advocate Christ Medical Center's Trauma Registry. The data was then tabulated and presented in aggregate fashion. For the study period, 87 patients met the only inclusion criteria; they were treated by the author for jejunoileal enterotomies (alone or in combination with other injuries) secondary to penetrating trauma (i.e. gunshot wounds) using

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a damage control approach and leaving their abdomens open. Their demographics are listed in Table 1. All were treated using the following surgical technique: once access to the abdomen was established using a standard laparotomy incision, all ongoing bleeding and other immediately life-threatening injuries were addressed according to their extent and priority, and following accepted standards of care. Next, the small bowel was inspected in a systematic fashion by running it from the ligament of Treitz to the ileocecal valve. Enterotomies were identified and controlled using Babcock clamps (AROSurgical Instruments, Newport Beach, CA, USA). Once the number and location of each injury were determined, a 80-mm GIA stapler (Covidien-Medtronic, Minneapolis MN, USA) with a blue (gastrointestinal) cartridge was brought into the field, and opened while keeping the back fulcrum engaged, so it was possible to manipulate it with only one hand. The limbs were inserted through the actual enterotomy, using the thumb of the operating hand to direct each limb to either proximal or distal fashion, while holding on to the bowel with the other hand (Fig. 1). The stapler was then closed and promptly fired, creating an anastomotic line. The stapler was next reloaded and used to close the resultant defect with another fire, while at the same time debriding the injured bowel wall. The technique was repeated with each injury until the small bowel was completely repaired and in continuity (Fig. 2). No attempts at resection were made, and there were no mesenteric defects to repair. Once this step was concluded, their abdomen was temporarily closed using the Abthera System (Acelity-KCI USA, San Antonio, TX, USA), and transported to the Surgical & Trauma Intensive Care (STIC) Unit for rewarming and resuscitation.

The patients were then scheduled for additional takebacks once their resuscitation was completed (usually 24–48 h after admission). The average number of takebacks before closure was 2 (1–4). Nine patients (all male) could not receive definitive closure of their abdominal fascia: four died before definitive closure was achieved, and five were managed by skin closure only. Four of them returned for Ventral Hernia repair and received a component-separation,

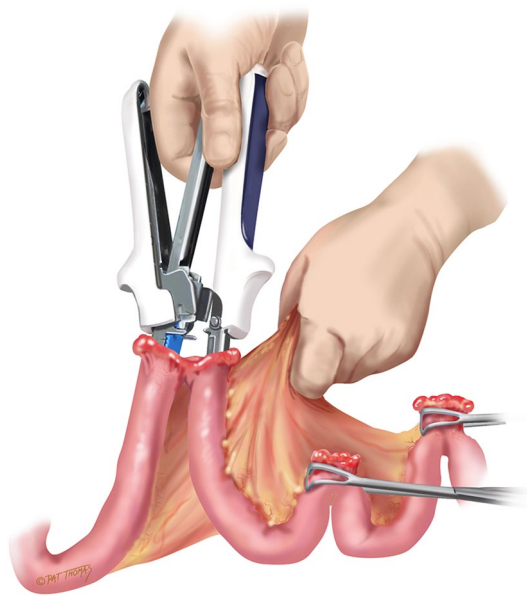


Fig. 1 First step during the modified Finney stapled enteroplasty: the legs of the instrument are introduced into each limb through the existing injury, guided by the dominant hand (right hand illustrated). Counter traction provided by the other hand. Illustration by Pat Thomas, CMI, FAMI

by the same surgeon. Inspection of the bowel during those reoperations showed no anomalies.

Complications are listed in Table 2. All five deaths on the study population were secondary to associated injuries: one missed thoracic esophageal injury, one GSW to the head, one failed popliteal repair leading to amputation, stump infection and septic shock, one paraplegic patient with hospital-acquired pneumonia and septic shock, and one pulmonary embolism (that occurred 3 days after fascial closure was achieved).

Discussion

John Miller Turpin Finney (1863–1942) was, by any standard of measure, the finest surgeon of his generation. A Harvard Medical School graduate and one of the first Halsted

Table 1 Patient Demographics

Patients	Number	Age	ISS	LOS (days)	EBL (ml)	Enterocutaneous fistula
Male	81	21 (14–52 years old)	18 (14.2)	16.9 (22.9)	630 (850.66)	None
Female	6	19 (15–23 years old)	9 (6.4)	8 (2.8)	480 (986.12)	None

Age expressed in median and range

ISS (injury severity score): values expressed as median and standard deviation

LOS (length of stay): values expressed as median and standard deviation

EBL (estimated blood loss): expressed in median and standard deviation

Enterocutaneous fistula during the hospital stay

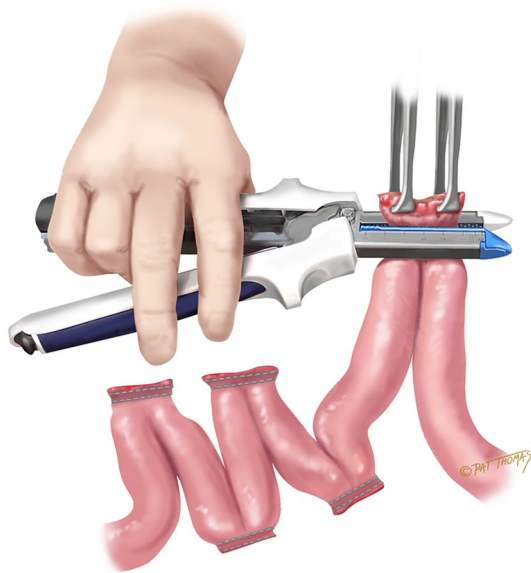


Fig. 2 Second step during the modified Finney stapled enteroplasty: once the instrument is fired and removed to complete Step 1, is then reloaded and applied as illustrated to close the enterotomy, while simultaneously providing debridement to the injury. When treating injuries in close proximity, is best to alternate the direction of the instrument firing, as depicted. This achieves a functional termino-terminal configuration. Illustration by Pat Thomas, CMI, FAMI

residents at the Johns Hopkins Hospital, he specialized in gastrointestinal surgery, leading his name to several surgical techniques including the one under discussion now. He

went on to become the founder and first president of the American College of Surgeons, and by the time of his death his name has been considered at various points for the Presidency of Princeton University, the chairmanship at Hopkins and as a Senator for the state of Maryland. Likewise, his Finney Pyloroplasty technique has been adapted for strictureplasty (in Crohn’s disease) and now for bowel sparing GSW reconstructions.

The two main differences in between blunt and penetrating intestinal trauma is the mechanism of disruption of the intestinal wall and the degree of destruction of the mesenteric pedicles. Whereas in a GSW or SW the injuring force is highly localized, and often there is a clear cut in the bowel wall, with bleeding borders and localized (at least initially) contamination; blunt traumatic bowel injuries frequently disrupt both the wall and the underlying mesentery, creating either massive (read exsanguinating) bleeding or severe intimal vessel damage, rendering the damaged bowel both irreparable and ischemic [10]. This coupled with the intense contamination of the area mandates a second look reconstruction after the initial resection. Ironically, the blunt damaged segments are often much shorter than the total amount of bowel involved in a GSW with a long intra-abdominal trajectory, hence the opportunity to spare bowel length is much higher in penetrating trauma by adopting this technique.

Technical considerations during surgery include the location of the injury in the bowel and the instruments required for use. While the illustrations show injuries located on the antimesenteric side, juxtamesenteric injuries are (once all bleeding is under control) treated in a similar way. Care must

Table 2 Complications

Complications	Number	Percentage (%)
Intra-abdominal abscess (after closure was achieved) ^a	4	5
Missed injuries (esophageal-mortality)	1	1
Deep venous thrombosis (one pulmonary embolism-mortality) ^b	5	6
Bullet tract infection and other SSSI’s ^c	6	7
Empyema (secondary to retained hemothorax)	2	3
Vascular repair failure (mortality)	1	1
C-difficile-related colitis	1	1
Cerebral edema with herniation (mortality)	1	1
Pneumonia	3	4
Mortalities	4	5

^aAll four patients had additional colonic injuries, that were repaired primarily. Abscesses were drained by interventional radiology successfully

^bUpon review of the medical record, all patients with DVT’s had received mechanoprophylaxis with sequential compression devices and chemoprophylaxis with low molecular weight heparin in compliance with our current clinical guidelines

^cThis was the most common form of infection and the most common complication. Bullet tracts were treated with surgical irrigation and washout in the operating room and (whenever feasible) packed with iodoform gauze, that was then removed 48 h later during wound inspections. Projectiles were removed only if accessible

be taken to direct the surfaces of the cartridge and the anvil of the instrument towards the antimesenteric margin; the second step is otherwise identical. When selecting a cartridge size for the procedure, aim is to create a final anastomosis of no less than 3 cm in diameter. Using the 50–55-mm cartridges for the first step will result (after the second step, which is the combined closure of the enterotomy and debridement of the intestinal wall) in an anastomotic junction that is too narrow and tight that may result in iatrogenic small bowel obstruction, especially considering the fact that the bowel will experience significant edema in the postoperative period (due the combination of the traumatic injury, the surgical trauma and the resuscitation).

In regards to cost, whereas it is true that silk is cheaper than steel and plastic, the time savings in the operative time (especially when the number of enterotomies is greater than 3) more than offset this initial cost [11]. Any intervention that saves the patient from a future of TPN or bowel transplantation is a significant cost saving, as our group has already shown [11].

Conclusion

The technique for modified Finney enteroplasty (as depicted here) is a useful adjunct for damage control after penetrating trauma for gunshot wounds. It preserves surgical speed, while avoiding small bowel anastomotic disruptions (even during and after the use of open abdomen techniques), and potential postoperative short bowel syndrome.

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Compliance with ethical standards

Conflict of interest The author declares that he has no conflict of interest.

Research involving human participants and/or animals All procedures performed in studies involving human participants in our facilities are carried out in accordance with the ethical standards and policies of the institutional review board, and with the 1964 Helsinki declaration and its later amendments. For this type of retrospective study a formal

research consent is not required. This article does not contain any studies with animals performed by the author.

Informed Consent In the presence of the author, each patient (or his/her legal representative when it applies, and when feasible) included in this study has signed an informed consent to the surgical procedure, which underlines that the procedures adheres to the ethical and medical standard criteria and in which the patient also gives permission for medical data to be used (in de-identified and/or aggregated form) for scientific purposes, including publications.

References

1. Waibel BH, Rotondo MM (2012) Damage control surgery: it's evolution over the last 20 years. *Rev Col Bras Cir* 39(4):314–321
2. Glance LG, Osler TM, Mukamel DB, Dick AW (2012) Outcomes of adult trauma patients admitted to trauma centers in Pennsylvania, 2000–2009. *Arch Surg* 147:732–737
3. Christensen N (1982) Small bowel and mesentery. In: Blaisdell FW, Trunkey DD (eds) *Trauma management. I. Abdominal trauma*. Thieme-Stratton, New York, pp 149–163
4. Adesanya AA, da Rocha-Afodu JT, Ekanem EE, Afolabi IR (2000) Factors affecting mortality and morbidity in patients with abdominal gunshot wounds. *Injury* 31(6):397–404
5. Ke J, Wu W, Lin N, Yang W, Cai Z, Wu W, Chen D, Wang Y (2017) A novel method for multiple bowel injuries: a pilot canine experiment. *World J Emerg Surg*. 12:44. <https://doi.org/10.1186/s13017-017-0155-0> (eCollection 2017)
6. Behrman SW, Bertken KA, Stefanacci HA, Parks SN (1998) Breakdown of intestinal repair after laparotomy for trauma: incidence, risk factors, and strategies for prevention. *J Trauma* 45(2):227–231 (discussion 231–3)
7. Burlew CC, Moore EE, Cuschieri J, Jurkovich GJ, Codner P, Crowell K, Nirula R, Haan J, Rowell SE, Kato CM, MacNew H, Ochsner MG, Harrison PB, Fusco C, Sauaia A, Kaups KL (2011) WTA Study Group: Sew it up! A Western Trauma Association multiinstitutional study of enteric injury management in the postinjury open abdomen. *J Trauma* 70(2):273–277. <https://doi.org/10.1097/TA.0b013e3182050eb7>
8. Thompson JS (2000) Comparison of massive vs. repeated resection leading to short bowel syndrome. *J Gastrointest Surg* 4(1):101–104
9. Dabney A, Thompson J, DiBaise J, Sudan D, McBride C (2004) Short bowel syndrome after trauma. *Am J Surg* 188(6):792–795
10. Dauterive AH, Flancbaum L, Cox EF (1985) Blunt intestinal trauma. A modern-day review. *Ann Surg* 201(2):198–203
11. Benedetti E, Testa G, Sankary H et al (2004) Successful treatment of trauma-induced short bowel syndrome with early living related bowel transplantation. *J Trauma* 57(1):164–170