

Gunshot wound to big red

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Maryland, USA**Correspondence to**Dr David V Feliciano;
davidfelicianomd@gmail.com**HISTORY**

A 22-year-old man presented to the trauma center with a single gunshot wound to the right upper quadrant. The patient's systolic blood pressure was reported to be 80 mm Hg in the field.

EXAMINATION

The patient was alert and responsive on arrival. His initial vital signs were a heart rate of 120 beats per minute, a systolic blood pressure of 138 mm Hg, and a respiratory rate of 20/min. His abdominal examination was significant for a gunshot wound approximately 10 cm inferior to the right costal margin and 6 cm lateral to the midline. In addition, his abdomen was distended and diffusely tender to palpation.

MANAGEMENT

After blood was drawn for type and cross-match, the patient was moved to the operating room. A massive transfusion protocol was initiated, and a cephalosporin antibiotic was administered. After intubation, a midline exploratory laparotomy was performed. A significant hemoperitoneum was evacuated. At this point, the anesthesiologist stated that the patient's systolic blood pressure had dropped to 80 mm Hg. On rapid inspection of the abdominal cavity, through-and-through wounds to the prepyloric gastric antrum, through-and-through wounds to the head of the pancreas, and a large midline supramesocolic hematoma were noted. Division of the gastrocolic omentum allowed for exposure and suture repair of the anterior and posterior holes in the prepyloric antrum. A few peripancreatic bleeders were ligated as the head of the pancreas was inspected. The location of the through-and-through wounds in the head of the pancreas suggested that neither the common bile duct nor the main pancreatic duct of Wirsung was injured.

QUESTION

The most appropriate next step at operation is:

- Left anterolateral thoracotomy/cross-clamp descending thoracic aorta
- Add median sternotomy to midline laparotomy incision
- Left medial mobilization maneuver
- Cattell-Braasch maneuver

MANAGEMENT

At this point, the midline supramesocolic hematoma was larger than when first observed. It was approached by a left medial mobilization maneuver after division of the line of Toldt lateral to the sigmoid and descending colons. Retroperitoneal

finger dissection posterior to the hematoma by the surgeon on the right side of the operating table was combined with use of a Metzenbaum scissors by the assistant on the left side. As the descending colon, splenic flexure, left kidney, spleen and tail/body of the pancreas, and the fundus of the stomach were elevated, considerable arterial bleeding was noted to be coming from the upper midline retroperitoneum. Laparotomy pad compression was partially successful in controlling this hemorrhage. A finger was inserted into the left side of the aortic hiatus of the diaphragm at the 2 o'clock position, and the electrocautery was used to divide 10 cm of the left hemidiaphragm in a radial fashion. After the distal descending thoracic aorta was visualized, a DeBakey aortic clamp was applied for proximal vascular control. Much of the arterial hemorrhage stopped at this point. With some dissection above the vertebral bodies at this level, a large posterior laceration of the supraceliac abdominal aorta was noted. This laceration did not appear to be amenable to a suture repair. A second aortic cross-clamp was then applied just distal to the origin of the celiac axis, and the patient's systolic blood pressure rose to 100 mm Hg over the next several minutes.

QUESTION

The most appropriate management of the large laceration in the posterior supraceliac abdominal aorta is resection and:

- Insertion of a thoracostomy tube as an intravascular shunt
- Insertion of a nonporous vascular prosthesis
- Insertion of a spiral vein graft constructed from the greater saphenous vein
- Insertion of a borrowed segment of the infrarenal inferior vena cava

MANAGEMENT

The celiac axis was divided between clamps and ligated. The injured segment of the supraceliac abdominal aorta was then resected between the aortic clamps. A 16 mm polytetrafluoroethylene (PTFE) tube graft was sewn in place with 3-0 polypropylene sutures. Before the distal anastomosis was completed, proximal and distal flushing of the aorta was performed. The distal DeBakey aortic clamp was not replaced to allow for evacuation of air from under the suture line before the final knot in the anastomosis was tied down. After gradual removal of the proximal DeBakey aortic clamp, arterial flow to the lower half of the body was re-established. Unfortunately, the patient's systolic blood pressure dropped from 90 mm Hg to 60 mm Hg at this point. Rapid infusion of packed red blood cells, crystalloid solutions, and 200 mEq of sodium bicarbonate over

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10 min gradually improved the patient's systolic blood pressure to 90 to 100 mm Hg.

A closed suction drain was placed near the wounds in the head of the pancreas. Because of diffuse oozing (presumed nonmechanical bleeding), intra-abdominal packing with laparotomy pads was performed and a plastic silo bag was sewn to the skin edges of the midline abdominal incision.

In the postoperative period, the patient's coagulopathy was corrected while episodes of hypotension were treated with the infusion of crystalloid solutions as the hemoglobin was stable. The patient was returned to the operating room on the second postoperative day. After removal of the laparotomy pads, the left hemidiaphragm and the left side of the aortic hiatus were repaired with 0 polypropylene sutures. A viable pedicle of omentum was mobilized and placed through the bullet track in the head of the pancreas, and the retroperitoneum was closed over the PTFE graft in the supraceliac aorta. A skin only closure of the abdominal incision completed the operation.

The patient's third operation on the 10th postoperative day included a washout, insertion of clean closed suction drains adjacent to the head of the pancreas, and closure of the musculoaponeurotic layer of the abdominal wall. The subsequent postoperative course was complicated by the following: left pleural effusion; infected (MRSA and *Acinetobacter*) pancreatic fistula and peripancreatic fluid collection; need for repeated manipulation of the peripancreatic drains; inadvertent removal of one peripancreatic drain; urinary tract infection (*Acinetobacter*); a sacral decubitus. His care during this period was further complicated by his refusal to have abdominal CT scans on "six" separate occasions. The patient was discharged from the hospital on the 46th post-injury day and immediately taken into custody by the police.

DISCUSSION

Injuries to the diaphragmatic, supraceliac, or visceral abdominal aorta are rarely seen in trauma centers, presumably because many patients exsanguinate at the scene. Therefore, the majority of patients with vital signs who arrive in the trauma center with an injury in this location will have a large midline supramesocolic hematoma exerting a tamponade effect.^{1,2}

An increasing number of trauma centers around the world would have inserted a Resuscitative Endovascular Balloon Occlusion of the Aorta (REBOA) device in zone I in this patient with prehospital hypotension before transfer to the operating room.³ The patient described, however was treated in the pre-REBOA era.

On occasion, direct proximal control of the abdominal aorta (rather than left medial mobilization) as needed for open repair of ruptured abdominal aortic aneurysms might be required if the midline supramesocolic hematoma described earlier has ruptured. This can be accomplished by use of an aortic compression device if there is some space between the aortic hiatus of the diaphragm and the area of injury.⁴

The other option is to have the assistant place traction to the left on the lesser curve of the stomach as the surgeon manually breaks through the lesser omentum away from the nerves of Laterjet. The surgeon then moves his or her left hand posteriorly until the pulsations in the supraceliac abdominal aorta and the muscle fibers of the aortic hiatus of the diaphragm are palpated. Using the fingers, a stripping motion on either side of the supraceliac abdominal aorta will separate away some of the fibers of the hiatus to allow for a more superior placement of a DeBakey aortic clamp using the surgeon's right hand.⁵

An intact supramesocolic hematoma allows for more time to obtain proximal aortic control using the left medial mobilization maneuver. Originally described as part of a thoracoabdominal approach to elective repair of four thoracoabdominal aneurysms by DeBakey *et al*, this technique has now been widely used in elective and trauma vascular surgery to expose the proximal abdominal aorta for 65 years.⁶ Disadvantages of the left medial mobilization maneuver have been well described and include the following: (1) 5–7 min time period to perform the maneuver; (2) risk of iatrogenic injury to the spleen, left kidney, or posterior renal artery during mobilization of these structures; (3) creation of a fold in the visceral abdominal aorta caused by anterior rotation of the left kidney.⁷ In the patient described, the area of injury was in the supraceliac abdominal aorta. Therefore, there was no need, in retrospect, to mobilize the left kidney during the medial mobilization.

Division of the left side of the aortic hiatus of the diaphragm as was performed in the patient described is a useful adjunct. It allows for visualization of the distal descending thoracic aorta proximal to the celiac ganglia and extensive lymphatics that cover the supraceliac aorta. One helpful technical point is to mark the midpoint of the phrenotomy on either side with a metal clip. This will aid in the repair of the hemidiaphragm when the patient is hemodynamically stable.

As most penetrating injuries to the celiac axis are managed with ligation, the choice of intentional division and ligation of this vessel for improved exposure was appropriate in the patient described. This option should always be considered when there are wounds to the immediately adjacent proximal superior mesenteric artery or the visceral abdominal aorta.

The combination of an injury to the gastrointestinal tract and any major abdominal artery increases the risk of a postoperative infection of the vascular repair, particularly if an interposition graft has been inserted. Options to avoid the use of a plastic graft in the suprarenal or infrarenal abdominal aorta described in the literature over the past 25 years include the following: (1) handmade spiral vein graft from the greater saphenous vein; (2) borrowed segment of infrarenal inferior vena cava; (3) a patch of bovine pericardium tailored to form a tube graft.⁷ Unfortunately, all of these options are very time consuming in the middle of a major trauma laparotomy with the abdominal aorta clamped. With time a factor, almost all patients have had woven Dacron, albumin-coated Dacron, or PTFE graft insertion into the suprarenal or infrarenal abdominal aorta during trauma laparotomies over the past 45 years.⁸ The graft infection rate is unknown as there are so few survivors of graft repair of the abdominal aorta in the American literature. In addition to perioperative antibiotics, operative maneuvers to decrease the risk of a postoperative suture, patch, or graft infection include the following: (1) clamping, stapling, or isolating injuries to the gastrointestinal tract under folded laparotomy pads during the vascular repair; (2) antibiotic irrigation of the operative field around the injured vessel before and after the vascular repair; (3) closure of the retroperitoneum over the abdominal aorta no matter what type of repair has been performed. Absence of adequate retroperitoneum to cover a graft in the suprarenal or infrarenal abdominal aorta should prompt coverage with a mobilized viable pedicle of gastrocolic omentum. This pedicle can be placed "backwards" into the lesser sac and then through the transverse mesocolon or passed laterally around the ligament of Treitz into the retroperitoneum.⁹

After declamping and restoring arterial flow through the newly inserted PTFE prosthesis, the patient had a period of hypotension. One reason for this would be rapid redistribution

of the available blood volume. Another would be the “washout acidosis” or “hyperkalemia-acidosis” syndrome well known to all elective aortic surgeons. This syndrome is presumably due to the death of cells from ischemia in tissues distal to the aortic cross-clamp, the release of potassium from these cells, and a metabolic acidosis from ischemia and hyperkalemia. This syndrome is minimized in emergent or elective open aortic surgery by the infusion of blood or crystalloid solutions and ampules of sodium bicarbonate prior to gradual release of the aortic cross-clamp.

The survival rate after injuries to the suprarenal aorta during the 1970s to the 1990s was 35%.^{7–10} In one review in 2001, the survival rate was only 8.3%.¹¹ Another review of 24 patients from 2007 noted a survival rate of 24% if patients dead on arrival were excluded.¹²

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REFERENCES

1. Feliciano DV, Moore EE, Biffl WL. Western Trauma Association critical decisions in trauma: management of abdominal vascular trauma. *J Trauma Acute Care Surg* 2015;79:1079–88.
2. Richards AJ, Lamis PA, Rogers JT, Bradham GB. Laceration of abdominal aorta and study of intact abdominal wall as tamponade: report of survival and literature review. *Ann Surg* 1966;164:321–4.
3. Brenner M, Inaba K, Aiolfi A, DuBose J, Fabian T, Bee T, Holcomb JB, Moore L, Skarupa D, Scalea TM, et al. Resuscitative endovascular balloon occlusion of the aorta and resuscitative thoracotomy in select patients with hemorrhagic shock: early results from the American Association for the Surgery of Trauma’s Aortic Occlusion in Resuscitation for Trauma and Acute Care Surgery Registry. *J Am Coll Surg* 2018;226:730–40.
4. Conn J, Trippel OH, Bergan JJ. A new atraumatic aortic occluder. *Surgery* 1968;64:1158–60.
5. Veith FJ, Gupta S, Daly V. Technique for occluding the supraceliac aorta through the abdomen. *Surg Gynecol Obstet* 1980;151:426–8.
6. DeBakey ME, CREECH O, MORRIS GC. Aneurysm of thoracoabdominal aorta involving the celiac, superior mesenteric, and renal arteries; report of four cases treated by resection and homograft replacement. *Ann Surg* 1956;144:549–73.
7. Feliciano DV, Asensio JA. Abdominal vessels. In: Feliciano DV, Mattox KL, Moore EE, *Trauma*. Ninth Edition. New York: McGraw-Hill: publication pending.
8. Rubio PA, Reul FJ. Tube graft replacement of the suprarenal aorta with implantation of the superior mesenteric artery. *Vasc Surg* 1977;11:304–7.
9. Bunt TJ, Doerhoff CR, Haynes JL. Retrocolic omental pedicle flap for routine plication of abdominal aortic grafts. *Surg Gynecol Obstet* 1984;158:591–2.
10. Accola KD, Feliciano DV, Mattox KL, Bitondo CG, Burch JM, Beall AC, Jordan GL. Management of injuries to the suprarenal aorta. *Am J Surg* 1987;154:613–8.
11. Tyburski JG, Wilson RF, Dente C, Steffes C, Carlin AM. Factors affecting mortality rates in patients with abdominal vascular injuries. *J Trauma* 2001;50:1020–6.
12. Deree J, Shenvi E, Fortlage D, Stout P, Potenza B, Hoyt DB, Coimbra R. Patient factors and operating room resuscitation predict mortality in traumatic abdominal aortic injury: a 20-year analysis. *J Vasc Surg* 2007;45:493–7.