

Vascular Damage Control Approach Using Direct Deployment of Self-Expanding PTFE Stent Graft as an Alternative to Intra-Arterial Shunt

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The use of intravascular shunts for damage control purposes has been well described both in the battlefield and in the civilian environment. In this report, we present a case in which a self-expanding polytetrafluoroethylene (PTFE) stent graft was used as an alternative to traditional damage control intra-arterial shunt to successfully control bleeding and reestablish arterial flow in the aortoiliac segment. A 50-year-old male presented in extremis after sustaining multiple abdominal gunshot wounds. After resuscitative thoracotomy, laparotomy demonstrated transection of the right common iliac artery at its origin, destructive pancreatoduodenal injury with associated superior mesenteric vein injury, and multiple small bowel and colonic injuries. Because of the location of the injury at the aortoiliac junction, temporary intra-arterial shunt placement was not possible as no residual iliac cuff was available to secure a tie around the shunt proximally. A self-expanding PTFE stent graft was introduced and directed across the injury under direct visualization and deployed to bridge the defect from the aortic bifurcation to the right common iliac artery. After deployment, the stent was hemostatic and pulses were palpable in bilateral iliac and common femoral arteries. The associated intra-abdominal injuries were addressed and the abdomen packed and temporarily closed. Total operative time was 65 minutes. After a 4-hour period of resuscitation in the ICU, the patient became hemodynamically unstable and was re-explored. Diffuse bleeding was identified in all raw surfaces of the retroperitoneum, abdominal wall and chest wall. The area of the stent was hemostatic. The right colon was massively dilated from intraluminal bleeding, so a right hemicolectomy was performed. Despite resuscitative efforts and more than 100 units of blood products the patient expired. In this report, we described the use of direct endovascular repair using a self-expanding PTFE stent graft in the aortoiliac location as an alternative to temporary intra-arterial shunt placement. This technique allowed quick hemostasis and reestablishment of arterial flow in an area in which traditional intra-arterial shunts would not be feasible.

Keywords: *Abdominal Vascular Injury; Gunshot Wound; Endovascular; Stent; Damage Control; Intravascular Shunt*

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INTRODUCTION

Aortoiliac injuries are commonly associated with massive blood loss and high mortality rates ranging from 43% to 82% [1–3]. For patients who reach the hospital alive, the presence of shock, acidosis, and associated injuries pose significant challenges to the resuscitation efforts and definitive management of these complex injuries [1].

The role of damage control surgery is well established for patients in whom definitive repair cannot be achieved at the time of presentation due to precarious physiologic condition and/or overwhelming injury burden.

In addition to hemorrhage and contamination control, maintenance of arterial flow is important to preserve limb and life. Although ligation is the most straightforward damage control strategy for vascular injuries, the interruption of arterial flow may result in limb loss or death. For critically ill patients, however, definitive vascular reconstruction may not be possible at the initial operation, particularly if a significant burden of associated injuries is present. In those cases, time-consuming reconstructions may aggravate the commonly present triad of acidosis, hypothermia, and coagulopathy, resulting in further morbidity or death. The use of intravascular shunts for damage control purposes has been well described both in the battlefield and in the civilian environment [4–7]. These intravascular shunts can temporarily reestablish blood flow until definitive vascular repair is possible.

In this report, we present a case in which a self-expanding polytetrafluoroethylene (PTFE) stent graft was used as an alternative to traditional damage control intra-arterial shunt to successfully control bleeding and reestablish arterial flow in the aortoiliac segment.

CASE DESCRIPTION

A 50-year-old male presented to the emergency room after sustaining multiple abdominal gunshot wounds. Pre-hospital time was 18 minutes. Upon arrival, the patient was in extremis without palpable pulses. After cardiac motion was identified on ultrasound, a left anterolateral resuscitative thoracotomy was performed with cross-clamping of the descending thoracic aorta and internal cardiac massage concurrently with venous access establishment and massive transfusion protocol initiation. Return of spontaneous cardiac activity was identified and the patient was taken emergently to the operating room.

The abdominal cavity was entered through a midline laparotomy, and massive hemoperitoneum was encountered and evacuated. Active bleeding from the area of the aortic bifurcation was identified. The bleeding was controlled with direct manual pressure and the retroperitoneum was exposed with a Cattell-Braasch maneuver. Complete transection of the right common iliac artery at its origin from the aorta was identified. Vascular clamps were applied to the infrarenal aorta and to the left common iliac artery, controlling the bleeding and allowing removal of the thoracic aortic cross-clamp and quick assessment of the additional intra-abdominal injuries, which were extensive including a complex duodenopancreatic injury and multiple small bowel and colonic injuries.

While ongoing balanced ratio blood product resuscitation was being performed, the need for damage control approach was determined. The area of the duodenopancreatic complex was packed to control active bleeding and attention was redirected to the aortoiliac injury.

Because of the location of the injury at the aortoiliac junction, temporary intra-arterial shunt placement would not be possible as no residual iliac cuff was available to secure a tie around the shunt proximally. The decision was made to proceed with a self-expanding PTFE stent graft to bridge the defect from the aortic bifurcation to the right common iliac artery.

First, a Fogarty thromboembolectomy catheter was passed distally into the right common iliac artery and a small amount of thrombus retrieved resulting in brisk back bleeding from the right common iliac artery. Heparinized saline solution was locally injected into the right common iliac artery and a vascular clamp applied. Systemic heparinization was not performed. Using Seldinger technique the infrarenal aorta was directly accessed with a micropuncture access kit in an antegrade fashion and a 5 Fr micro sheath introduced over the wire. A 0.035" J wire was advanced into the aorta and manually directed through the injury and into the right common iliac artery under direct visualization. The 5 Fr sheath was exchanged over the wire for a 12 Fr sheath and a 13 mm × 100 mm self-expanding PTFE stent graft (Viabahn Endoprosthesis, WL Gore & Associates, Flagstaff, AZ) was introduced and directed across the injury under direct visualization. For stent sizing, we decided to use a diameter to achieve approximately 20–30% common iliac oversizing and length to bridge the gap between the aorta and the right common iliac artery without covering the right internal iliac artery. Stent position was confirmed with manual palpation and direct visualization. The stent was successfully deployed under direct visualization (Figure 1) and the deployment system removed through the sheath. Vascular clamps were then released and flow reestablished. Palpable pulses were confirmed in bilateral iliac arteries and bilateral common femoral arteries. No significant bleeding was identified at the proximal and distal stent attachment sites. To avoid migration of the stent at the proximal attachment site, the stent was secured to the arterial wall with three stitches using 6-0 polypropylene suture. The wire and sheath were removed from the aorta and hemostasis at the access site achieved with a 5-0 polypropylene stitch.

After the aortoiliac injury had been controlled and flow reestablished to the right lower extremity, the remainder of the intra-abdominal injuries were fully addressed. Complete assessment of the duodenopancreatic region revealed a destructive pancreatic head injury with associated superior mesenteric vein (SMV) injury and devascularization of the second and third portions of the duodenum. The SMV was primarily repaired with a running suture of 6-0 polypropylene and a duodenopancreatectomy was performed and left in discontinuity. Multiple small bowel resections and a sigmoidectomy were then performed using GIA staplers and left in discontinuity. The retroperitoneum was packed and a negative pressure dressing was placed over both the midline

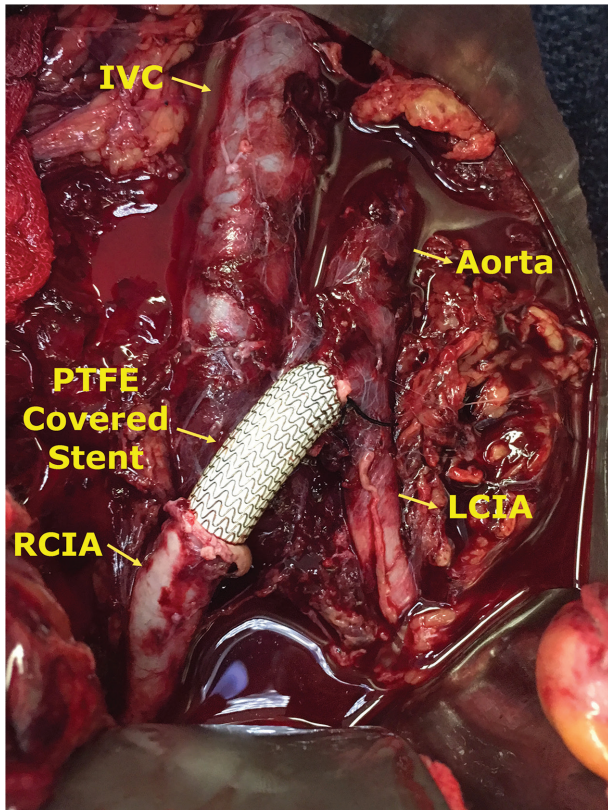


Figure 1. Self-expanding PTFE stent graft successfully deployed, bridging the gap between the aorta and the right common iliac artery and achieving adequate hemostasis. IVC, inferior vena cava; RCIA, right common iliac artery; LCIA, left common iliac artery.



Figure 2. Blood products being used as part of the massive transfusion protocol.

laparotomy and left thoracotomy sites for temporary closure. Total operative time was 65 minutes.

The patient was taken to the surgical intensive care unit (ICU) for ongoing resuscitation, with the intent of returning him to the operating room as soon as the coagulopathy, acidosis, and hypothermia were corrected. In the ICU, he continued to require multiple blood products for hemodynamic instability and diffuse bleeding. Although this bleeding and his acidosis had improved initially, over the next four hours his condition became unstable again, thus warranting immediate re-exploration. Upon return to the operating room, diffuse bleeding was identified in all raw surfaces of the retroperitoneum, abdominal wall and chest wall. There was no evidence of bleeding in the area of the stent. The right colon was found to be massively dilated from intraluminal bleeding. A right hemicolectomy was performed. The patient briefly lost pulses but regained them with initiation of advanced cardiovascular life support protocol and internal cardiac massage. However, his diffuse coagulopathy resulted in continuous diffuse bleeding from all raw surfaces. While packing was being performed to control the diffuse bleeding another episode of asystole occurred. Despite resuscitative efforts

and more than 100 units of blood products at this point (see Figure 2), the patient expired.

DISCUSSION

Although the use of intravascular shunts can be traced back to the early part of the previous century [6] the demonstration of its safety as a temporary bridge for definitive vascular repair did not occur until they began to be used as part of a damage control strategy in the battlefields of Iraq and Afghanistan. Since then, safe and successful use of intravascular shunts as part of a damage control strategy has been demonstrated in the military as well as in the civilian setting [4–7].

In this report, we described the use of direct endovascular repair using a self-expanding PTFE stent graft in the aortoiliac location as an alternative to temporary intra-arterial shunt placement. This technique allowed quick hemostasis and reestablishment of arterial flow in an area in which traditional intra-arterial shunts would not be feasible. Although this patient did not survive due to the extreme severity of his injuries and physiologic derangement, the use of the aforementioned technique is noteworthy as it allowed quick and effective

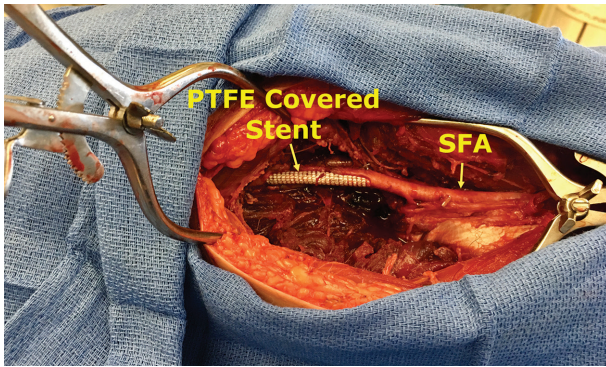


Figure 3. Self-expanding PTFE stent graft directly deployed in the femoropopliteal segment. SFA, superficial femoral artery.

control of his major arterial injury, respecting damage control principles.

A similar approach has been described for extremity vascular trauma by Davidson et al., who elegantly described their proposed technique of direct site deployment of self-expanding stent grafts as an alternative to shunting [8]. Their proposed technique involves removing the endoprosthesis from the deployment system and inserting the stent directly into the injured vessel and deploying the device under direct visualization. In our case, wire advancement across the injured segment under direct visualization using antegrade aortic wire access resulted in a safe platform for stent positioning and deployment. This allowed quick stent deployment without the need for fluoroscopy and avoided the back-table preparation of the device described by Davidson et al. In fact, we have recently used the technique presented in this case report in the femoropopliteal segment with success (Figure 3).

Potential limitations of this technique include the possibility of inaccurate stent deployment with coverage of the right internal iliac artery if deployed too low and jailing of the left common iliac artery if deployed too high, extending far into the aorta. Unilateral coverage of the internal iliac artery in this scenario would carry minimal consequence. Occlusion of the left common iliac artery, on the other hand, would not be acceptable and stent removal would be required.

Had this patient survived to definitive repair, a decision would have to be made regarding management of the stent graft. Because of the limited proximal seal zone, the possibility of distal migration would be high. After adequate resuscitation, the options for definitive repair would include removal of the stent graft and in-situ repair with a synthetic graft or an extra-anatomical bypass followed by stent removal, primary closure of the aorta and ligation of the right common iliac artery. Due to the extensive contamination and the significant risk of pancreatic leak after Whipple reconstruction, our preference would be to create a femoro-femoral bypass with an 8 mm PTFE graft followed by stent removal, primary

closure of the aorta and ligation of the right common iliac artery.

Mortality for patients requiring damage control intra-arterial shunts for truncal vascular injuries is higher (50%) compared to those patients in which the shunt is used in peripheral vessels (10%) [7]. The presence of complex associated intracavitary injuries such as those exemplified in the reported case is likely the reason for that higher mortality [1].

A significant proportion of patients with penetrating abdominal vascular injuries die prior to reaching the hospital. Ball et al. demonstrated that a decrease in pre-hospital time was associated with both an increase in the incidence and mortality of abdominal vascular injuries [9]. In the case presented here, a resuscitative thoracotomy was performed for a patient with abdominal gunshot wounds who was pulseless on arrival to the hospital after a short pre-hospital time. Because the survival rate for patients undergoing resuscitative thoracotomy for penetrating abdominal vascular injury is 2% [3] critics of resuscitative thoracotomy indication may view this intervention as futile in this setting. At our institution, however, we have a liberal indication policy for resuscitative thoracotomy, but use the presence of cardiac activity on ultrasound to select those patients who may have a chance of survival [10].

The use of endovascular devices and techniques for the management of traumatic vascular injuries is one of the most exciting developments in the field of trauma care. The endovascular approach has become the primary treatment modality for blunt thoracic aortic injuries [11–14] and there is growing interest in the application of endovascular strategies in other arterial anatomic locations, particularly those areas of challenging access [15–19]. As the field of endovascular surgery continues to expand, advances in equipment and technique follow, and surgeons experience develops, opportunities for creative application of these techniques, devices, and strategies will become commonplace in the care of the injured patient.

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