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Endovascular treatment of a penetrating injury of the suprarenal inferior vena cava

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ABSTRACT

In this case, a 22-year-old man sustained multiple gunshot wounds to the abdomen, which required in extremis surgical exploration with damage control laparotomy and hemostatic resuscitation in the surgical intensive care unit. Diagnostic angiography was negative and an inferior vena cava (IVC) injury was suspected. He was returned to the operating room, where the infrarenal IVC was accessed by direct puncture and venography demonstrated active extravasation of the suprarenal vena cava. The injury was successfully sealed with two overlapping endovascular aortic grafts, with care taken to preserve flow from the renal and hepatic veins. He made a full recovery and was discharged home on hospital day 20. Outpatient follow-up computed tomography at 2 months revealed a patent stent with preserved branches. Stent graft repair of penetrating IVC injury can be lifesaving and warrants further investigation. (J Vasc Surg: Venous and Lym Dis 2019;7:247-50.)

Keywords: Inferior vena cava; Injury; Endovascular; Stenting

Inferior vena cava (IVC) injuries are encountered in almost 5% of exploratory laparotomy in large trauma series. Such injuries carry a dismal prognosis with mortality >50% in the field, of which 75% is directly secondary to exsanguination. Patients who reach a hospital and undergo operative intervention die in 30% of cases within 24 hours.[1,2]

Whereas manual tamponade[3] and shunting[4-6] enable temporary hemorrhage control, conventional approaches to definitive repair are marked by difficulty of exposure and visualization in the setting of concomitant injuries along with morbid complications. In fact, ligation of the IVC significantly increases the need for early fasciotomy.[7] Primary venorrhaphy remains challenging even in spite of adjunct balloon endovascular occlusion.[8,9]

Currently, 16% of traumatic arterial injuries are managed by endovascular techniques, mostly represented by direct intra-arterial embolization.[10] However, few venous stent repairs are described. In this case, intraoperative details of endovascular repair of a penetrating suprarenal IVC injury and perioperative outcomes are reported. The patient's consent was obtained to report this case.

CASE REPORT

Presentation of the patient and initial exploration. This patient is a 22-year-old man without past history who presented to a level I trauma center with multiple gunshot wounds to the epigastrium, right costovertebral angle, and left medial thigh. On initial assessment, the patient was found to be unstable; a focused assessment with ultrasound for trauma was positive for fluid in the subhepatic recess (Morison pouch). With the combination of hemodynamic instability and penetrating injury, he was emergently taken for a damage control trauma laparotomy, at which massive hemorrhage was noted. Four-quadrant and pelvic packing was performed along with open portal venous repair. After temporary abdominal closure, the patient was transferred to the surgical intensive care unit with improved hemodynamics for continued hemostatic resuscitation including 58 units of blood products.

Endovascular repair of IVC injury. In the surgical intensive care unit, recurrent hemodynamic instability prompted aortic angiography. A negative result (Fig 1) was followed by immediate return to the operating room. On re-exploration, an emergent vascular surgery consultation was requested for ongoing hemorrhage thought to arise from the IVC. After adequate yet difficult exposure further obscured by coagulopathy, without clear identification of the level of injury, primary venorrhaphy was not possible. The decision was therefore made to proceed with hybrid endovascular stent graft repair with open access to the infrarenal IVC.

A 6F sheath was placed in the most distal portion of the IVC just above its bifurcation over a 0.035-inch J-wire for diagnostic venography. After confirmation of extravasation of contrast material along the right posterolateral aspect of the suprarenal

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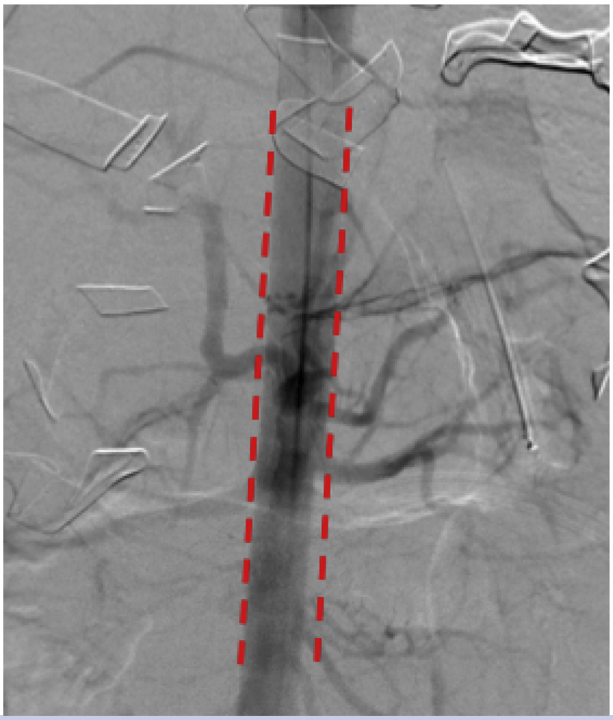

Fig 1. Aortic angiogram negative for extravasation of contrast material. The *dashed red lines* mark the contours of the aorta.

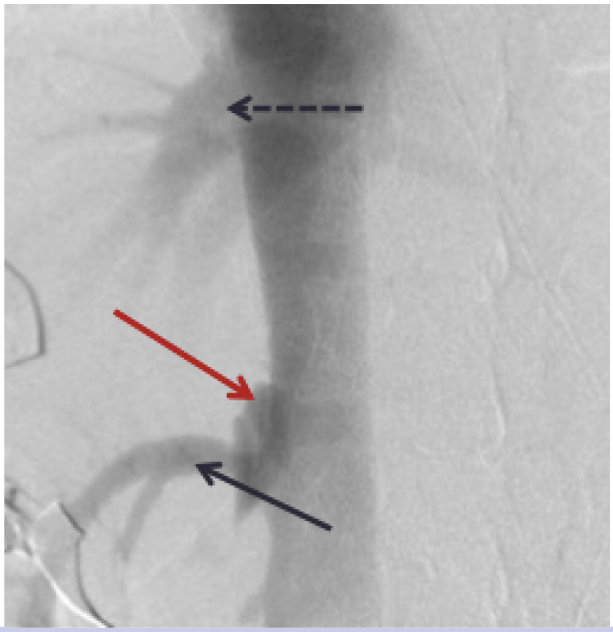

Fig 2. Intraoperative venogram positive for extravasation demonstrated by the *red arrow*. Patent hepatic and right renal veins are marked by the *dashed arrow* and *black arrow*, respectively.

IVC (Fig 2), the sheath was upsized to 18F to enable device delivery. After approximate sizing based on initial venography, proximal 28- × 82-mm and distal 28- × 28- × 70-mm Endurant (Medtronic, Santa Rosa, Calif) covered stents were deployed in sequence between the hepatic and renal IVC branches. Balloon angioplasty was not performed to avoid further venous wall disruption. Completion venography demonstrated absence of extravasation, stent position between the eighth thoracic and first lumbar vertebral bodies, and patent renal and hepatic veins (Fig 3). The venotomy was closed with a running 5-0 Prolene suture.

Postoperative outcomes. The patient received an additional 11 units of blood products. He remained hemodynamically stable with transient acute kidney injury and shock liver, which resolved on hospital days 3 and 5, respectively. A 7-day lower extremity duplex ultrasound examination was negative for thrombosis bilaterally. He was prescribed prophylactic subcutaneous heparin on postoperative day 6 with no long-term antiplatelet therapy. He was discharged home after a 20-day hospital stay leading to full recovery.

A 2-month follow-up computed tomography scan (Fig 4) showed a patent stent in stable position with patent bilateral iliac veins. The plan for further follow-up at this point consists of biannual cross-sectional imaging.

DISCUSSION

This case describes successful endovascular stent repair of catastrophic suprarenal IVC injury with satisfactory midterm outcomes. Applying principles similar to the management of a ruptured abdominal aortic aneurysm, stent graft repair of the IVC has been reported in cases of iatrogenic injury during spine surgery[11] as well as in resection of retroperitoneal masses,[9,12] with a 15-month documented patency.[13] In spine surgery, an endovascular approach seems to be facilitated by ready access to fluoroscopy.[11]

Recognizing the need for a multimodal approach to severe injuries,[14] interest in the combined expertise of vascular surgeons and acute care trauma surgeons and use of hybrid operating suites have been increasing.[15] In complex traumatic vascular injuries, endovascular repair represents a useful addition to the therapeutic arsenal.[16] Indeed, numerous advantages of an endovascular repair of IVC injury include minimized dissection,[17] decreased subsequent coagulopathy,[18] reduced procedure time,[19] and improved physiologic parameters and venous return with avoidance of prolonged clamping.[8]

However, to date, surgical technique has not been standardized. First, the initial injury assessment can be limited by injection of contrast material in a low-pressure and high-flow system.[19] Selective cannulation for identification of the renal and hepatic venous branches might be necessary and cumbersome.[16] Second, the optimal access site is unclear. Unilateral and bilateral femoral accesses have equally been described,[11] whereas reports of direct IVC access with subsequent direct repair remain rare.[9] Rosenthal et al[20] commented on the use of a purse-string suture to minimize additional bleeding from the access sheath while potentially reducing the risk of stenosis. Sheath size, additional iliofemoral system injury,

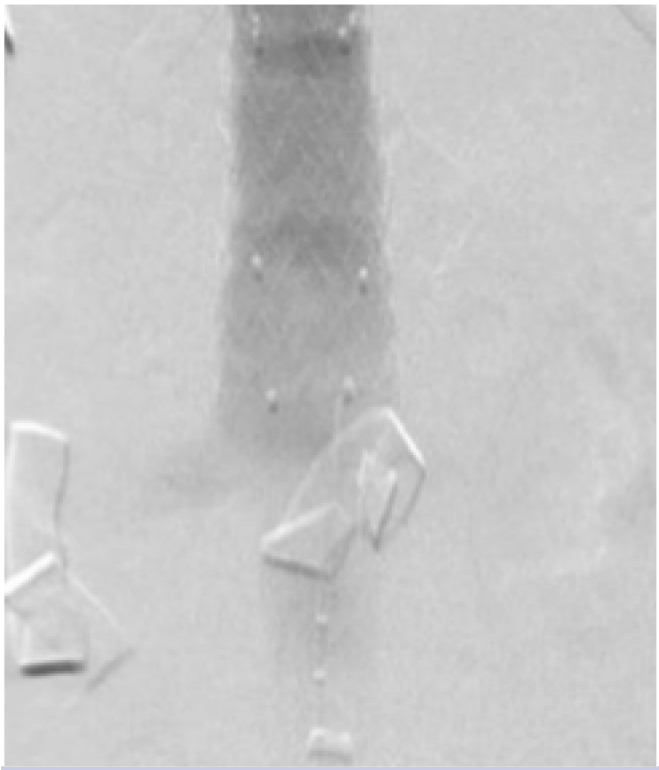

Fig 3. Completion angiogram with absent extravasation of contrast material and confirmed stent placement between the hepatic and renal veins.

diagnostic threshold of direct IVC vs femoral venography, and working distance between access site and device deployment target must all be considered. Third, placement of a large sheath in a fragile vessel is associated with a risk of worsened injury. For example, Briggs et al[12] described repair through a 22F sheath, whereas this report involves a smaller 18F sheath. Fourth, the order of sequential stent deployment remains inconsistent[21] but should focus on hemorrhage control and preservation of side branches. The use of pediatric stent grafts instead of off-label arterial devices has been successfully reported to that effect.[13] Although parallel temporary balloon occlusion can be helpful,[12] it was not used in this case and could have optimized exposure for primary repair.[8,12] Prosthetic endovascular graft infection in a contaminated field has rarely been published and seems unlikely in the absence of hollow viscus injury.[2,22] Whereas caval erosion and migration are well known complications of indwelling IVC filters, scarce data exist on the off-label use of intra-arterial devices in the venous system.[23,24] Furthermore, no consensus prevails on the optimal device choice, and reports span aortic stent graft to modified self-expanding stents.[9,16,25] Inappropriate sizing of arterial stent grafts for venous use might result in worsened outcomes, and follow-up imaging is critical to assess for position and branch occlusion. Although it was not used in this case, intravascular ultrasound may serve as an adjunct for best device selection, bearing in mind that venous diameter measurements in a hypovolemic patient may still be inaccurate. Finally, neointimal hyperplasia resulting in a 27% luminal diameter reduction has been reported in an IVC canine model.[25] Antiplatelet and anticoagulation therapy could mitigate the risk of indwelling venous stent grafts. Recommendations on this novel approach are awaited. Surgical simulation and further animal model descriptions[18] could prove helpful.

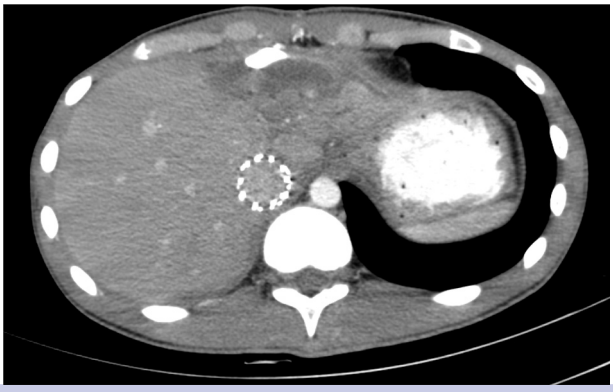

Fig 4. Computed tomography of the abdomen and pelvis at 2-month follow-up demonstrates patent inferior vena cava (IVC) stent.

CONCLUSIONS

Endovascular stent repair of the injured IVC is an effective and lifesaving alternative to open difficult access and control. Combined with hemostatic resuscitation and critical care management, success was demonstrated with positive midterm outcomes. Efforts need to continue in procedure streamlining, indwelling dedicated venous device development, and longer term clinical and imaging data collection.

REFERENCES

1. Huerta S, Bui TD, Nguyen TH, Banimahd FN, Porral D, Dolich MO. Predictors of mortality and management of patients with traumatic inferior vena cava injuries. Am Surg 2006;72:290-6.
2. Carr JA, Kralovich KA, Patton JH, Horst HM. Primary venorrhaphy for traumatic inferior vena cava injuries. Am Surg 2001;67:207-13; discussion: 213-4.
3. Bui TD, Mills JL. Control of inferior vena cava injury using percutaneous balloon catheter occlusion. Vasc Endovascular Surg 2009;43:490-3.
4. Buechter KJ, Gomez GA, Zeppa R. A new technique for exposure of injuries at the confluence of the retrohepatic veins and the retrohepatic vena cava. J Trauma 1990;30:328-31.
5. Thomford NR, Papouras WC, Durzinsky DS. Active venovenous bypass of the retrohepatic vena cava utilizing two atrial cannulae. Am Surg 1998;64:791-4.
6. Wang TG, Liu RH, Li FS, Yu SJ, Sun RR, Dong JH. A temporary stent graft as a new shunt for juxtahepatic vena cava injury. J Trauma Acute Care Surg 2014;77:351-5.
7. Sullivan PS, Dente CJ, Patel S, Carmichael M, Srinivasan JK, Wyrzykowski AD, et al. Outcome of ligation of the inferior vena cava in the modern era. Am J Surg 2010;199:500-6.

8. Reynolds CL, Celio AC, Bridges LC, Mosquera C, O'Connell B, Bard MR, et al. REBOA for the IVC? Resuscitative balloon occlusion of the inferior vena cava (REBOVC) to abate massive hemorrhage in retrohepatic vena cava injuries. J Trauma Acute Care Surg 2017;83:1041-6.
9. Erzurum VZ, Shoup M, Borge M, Kalman PG, Rodriguez H, Silver GM. Inferior vena cava endograft to control surgically inaccessible hemorrhage. J Vasc Surg 2003;38:1437-9.
10. Avery LE, Stahlfeld KR, Corcos AC, Scifres AM, Ziembicki JA, Varcelotti J, et al. Evolving role of endovascular techniques for traumatic vascular injury: a changing landscape? J Trauma Acute Care Surg 2012;72:41-6; discussion: 46-7.
11. Bonasso PC, Lucke-Wold BP, d'Audiffret A, Pillai L. Primary endovascular repair of ilio-caval injury encountered during anterior exposure spine surgery: evolution of the paradigm. Ann Vasc Surg 2017;43:316.e1-8.
12. Briggs CS, Morcos OC, Moriera CC, Gupta N. Endovascular treatment of iatrogenic injury to the retrohepatic inferior vena cava. Ann Vasc Surg 2014;28:1794.e13-5.
13. Filippini S, Desebbe O, Gamondes D, Henaine R. Synergy between stents and extracorporeal membrane oxygenation in multitrauma patients with inferior vena cava injury. Eur J Cardiothorac Surg 2013;44:1140-2.
14. Denton JR, Moore EE, Coldwell DM. Multimodality treatment for grade V hepatic injuries: perihepatic packing, arterial embolization, and venous stenting. J Trauma 1997;42: 964-7; discussion: 967-8.
15. Brenner M, Hoehn M, Teeter W, Stein D, Scalea T. Trading scalpels for sheaths: catheter-based treatment of vascular injury can be effectively performed by acute care surgeons trained in endovascular techniques. J Trauma Acute Care Surg 2016;80:783-6.
16. Hommes M, Kazemier G, van Dijk LC, Kuipers EJ, van Ijsseldijk A, Vogels LM, et al. Complex liver trauma with bilhemia treated with perihepatic packing and endovascular stent in the vena cava. J Trauma 2009;67:E51-3.
17. Ravikumar S, Stahl WM. Intraluminal balloon catheter occlusion for major vena cava injuries. J Trauma 1985;25: 458-60.
18. Porta RM, Poggetti RS, Pereira O, Chammas C, Fontes B, Fratezi A, et al. An experimental model for the treatment of lethal bleeding injury to the juxtahepatic vena cava with stent graft. J Trauma 2006;60:1211-20.
19. Castelli P, Caronno R, Piffaretti G, Tozzi M. Emergency endovascular repair for traumatic injury of the inferior vena cava. Eur J Cardiothorac Surg 2005;28:906-8.
20. Rosenthal D, Wellons ED, Shuler FW, Levitt AB, Henderson VJ. Retrohepatic vena cava and hepatic vein injuries: a simplified experimental method of treatment by balloon shunt. J Trauma 2004;56:450-2.
21. de Naeyer G, Degrieck I. Emergent infrahepatic vena cava stenting for life-threatening perforation. J Vasc Surg 2005;41: 552-4.
22. Ombrellaro MP, Freeman MB, Stevens SL, Diamond DL, Goldman MH. Predictors of survival after inferior vena cava injuries. Am Surg 1997;63:178-83.
23. Toyoda N, Torregrossa G, Itagaki S, Pawale A, Reddy R. Intracardiac migration of vena caval stent: decision-making and treatment considerations. J Card Surg 2014;29:320-2.
24. Lin X, Fang L, Wang Y. Multiple heart injuries caused by fracture and migration of the inferior vena stent. Eur Heart J 2013;34:625.
25. Watarida S, Nishi T, Furukawa A, Shiraishi S, Kitano H, Matsubayashi K, et al. Fenestrated stent-graft for traumatic juxtahepatic inferior vena cava injury. J Endovasc Ther 2002;9:134-7.

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