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Case Report

Physician-Modified Fenestrated Endovascular Repair for Iatrogenic Innominate Vein Injury

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Iatrogenic innominate vein injuries are rare complications associated with internal jugular venous catheters. These complications are accompanied by high morbidity and mortality rates in patients with severe underlying medical conditions. Without proper treatment, emergency surgery may be needed due to acute cardiac tamponade or hemothorax. Endovascular repair can be advantageous for patients with significant medical comorbidities. Herein, we report the case of a 62-year-old female with an iatrogenic injury to the innominate vein at the subclavian vein and internal jugular confluence due to a malpositioned left internal jugular catheter. A customized fenestrated endograft was positioned with fenestration oriented to the internal jugular vein and a new tunneled catheter was inserted across the fenestration into the superior vena cava upon removal of the malpositioned catheter. In addition, a brachio-basilic arteriovenous fistula was created. At one month follow-up, the patient had a palpable thrill over the arteriovenous fistula and a functioning tunneled catheter.

Key Words: Endovascular procedures, Iatrogenic disease, Brachiocephalic vein, Jugular veins

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INTRODUCTION

The incidence of early complications of central venous access, including injury to the surrounding structures or catheter tip malposition, is reported to be approximately 7%. Specific complications such as hematoma and pneumothorax occur in approximately 4% of patients [1]. Iatrogenic injury to the innominate vein (INV) is a rare complication associated with internal jugular vein (IJV) catheters. Given the location of the INV in the mediastinum, injuries to this vein and open surgical repair can result in significant morbidity and high mortality rates in patients with severe underlying medical conditions [2]. Furthermore, without prompt recognition and repair, acute cardiac tamponade or hemothorax may occur, which can be fatal [3]. Endovascular repair can be advantageous in patients with significant medical comorbidities because it avoids median sternotomy and minimizes overall blood loss. Previous reports of successful endovascular repair of INV injury utilized balloon angioplasty and placement of tubular covered stents [4]. When injury is at the confluence of the subclavian vein (SCV) and IJV, the use of a simple covered stent results in coverage of one of these branches. In this case report, we describe the novel use of a fenestrated endovascular stent graft to repair an iatrogenic injury to the INV at the SCV-IJV confluence. This case report has IRB exemption approval from the institution and patient consent was obtained for publication.

CASE

A 62-year-old female with a history of hypertension, congestive heart failure, coronary artery disease status post

drug-eluting stent (2019), interstitial lung disease, diabetes, hypothyroidism, depression, and chronic kidney disease presented to outside hospital for anasarca and shortness of breath with pleural effusion. The patient was deemed to have progressed from stage IV to stage V chronic kidney disease. A left IJV tunneled catheter was placed, however, was noted to be malpositioned. Computerized tomography (CT) scan revealed that the catheter was traversing across the inferior wall of the left INV at the IJV-SCV confluence, with the tip next to the pulmonary artery. The patient was subsequently transferred to our institution for higher level of care. Physical examination showed decreased breath sounds bilaterally and fine crackles in the right lower lobe and pain at the tunneled dialysis catheter site. Vital signs were stable, and echocardiogram revealed reduced left ventricular ejection fraction of 29%.

CT chest scan showed the left IJV catheter terminating in the mediastimum, a small hematoma around the tip of the extravascular catheter, and bilateral pleural effusion with adjacent lung collapse. Cardiac enlargement was demonstrated by an enlarged main pulmonary artery consistent with underlying pulmonary hypertension (Fig. 1). Given the patient's comorbidities, endovascular repair options were explored. The location of the INV injury, as well as the need for hemodialysis access were considered in endovascular planning. Off-label nature of the procedure, as well as its risks and benefits were discussed with the patient.

A customized fenestrated covered stent was constructed by modifying a bell-bottom Zenith spiral limb endograft (ZSLE-20-39-ZT; Cook Medical, Bloomington, IN, USA) to create a single fenestration designed for the IJV (Fig. 2). The stent graft was oversized by 20% based on the diameter of the INV and SCV on the centerline reconstruction of the CT scan using 3mensio (3mensio Medical Imaging BV, v 10.0; Maastricht, Netherlands). Given the focal nature of this injury, the shortest length was chosen, and the diam-

Fig. 2. The customized fenestrated covered stent constructed by modifying a bell-bottom Zenith spiral limb endograft with a single fenestration for the internal jugular vein was reverse loaded in the sheath.

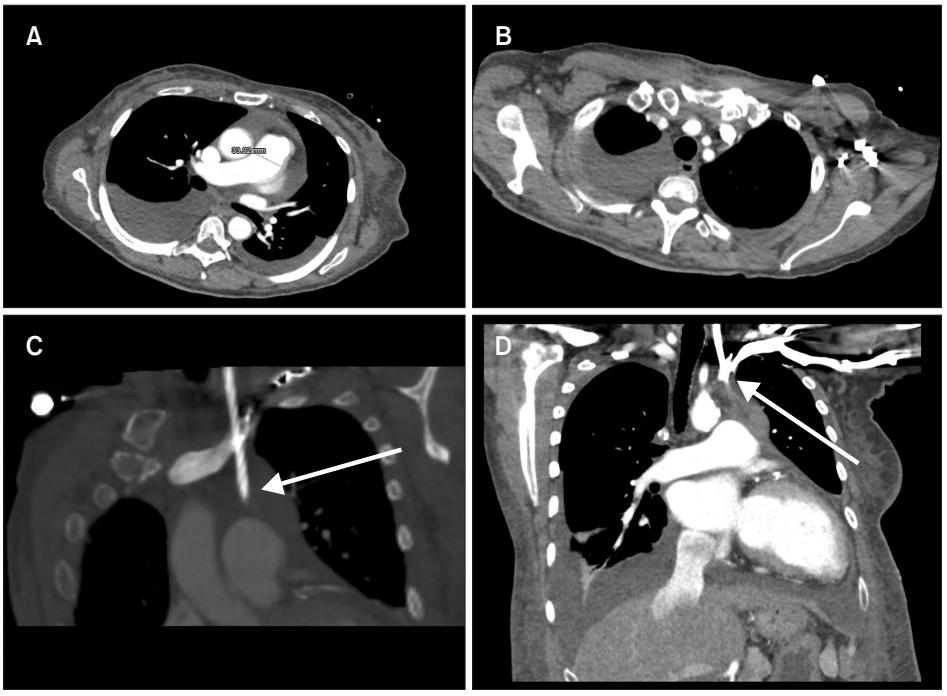

Fig. 1. (A) Initial computed tomography angiography showed enlarged pulmonary artery, reflecting the underlying pulmonary hypertension. (B) Bilateral pleural effusions with adjacent lung collapse. (C, D) Malpositioned tunneled catheter (arrow) penetrated the inferior wall of the internal jugular vein and subclavian vein confluence into the proximal innominate vein.

eter difference between the INV and SCV adjacent to the injury made the reversed bell-bottom Zenith iliac limb suitable. This modified device was reverse loaded in the sheath, so that the bell-bottom was facing the leading edge.

Under general anesthesia, the left axillary vein was exposed via a 4-cm incision in the upper arm. Axillary vein was accessed and sequentially upsized to a 12-Fr sheath. A venogram was performed, showing the tunneled catheter penetrating the inferior wall of the INV at the IJV-SCV confluence, with the catheter tip in the mediastinum (Fig. 3A). The customized fenestrated endograft was positioned with the fenestration oriented to the IJV. Then, the tunneled catheter was removed over a wire. This was immediately followed by the deployment of the fenestrated endograft. The fenestration was catheterized by redirecting the wire from the IJV (Fig. 3B). A new tunneled catheter was inserted over this wire across the fenestration into the superior vena cava. The access site at the axillary vein was closed transversely with interrupted 6-0 Prolene suture (Ethicon Inc, Raritan, NJ, USA). In addition, a brachio-basilic arteriovenous fistula was created. The patient recovered from the operation without complications and was discharged home in 2 days. At 1 month follow-up, the patient had a palpable thrill over the arteriovenous fistula and a functioning tunneled catheter. The only symptom was left arm swelling, which was managed with compression. CT scan showed a patent fenestrated venous endograft and duplex ultrasonography showed no signs of stenosis.

DISCUSSION

Direct, isolated traumatic injuries to the INV are reported to be rare, mainly due to the surrounding anatomic structures such as the sternum, ribs, and clavicles that provide protection. Iatrogenic INV injuries most commonly associated with central venous catheter insertion can be life-threatening if not recognized and treated expeditiously [5]. The anatomic considerations for such injuries include the near-perpendicular junction of the left IJ with the horizontal subclavian vein, and the sharper angle of the left INV [6]. Perforation of a central vein can occur when the wire is pulled back too far, and fails to provide safe guide during the dilator advancement [7]. Patients with INV injury can present with chest pain and CT imaging often demonstrate a long cord-like hematoma lining the vessel and upper mediastinum. A hematoma larger than 5 cm and active extravasation have been cited as indications for surgical intervention [3]. The surgical approach typically involves median sternotomy and repair configurations ranges from primary repair, patch angioplasty, to interposition graft [8].

Endovascular repair of central venous injuries with balloon angioplasty to covered stent placement has been described in patients who are at a high risk for open surgical repair. The first successful stent graft repair for superior vena cava (SVC) rupture was reported in 2003 by Burket [9]. In 2007, Azizzadeh et al. [4] described the use of a covered stent to repair an iatrogenic SVC injury, demonstrating the advantage of endovascular rapid control of exsanguinating

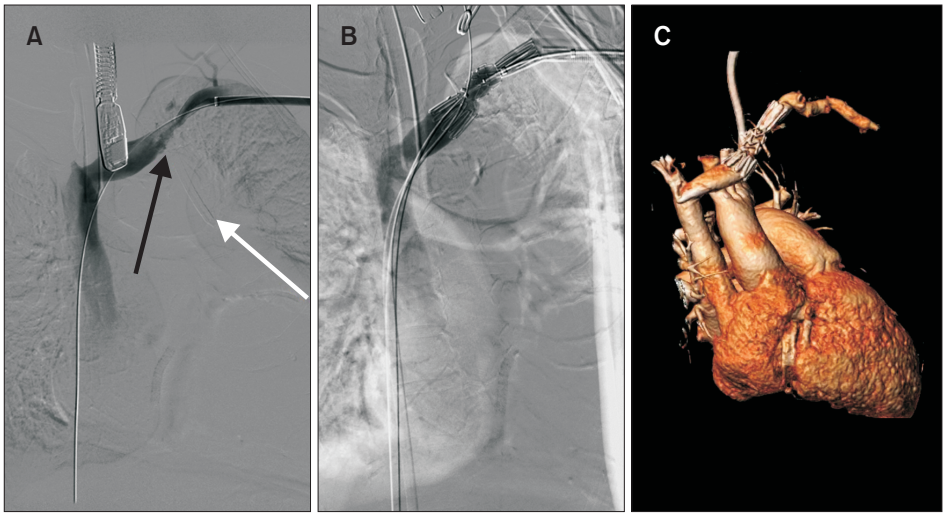

Fig. 3. (A) Venogram prior to the subclavian-innominate vein fenestrated endograft placement showed the tunneled catheter penetrating the inferior wall of the innominate vein (INV) at the internal jugular and subclavian vein confluence (black arrow), with the catheter tip (white arrow) in the mediastinum. (B) After fenestrated endograft deployment. (C) Three-dimensional volume rendering reconstruction showed the patency of the left subclavian-INV fenestrated stent graft and tunneled catheter through the fenestration at one month follow-up.

hemorrhage. In 2015, Song et al. [10] reported the first case of a successful endovascular repair of an iatrogenic INV injury using a covered stent graft.

To the best of our knowledge, this is the first report of the use of a physician modified endograft (PMEG) to repair INV injury. Recently, PMEGs have emerged as a valuable technique in urgent and emergent repair of complex abdominal and thoracoabdominal aortic aneurysms by enabling the construction of patient-specific fenestrated, branched endografts. [11-15]. In our patient, the use of PMEG provided several advantages over conventional tubular covered stents. First, the fenestration in the endograft preserved the flow through the left IJV. Second, this fenestration allowed passage of a dialysis catheter. Third, complete and secure seal allowed creation of an arteriovenous fistula, which augmented the flow through the endograft and provided a long-term dialysis access.

However, it must be noted that the long-term patency of stent grafts, especially PMEGs, in the venous system has not been well-described in literature and remains unclear. Altuwaijri et al. [16] showed that at 7-year follow-up of a covered stent at the SVC rupture site, it was still sealing the injury, but showed no signs of flow within. Common challenges of central venous stenoses in dialysis patients must be considered. Associated with the prolonged catheter usage, central venous stenosis can preclude the formation of a new dialysis access in the ipsilateral arm [17]. While the use of covered or uncovered stents as a treatment for central venous stenoses has been reported with mixed patency rates [18,19], some have attributed the lower patency of covered stents in the central vein to coverage of major venous confluences. To that end, it should be noted that our patient's endovascular repair configuration differs from the previous cases reported in the literature by 1) preserving both IJV and SCV flow and 2) constructing an ipsilateral arteriovenous fistula. Long-term durability and patency of this repair remains to be determined. In conclusion, we report the first case of the use of a PMEG to simultaneously repair iatrogenic INV injury at the major venous confluence, while preserving dialysis access.

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None.

CONFLICTS OF INTEREST

Sukgu M. Han, M.D., M.S. is a consultant for WL Gore & associates, Cook Medical, Terumo Aortic, and Medtronic. The other authors have nothing to disclose.

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AUTHOR CONTRIBUTIONS

Concept and design: SMH. Analysis and interpretation: KBL, AJP. Data collection: KBL, AJP. Writing the article: KBL, SMH. Critical revision of the article: all authors. Final approval of the article: all authors. Statistical analysis: none. Obtained funding: none. Overall responsibility: SMH.

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