Brachiocephalic Vein Bypass with Sternal Reconstruction for Symptomatic Occlusion

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Complications attributed to central venous stenosis and subsequent thrombosis are increasing in frequency and are most commonly associated with neointimal fibroplasia as well as neoplastic, fibrotic, and traumatic pathologies. We present the successful venous bypass and thoracic wall reconstruction of a 58-year-old female with chronic atypical symptoms secondary to brachiocephalic vein occlusion from congenital thoracic dystrophy.

Chronic central venous stenosis and obstruction, as a consequence of intraluminal endothelial damage, is usually related to the insertion of large bore catheters for hemodialysis or therapeutic infusions and medical devices such as pacemakers. De novo presentations remain rare. Although the majority of patients remain asymptomatic, pain, edema, and discoloration of the upper extremity may occur because of venous congestion while atypical neurological sequelae including headache, visual impairment, seizures, and peripheral neurological deficits remain infrequent.[1] Acute presentations warrant emergent treatment within the first week to restore flow to minimize long-term sequelae from venous hypertension.[2] Chronic management strategies require a multimodal approach with anticoagulation, percutaneous and open revascularization combined with removal of the previously inserted intravenous catheter or device if appropriate. The authors present a patient with brachiocephalic vein stenosis secondary to a congenital compressive sternal deformity in a venous access naïve patient.

CASE REPORT

A 58-year-old female presented with chronic holocephalic retro-orbital exertional headaches associated with light, sound, and odor sensitivity with an increased frequency over 10 years. She also described intermittent vertigo, neck and shoulder discomfort, and an atypical paresthesia over the left side of her neck and face combined with bulging of her left-sided neck veins. There was no significant past medical history, specifically no venous thromboembolic disease, previous venous access catheters, or trauma. Social history was negative. The patient had breast reduction surgery in May 2011 which did not alleviate her symptoms. In December 2011, her headaches increased in frequency and severity and she also became syncopal on rising from a lying position. A contrast-enhanced computed tomography (CT) angiogram identified significant narrowing of the left brachiocephalic vein just after its origin, extending across the mediastinum between the sternum and the transverse aortic arch aorta with concentric narrowing relating to either intraluminal thrombus or extrinsic compression. In contrast to a localized pectus excavatum abnormality, the anterior/posterior dimension between the sternum and spine was generally narrowed at <3.5 cm throughout the mediastinum.

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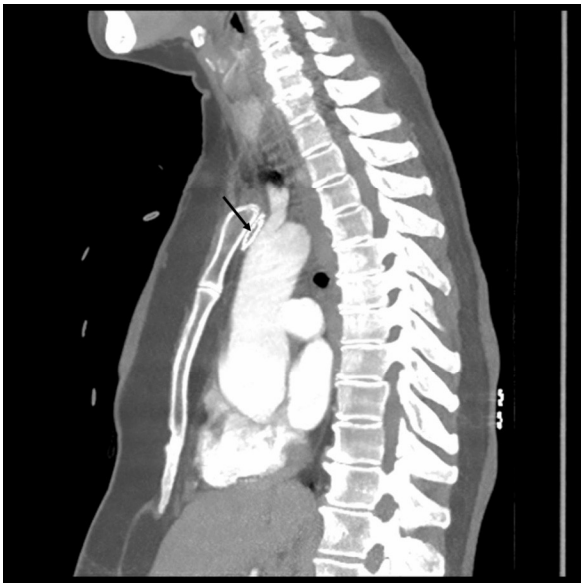

Fig. 1. Coronal CT angiogram of the mediastinum demonstrating extrinsic compression of the left brachiocephalic vein stent (*black arrow*) between the sternum anteriorly and the arch of the aorta posteriorly.

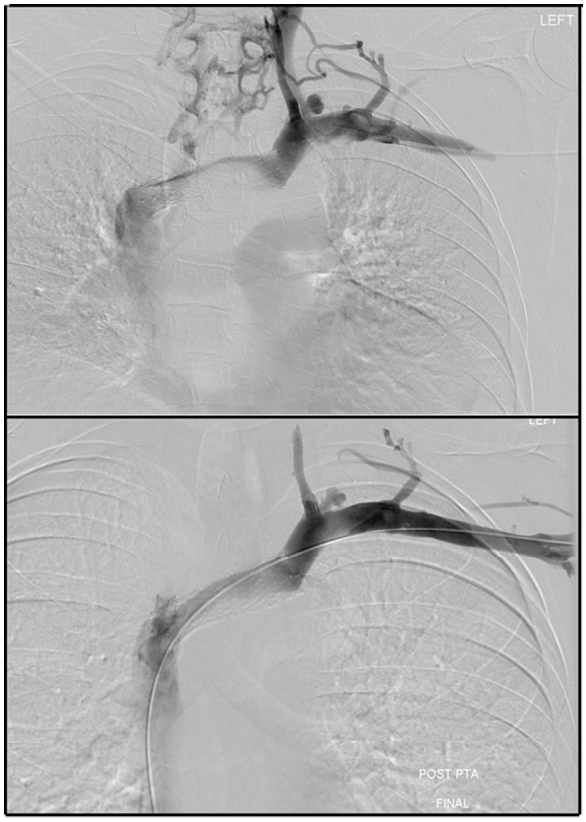

Fig. 2. Repeat venography demonstrating significant in-stent stenosis over 6 cm in length and evidence of collateralization which was treated with further angioplasty leading to improved luminal diameter and a reduction in collateral vessel distribution. The right-sided central venous system was patent.

Subsequent venography revealed a filling defect in the left brachiocephalic vein, suggestive of possible thrombus, and normal patency of the superior vena cava (SVC), jugular and upper extremity venous systems. Although initial percutaneous brachiocephalic vein thrombolysis and angioplasty was not effective, left brachiocephalic vein stenting performed at an outside institution 2 weeks later significantly alleviated her symptoms. She represented in April 2012 with recurrence of symptoms including headache, neck, and shoulder pain with associated edema of left upper chest wall and neck. Subsequent CT imaging suggested extrinsic compression of the previously inserted brachiocephalic stent (Fig. 1). Repeat venography in May 2012 identified mild in-stent narrowing within the left brachiocephalic vein without significant collateralization. Sequential brachiocephalic vein angioplasty was performed through the stent, with an 8 mm followed by a 10 mm balloon (Mustang; Boston Scientific, Quincy, MA), resulting in a 5-week symptomatic improvement. Further venography for symptomatic recurrence in November 2012 demonstrated more significant narrowing of the brachiocephalic vein with new evidence of collateralization. She underwent further angioplasty which provided similar short-term beneficial effects (Fig. 2).

Despite atypical symptoms, the patient reported consistent improvement after each percutaneous venoplasty procedure. The patient was then referred to our vascular surgery service. Following review of all cross-sectional images, it was determined that operative decompression and venous bypass were warranted because of extrinsic pressure created between the sternum and aortic arch. To expand the diameter of the upper chest, the upper manubrium, clavicle, sternum, and ribs were released from congenital adhesions and the pectoralis muscles were elevated. Because of the extent of sternal deformity and associated rigidity, multiple transverse rib osteotomies were performed from the first to third ribs at their sternocostal junctions. The manubrium itself was depressed inward and a sternal osteotomy was necessary to elevate. The left first and second ribs were grossly deformed and were excised leaving a 3- to 4-cm chest wall hernia that was subsequently closed with XCM biologic tissue matrix (DePuy Synthes, Inc, West Chester, PA). The right great saphenous vein (GSV) was endoscopically harvested and was inked in a longitudinal plane. It was cut along this plane throughout its total length and was then wrapped sequentially around a Hegar dilator. The spiral vein graft was constructed using 6/0 prolene sutures throughout its length followed by 2 locking sutures at the proximal and distal ends. The spiral vein graft was anastomosed between the junction of the left internal jugular/brachiocephalic vein and the SVC to bypass the left brachiocephalic vein using 5/0 prolene. Intra-operative duplex assessment confirmed good flow in the vein

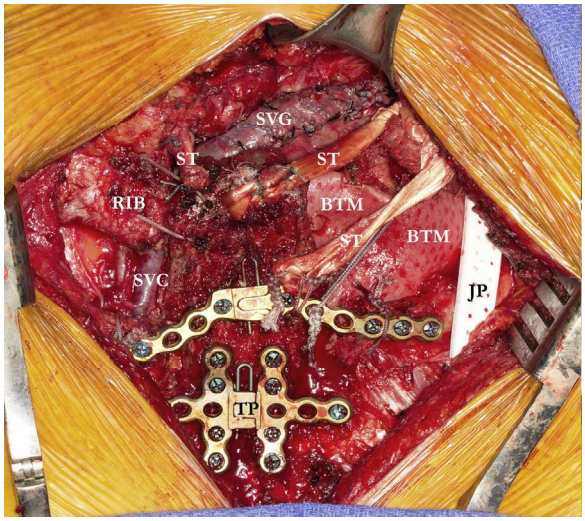

Fig. 3. End-to-side anastomosis using a spiral vein graft from the origin of the left brachiocephalic vein to the superior vena cava. Final sternal reconstruction where the sternal manubrial attachment was excised followed by elevation of the manubrium. Bilateral cadaveric semitendinosus grafting of the clavicle to the manubrium combined with titanium plating of the lower sternocostal joints was then performed in conjunction with XCM biologic tissue matrix grafting of left chest wall. BTM, biological tissue matrix; JP, Jackson–Pratt drain; ST, semitendinosus tendon; SVG, spiral vein graft; TP, titanium plate.

bypass. The chest wall was reconstructed using titanium plating and FiberWire (Arthrex, Naples, FL) to reattach the ribs and manubrium to the elevated sternum. After the manubrium was elevated to a more anterior position, a significant deficiency in clavicle length was present, especially on the left side. To reattach the clavicles, bilateral cadaveric semitendinosus grafting of clavicles to manubrium was performed (Fig. 3).

Post-operatively, the patient was extubated before admission to the intermediate care unit. Analgesic provision was optimized with fentanyl patient-controlled analgesia combined with oral methadone. The left upper extremity was supported in a sling. The patient was gradually mobilized and subsequently discharged on post-operative day 5. She confirmed continuation of symptomatic improvement at 1- and 6-month reviews where all of her atypical neurological symptoms had subsided. However, she subsequently required a chronic pain assessment for left shoulder trigger point discomfort 12 months post-operatively which was treated with an occipital nerve block.

DISCUSSION

Previous researchers have reported higher rates of central vein stenosis with subclavian compared with jugular-access catheters (42% vs. 10%) and that patients with a previously tunneled internal jugular catheter had twice the incidence of central vein stenosis than those without (65% vs. 30%, $P = 0.009$).[3] However, central vein stenoses can also occur in patients without a previous history of catheter placement.[3] Published case reports have described physiological etiologies for brachiocephalic venous stenosis including external compression of a previously inserted stent by respiratory chest wall motion and aortic arch flow-related pulsation without evidence of anatomical narrowing, or engorgement of the left jugular vein following left upper extremity arteriovenous fistula creation where compression of the brachiocephalic vein was related to a degenerative osteophyte in a hypertrophic sternoclavicular joint.[4–6] However, it appears the majority of these reports describe such sequelae in renal failure patients who have had a previous dialysis access procedure. To the authors' knowledge, brachiocephalic vein stenosis secondary to a congenital compressive sternal deformity remains rare with only one previously reported case.[7]

Although treatment of acute obstruction of central veins warrants urgent intervention, the management protocols for chronic occlusions are less descriptive ranging from conservative measures such as limb elevation and compression hosiery, chronic anticoagulation through to percutaneous interventions, or operative revascularization. Wisselink et al. demonstrated improved longer term outcomes with operative reconstruction compared with a single percutaneous transluminal angioplasty for the treatment of obstruction of the SVC and its major tributaries. Primary symptomatic relief was better in the operative group at 1 year (88% vs. 36%, $P < 0.05$) and 2 years (71% vs. 0%, $P < 0.01$).[8] However, these authors did suggest equivocal 1- and 2-year results between operative bypass and repeated angioplasty, while further research from the same group reported similar 6- and 12-month symptom-free intervals between surgical bypass and PTA with stenting.[8,9]

Following clinical assessment, delineation of the venous stenotic or occlusive segment may be performed using duplex ultrasound of the upper extremity, magnetic resonance imaging of the thoracic inlet and contrast-enhanced CT imaging of the chest wall and mediastinum according to clinical suspicion. Percutaneous venography permits complete venous assessment with an option to intervene. Although not performed in this case, the authors acknowledge that stenotic pressure gradient evaluation may have provided useful objective information while intravascular ultrasound may have elicited the anatomical compressive morphology as

well as the stenotic vein segment. A consistent history of recurrent symptoms, vein stenosis, and subsequent improvement following venoplasty combined with cross-sectional imaging of exogenous pressure on the brachiocephalic vein warranted open surgical brachiocephalic vein bypass and correction of the anatomical sternal deformity.

Open chest wall reconstructions to increase the anterior/posterior dimensions of the chest are often performed for pectus excavatum deformities which account for more than 90% of all congential chest wall deformities. Jaroszewski et al.[10] have previously reported that physiological impairments may worsen as the patient ages and that cardiopulmonary and psychosocial function improve after repair. In this case, surgical reconstruction of the thoracic wall with a modified Ravitch procedure involved resection of sternocostal cartilaginous attachments and placement of metallic plates and screws. Because of the extent of chest wall deformity and associated rigidity, the more minimally invasive Nuss technique, involving placement of a substernal concave bar which is then passed behind the sternum and ''flipped'' into a convex position to elevate the sternum outwards, was not considered as open resection provided the anteroom elevation and expansion necessary for satisfactory chest wall reconstruction while permitting the open venous bypass procedure.[10]

Although the superficial femoral vein has been extensively reported as a suitable bypass conduit, the authors chose to minimize lower limb operative morbidity through endoscopic harvest of the GSV and creation of a spiral vein graft while the chest wall was being explored by the thoracic surgery team.

Increasing the dimensions of the upper chest wall was deemed essential in our patient to reduce the risk of continued compression and potential compromise of the spiral vein graft. Such an extensive procedure required significant pre-operative counseling, an extensive multidisciplinary evaluation to rule out any other causative factors combined with optimization of post-operative analgesia and physical therapy during the recovery phase.

CONCLUSION

Recurrent angioplasty and stenting of central venous occlusive disease have minimal long-term efficacy in patients with compressive sternal wall deformities. In patients with consistent brachiocephalic venous occlusive symptoms secondary to anatomical sternal abnormalities, open brachiocephalic vein bypass offers the best opportunity for longer term relief provided that synchronous thoracic wall reconstruction is also performed.

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