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Emergency Intravascular Aortic and Iliac Artery Lithotripsy to Facilitate Thoracic Endovascular Aortic Repair of a Ruptured Thoracic Aortic Aneurysm: A Case Report

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Abstract: Thoracic endovascular aortic repair (TEVAR) is the preferred treatment for ruptured thoracic aortic aneurysms. Poor access vessels are a relative contraindication to TEVAR. Intravascular lithotripsy (IVL) has recently been shown to be effective in treating calcified and stenotic vessels. Prior to the introduction of IVL, plaque modification techniques to increase vessel compliance and luminal diameter were limited to technically complex and risky surgical and interventional radiologic procedures. We present a case demonstrating the use of IVL in the emergency setting to treat severe atherosclerotic stenoses in the abdominal aorta and the iliac artery to facilitate TEVAR of a ruptured thoracic aortic aneurysm.

Keywords: *Intravascular lithotripsy, thoracic endovascular aneurysm repair, thoracic aortic aneurysm, atherosclerosis*

Case Report

A 74-year-old woman with a history of abdominal aortic aneurysm, hypertension, chronic obstructive pulmonary disease without oxygen supplementation, and active smoking presented to the emergency department with severe shoulder and back pain for two hours and nausea. The patient's vital signs were stable and she underwent a computed tomography angiography (CTA) of the chest, the abdomen, and the pelvic vasculature. The examination revealed a contained thoracic aortic rupture into the mediastinum, an extensive hematoma measuring 9.2 x 6.5 cm, and either a ruptured focal pseudoaneurysm or a penetrating arterial ulcer in the proximal descending thoracic aorta (Figure 1).

Key Points

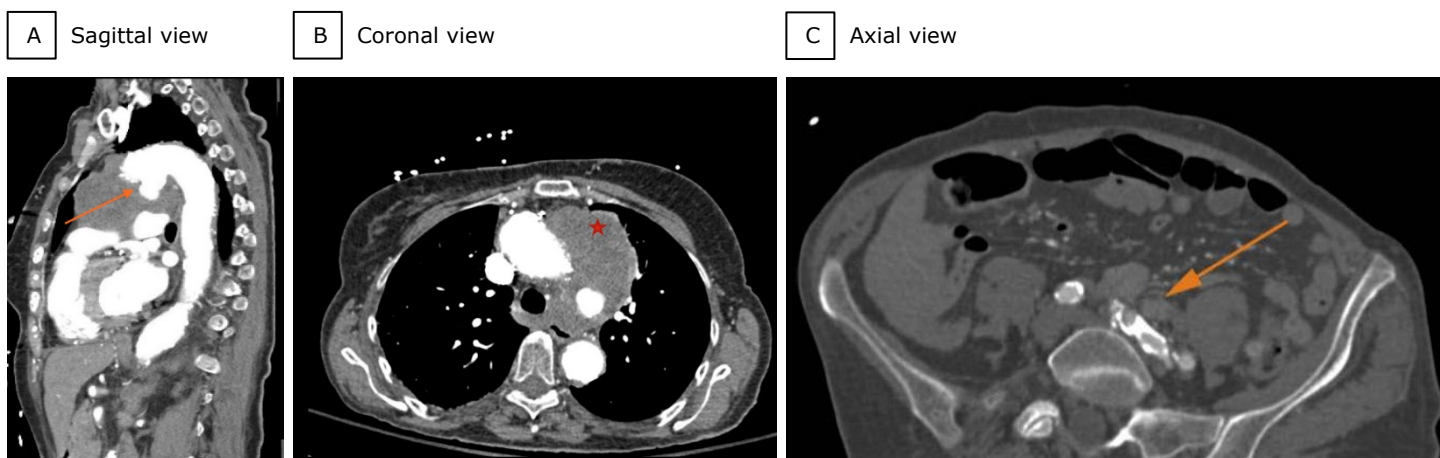
- Thoracic endovascular aortic repair (TEVAR) is the preferred treatment for ruptured thoracic aortic aneurysms.
- Poor access vessels are a contraindication to TEVAR.
- Intravascular lithotripsy can be used in the emergency setting to facilitate large-bore arterial access in severely atherosclerotic vessels.

The infrarenal aorta showed 3.8-cm aneurysmal dilatation with a high-grade, densely calcified focal stenosis measuring 5 mm and poststenotic 3.0-cm dilatation above the common iliac bifurcation. The iliac arteries were extensively calcified bilaterally with multiple high-grade focal stenoses (Figure 1).

The patient was admitted to the cardiothoracic intensive care unit where intravenous antihypertensive agents were administered with the goal to maintain heart rate below 80 beats per minute and systolic blood pressure below 120 mmHg. The decision was made to proceed with

emergency thoracic endovascular aneurysm repair (TEVAR) in the interventional radiology surgical suite. A lumbar drain was placed to prophylactically diminish the risk of spinal ischemia. General anesthesia was induced. Bilateral percutaneous access to the common

Figure 1. Preprocedural Contrast-enhanced CTA of a 74-year-old Woman with a History of Abdominal Aortic Aneurysm.



Sagittal view (A) shows a focal saccular outpouching (A, arrow) of the inferior aortic arch measuring 19 x 14 mm representing either a penetrating atherosclerotic ulcer or ruptured pseudoaneurysm. Coronal view (B) shows a large mediastinal hematoma (B, star) measuring 9.2 x 6.5 cm consistent with contained rupture of thoracic aortic aneurysm. Axial view (C) shows severe atherosclerotic disease in the abdominal aorta and the iliac arteries resulting in severe luminal narrowing (C, arrow) and decreased vessel compliance, which is a contraindication to endovascular repair.

femoral arteries was obtained. Initial aortoiliac angiography confirmed multiple high-grade stenoses within the left common and the external iliac arteries, a high-grade focal stenosis in the right common iliac artery, and the abdominal aortic aneurysm in the infrarenal aorta with a high-grade focal stenosis caused by a calcified plaque (Figure 2). The inadequate caliber of these access vessels precluded introduction of the TEVAR 20 French delivery system (20F sheath). Therefore, we decided to proceed with intravascular lithotripsy.

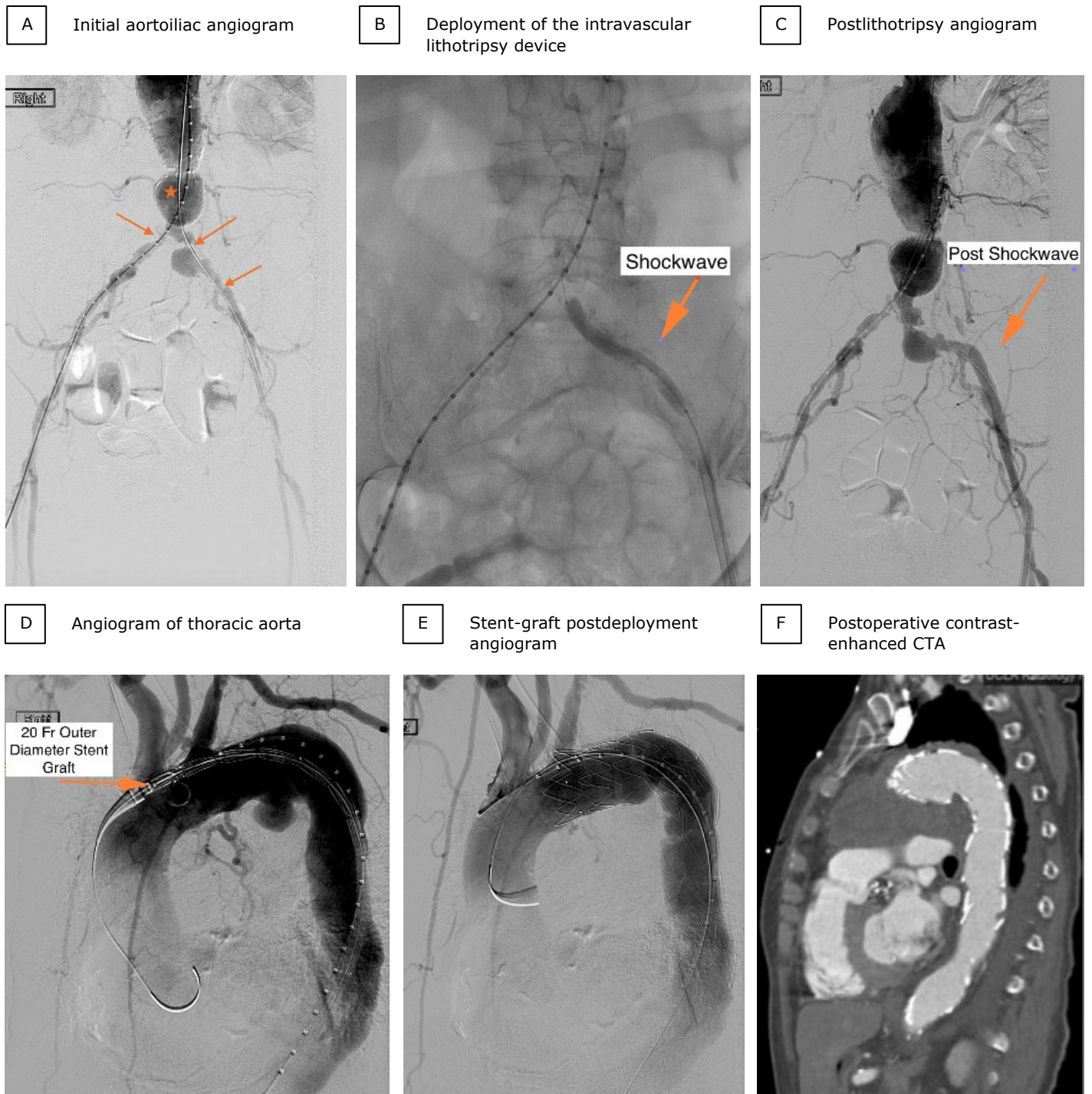
The left common femoral arteriotomy was performed, secured with a suture-mediated closure device (Perclose Proglide; Abbott), and dilated to facilitate insertion of the 7-mm intravascular lithotripsy device (Shockwave M⁵ Peripheral IVL catheter; Shockwave Medical Inc). The device was advanced into the abdominal aorta, and two discrete areas of focal stenosis were treated. Following the treatment of these stenoses, the device was manipulated back into

the left common iliac artery and the external iliac arteries. Because of severe disease in these vessels, multiple sites were treated. Following the treatment, there was a significant increase in vessel diameter with marked diminution in calcified plaque burden and no distal embolization (Figure 2).

With adequate vascular access achieved, an intravascular ultrasound was advanced into the thoracic aorta to evaluate the potential stent-landing zones. The intimal tear and rupture distal to the left subclavian artery (LSA) were confirmed, and the decision was made to proceed with placement of a stent graft from the LSA to the distal descending thoracic aorta (Figure 2).

The 20F-delivery sheath was advanced into the aorta, and a 34 x 34 x 174 stent-graft system (Valiant Navion FreeFlo Tapered; Medtronic) was advanced into position and successfully deployed. A completion angiography revealed a small type Ia endoleak that resolved following balloon angioplasty. Aortoiliac angiography confirmed

Figure 2. Intravascular Lithotripsy-enabled Endovascular Repair of Thoracic Aneurysm in a 74-year-old Woman.



Initial aortoiliac angiogram (A) reveals bilateral high-grade stenoses within the left common and the external iliac arteries, a high-grade focal stenosis in the right common iliac artery (A, arrows), and a 3.8 cm abdominal aortic aneurysm in the infrarenal aorta (A, star) with a high-grade focal stenosis caused by a calcified plaque. Deployment of the intravascular lithotripsy device (Shockwave M⁵ Peripheral IVL catheter; Shockwave Medical Inc) (B) in the left common iliac artery (B, arrow). Postlithotripsy angiogram (C) shows significant improvement in luminal diameter of the left common iliac artery (C, arrow), enabling the advancement of the large-bore TEVAR delivery sheath. Angiogram of the thoracic aorta (D) prior to deployment of the TEVAR shows focal outpouching of the inferior aortic arch (D, arrow) distal to the arch vessels. Postdeployment angiogram (E) shows exclusion of the aneurysm sac and patency of the arch vessels including the left subclavian artery. Postoperative contrast-enhanced CTA (F), sagittal view, shows a patent stent graft with the proximal landing zone just distal to the left subclavian artery and the terminating zone in the descending thoracic aorta.

antegrade flow bilaterally in the iliac arteries with residual right-sided high-grade stenosis. The right femoral arteriotomy was closed by manual compression.

The patient tolerated the procedure well, and there were no immediate complications. Intraoperative transesophageal echocardiography did not show any acute cardiovascular hemodynamic changes. Intubated and in good condition, the patient was transferred to the cardiothoracic intensive care unit. The patient's postoperative course was uncomplicated, and she was discharged on day 6 after the procedure. Postoperative CTA showed a patent stent graft with exclusion of the aneurysm and no evidence of endoleak (Figure 2). Follow-up surveillance includes imaging with CT angiography every 6 months.

Discussion

We described the use of intravascular lithotripsy to facilitate the delivery of a 20F sheath for thoracic endovascular aneurysm repair (TEVAR) of a ruptured thoracic aortic aneurysm in a patient with severe atherosclerotic disease and multi-focal stenoses of the abdominal aorta and the iliac arteries bilaterally.

TEVAR has rapidly become the treatment of choice in high-risk surgical patients with a number of acute aortic syndromes.^{1,2} The procedure is associated with decreased morbidity, mortality, length of stay, and cost compared with those of open surgical repair.¹ The procedure does not require thoracotomy, cross clamping of the aorta, or mechanical circulatory support. The major contraindication to TEVAR is poor vascular access that is not suitable for the large 20F sheath insertion.

The risk of advancing sheaths into the size-mismatched vessels includes life-threatening arterial dissection, rupture, or avulsion.³ Prior to introduction of intravascular lithotripsy (IVL) to vascular and interventional radiology, options for vascular access were limited to the creation of surgical or endovascular conduits, retroperitoneal common iliac access, and left ventricle/transapical

or transcaval access, all of which are associated with increased morbidity and mortality.³

Intravascular lithotripsy (IVL) has emerged as a safe and effective option in the treatment of severely calcified vessels.⁴⁻⁷ The principal mechanism of lithotripsy has been used in medicine for over 30 years in the treatment of nephrolithiasis, cholelithiasis, and joint calcifications. The basic pathology in atherosclerosis is intravascular calcium deposition that decreases vessel diameter, compliance, and mobility. The lithotripter generates acoustic waves and compressive stress that fractures the calcifications.⁸

IVL has become an important addition or an alternative to conventional angioplasty and atherectomy. Yet, unlike angioplasty, IVL does not require high-risk bailout stenting or stent grafting in severely calcified vessels, and, unlike atherectomy, it fractures calcification of both the intimal and the medial layers while minimally affecting the soft tissue of the vessels.^{4,5,8,9}

The Shockwave peripheral IVL catheter (Shockwave Medical Inc) is delivered on a semi-compliant balloon filled with saline-contrast mix and equipped with acoustic wave emitters.⁹ The balloon is inflated to relatively low subnominal pressure (4 atm) and brought into apposition with the vessel wall without stretching it⁵ while decreasing the risk of distal embolization, dissection, and rupture.^{9,10} The acoustic wave emitters distributed along the length of the balloon are aligned in channels that pulse at 1 Hz generating circumferential and transmural pressure and a localized energy field effect sufficient for fracturing calcium within the vessel.⁸ After several cycles of treatment, the balloon is inflated to nominal pressure (6 atm) to maximize vessel diameter and then deflated to repeat the treatment or to be repositioned, as required, for the treatment of another lesion.

Arterial access is a major challenge in complex endovascular procedures requiring large-bore sheaths. In this case, we demonstrate that IVL can be utilized in the emergency setting to facilitate vascular access for the treatment of acute aortic pathologies, including ruptured thoracic aortic aneurysms.

Author Contributions

Conceptualization, J.M.M., T.E.C., and M.K.; Acquisition, analysis, interpretation of data, and writing – original draft preparation, T.E.C. and M.P.; Review and editing, T.E.C., M.K., and J.M.M.; Supervision, J.M.M. All authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. All authors had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

Disclosures

J.M.M. reported receiving a research grant from Angiodynamics Inc, is an advisory board member of Argon Medical, and is a consultant to Argon Medical, Boston Scientific, BD Bard, and Pavment Inc. No other disclosures were reported.

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