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INTERMEDIATE

CASE REPORT: CLINICAL CASE

Renal Artery Stenosis Treated Successfully With Shockwave Intravascular Lithotripsy

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ABSTRACT

Renal artery stenosis (RAS) typically involves varying degrees of calcification, and treatment can be fraught with risk and suboptimal results. Intravascular lithotripsy (IVL) uses shockwaves to fragment calcium to facilitate angioplasty. We present a case of severe bilateral RAS successfully treated with IVL and stenting after conventional methods had failed. (**Level of Difficulty: Intermediate.**) (J Am Coll Cardiol Case Rep 2020;2:2424–8) © 2020 The Authors. Published by Elsevier on behalf of the American College of Cardiology Foundation. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

An 85-year-old woman had resistant uncontrolled hypertension that was not responsive to treatment despite the use of 4 medications, including amlodipine 10 mg, metoprolol tartrate 50 mg twice a day, lisinopril 20 mg, hydrochlorothiazide 25 mg, and clonidine 0.1 mg as needed. Despite this regimen, the patient reported blood pressure as high as 190/100 on home ambulatory monitoring. The patient was referred to us by her primary care physician to evaluate renal artery stenosis (RAS).

LEARNING OBJECTIVES

- To learn about potential complications associated with renal artery angioplasty and stenting.
- To understand the role of Shockwave IVL in calcific RAS.

PAST MEDICAL HISTORY

She had a history of coronary artery disease with previous 4-vessel coronary artery bypass, diabetes mellitus type 2, a nerve stimulator for chronic back pain, and dyslipidemia.

DIAGNOSTIC TESTING. Computed tomography studies suggested severe calcific bilateral RAS involving the ostia (**Figures 1A and 1B**). This was characterized as more severe, dense, and nearly occlusive on the left side.

MANAGEMENT. Her renal artery angiogram demonstrated calcified severe 85% ostial left RAS (**Figure 2A**) and calcified severe 70% ostial right RAS (**Figure 3A**). To revascularize the left renal artery, a 0.014 Spartacore wire was advanced into the renal artery branch vessels through a 7-F internal mammary guide

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catheter. Percutaneous transluminal renal angioplasty (PTRA) was attempted with a 4 mm × 15 mm Sterling balloon (**Figure 2B**); however, adequate expansion was not observed. We escalated to a 4 mm × 10 mm Wolverine cutting balloon (**Figure 2C**) and believed we achieved an adequate lumen. However, we were unable to fully advance a 6 mm × 18 mm Express LD Biliary stent past the lesion. More than 60% of the stent remained within the aorta. Further attempts to maneuver the stent forward led to separation of balloon and stent. We felt it would be problematic to deploy the stent even if we managed to pass a lower-profile balloon into the stent, and hence decided to retrieve it. The stent was successfully removed using a 10-mm Gooseneck snare and was externalized (**Figure 2D**).

At the outpatient clinic follow-up, we debated strategies to tackle the unyielding calcified lesion. Atherectomy in an intra-abdominal vessel was not an option due to the potential risk of a perforation or fatal intra-abdominal bleed. Next, we considered Shockwave intravascular lithotripsy (IVL), and planned to use the shorter 40-mm balloon. Renal arteries are typically only 5 to 10 mm long, and more than 25 to 30 mm of the balloon would remain in the aorta. Because the effect of Shockwave on plastic-based catheters is unknown, we planned to retract the guide catheter to avoid potential sheath damage by the shockwaves.

On reattempt, the left renal artery was selectively engaged with a 7-F renal double curve 1 guide catheter and a 0.014 Spartacore wire was navigated into a branch vessel. A 4 mm × 40 mm Shockwave IVL balloon was advanced past the lesion, and the guide catheter was withdrawn (**Figures 3B and 3C**). The balloon was inflated to 4 atmospheres (ATM), and a total of 160 pulses were administered with intermittent balloon repositioning. The lesion was dilated with a 5 mm × 20 mm Nanocross balloon, and a 6 mm × 18 mm Express LD Biliary stent was deployed. Excellent angiographic results were obtained with only 10% residual stenosis (**Figure 3D**). Cine images of the unexpanded Shockwave balloon within the lesion and partially within the guide (Video 1A) and cine image of the fully unsheathed and expanded Shockwave balloon with a waist at the lesion site (Video 1B) are included as video clips. We brought the patient back for a staged procedure to revascularize the calcified right RAS with Shockwave IVL facilitated stenting as done on the left side with excellent results (figures not included).

ABBREVIATIONS AND ACRONYMS

ATM = atmosphere pressure

IVL = intravascular lithotripsy

PTRA = percutaneous transluminal renal angioplasty

RAS = renal artery stenosis

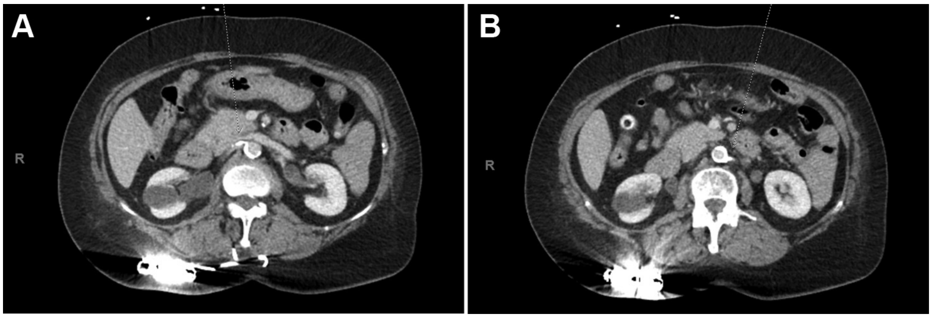
FOLLOW-UP

For the 3 separate procedures we used 110 ml, 80 ml, and 70 ml of contrast for the PTRA, left-side Shockwave IVL, and right-side Shockwave IVL, respectively. Renal function studies done pre-procedure, immediately post procedure, and late post procedure showed a serum creatinine of 0.98 mg/dl, 1.19 mg/dl, and 0.96 mg/dl, and a creatinine clearance of 65 ml/min/SA, 52 ml/min/SA, and 67 ml/min/SA, respectively, suggestive of mild contrast-induced nephropathy that resolved at follow-up. At her 3-week follow-up appointment, her antihypertensive medication dosages were reduced.

DISCUSSION

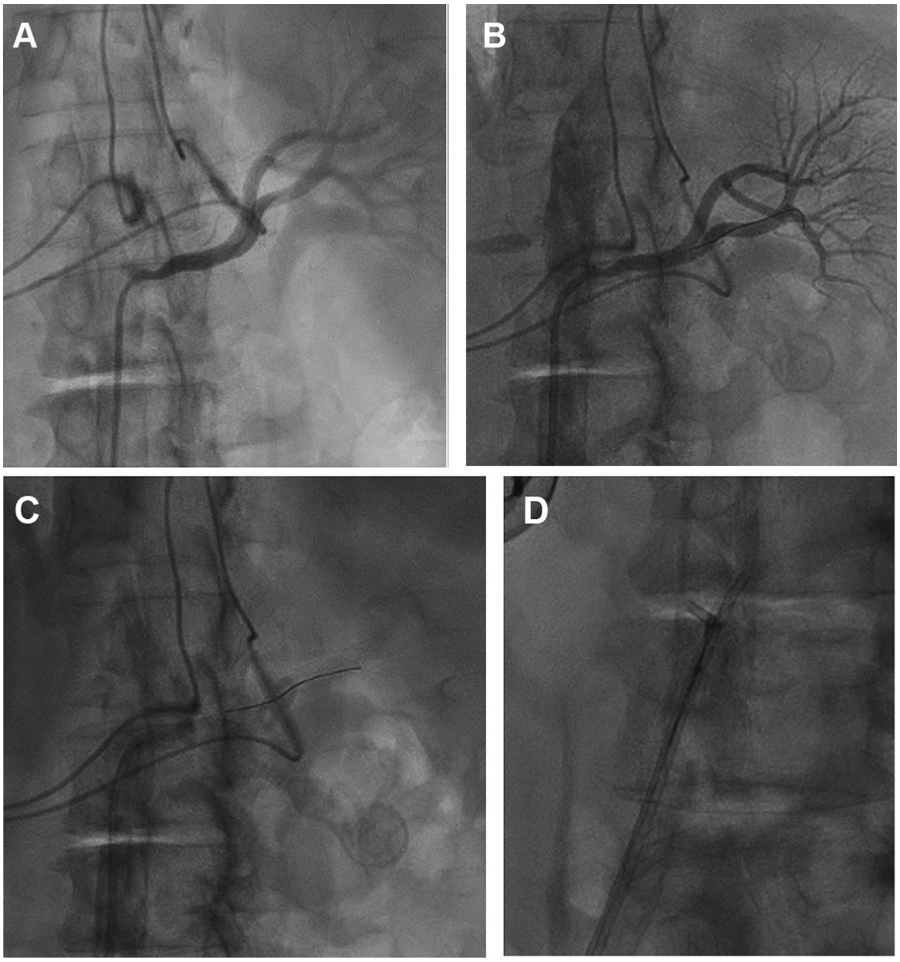
Atherosclerotic RAS is a leading cause of secondary hypertension and can lead to diminished renal function, acute coronary syndromes, and heart failure. The superiority of revascularization in comparison with medical management has not been

FIGURE 1 CT Abdomen Images Demonstrating Dense Calcific RAS



(A) The right renal artery with calcification seen in the ostium **(white arrow)**. **(B)** The left renal artery also with calcification seen in the ostium **(white arrow)**. CT = computed tomography; RAS = renal artery stenosis.

FIGURE 2 Initial Unsuccessful Attempt to Revascularize the Left Renal Artery

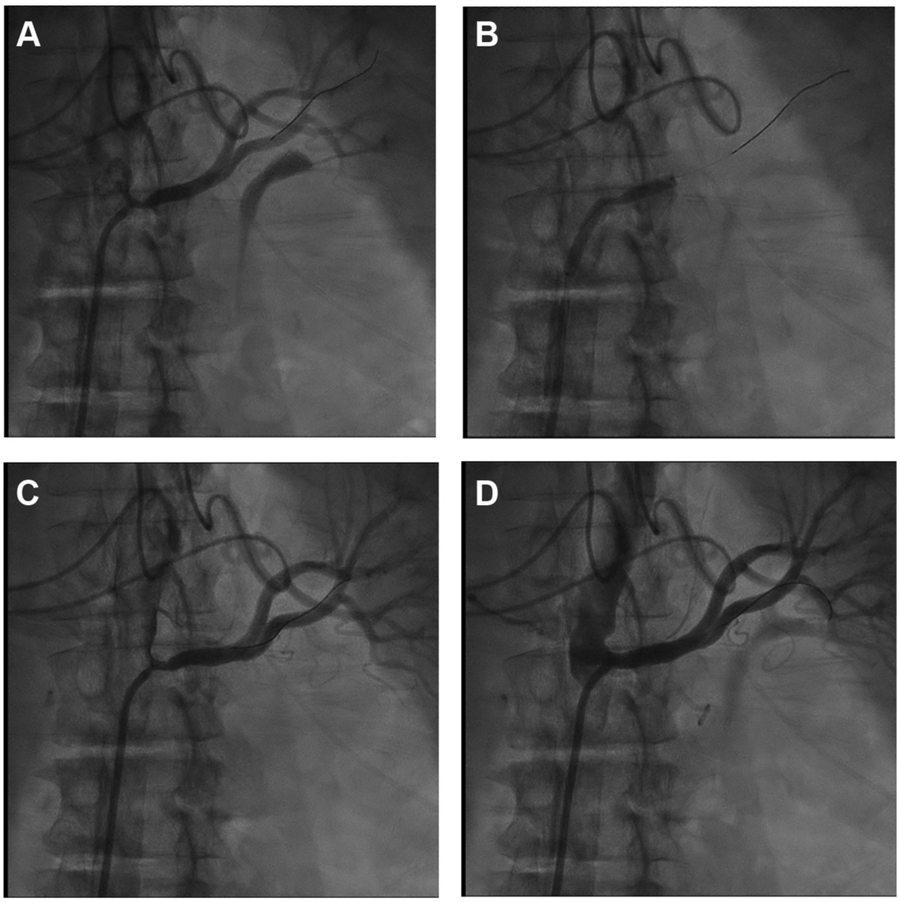


(A) Diagnostic left renal angiogram shows significant ostial calcific stenosis. **(B)** After noncompliant balloon angioplasty, angiogram shows no significant improvement. **(C)** Subsequent cutting balloon angioplasty of the left renal artery showed only minimal improvement. **(D)** The stent was separated from the balloon during advancement and had to be captured with a Gooseneck snare and externalized.

established in randomized controlled trials, albeit these trials had limitations (1,2). More specifically, in patients with bilateral RAS, a meta-analysis has demonstrated a lower requirement for antihypertensive medications. These patients, however, did not demonstrate any improvements in renal function, mortality, stroke, or congestive heart failure (3). In the subset of patients with bilateral RAS and resistant hypertension, revascularization is a reasonable option (4).

Calcific renal arteries are prone to complications during revascularization, including perforation and death (1). The introduction of Shockwave IVL for the treatment of calcified vasculature has afforded safer treatment options with decreased risk of perforation, dissection, or distal embolization. The Shockwave lithotripsy catheter, a balloon lined with emitters, is inflated to 4 ATM at the lesion site and sonic waves are delivered to selectively fragment calcium deposits in the vessel wall (5). The Shockwave does not debulk the lesion and the risk of distal embolization is minimized. This system is compatible with currently available pacemakers and defibrillators. Shockwave IVL has proven to be safe and effective in the treatment of lower extremity peripheral arterial disease (5) and to facilitate transcatheter aortic valve implantation (6). RAS lesions are typically 5 to 10 mm long but current Food and Drug Administration-approved balloons are 40 and 60 mm, leaving a large section of the balloon in the aorta. We recommend retracting

FIGURE 3 **Successful Reattempt to Revascularize the Left Renal Artery With Shockwave IVL**



(A) Left renal angiogram demonstrated almost unchanged stenosis. **(B)** Shockwave balloon inflation across the left renal artery. There is a narrow waist at the lesion with the balloon partially in the aorta and guide catheter has been withdrawn. **(C)** Left renal angiogram after Shockwave intravascular lithotripsy (IVL) treatment, showed moderate residual stenosis because IVL treatment only fractures calcium and does not debulk the lesion. **(D)** Left renal angiogram after stent deployment shows good expansion of stent.

the guide catheter to avoid potential sheath damage by the shockwaves because the effect of Shockwave on plastic-based catheters is unknown. Alternatively, single pulses can be given that activate only distal but not proximal emitters. These issues will likely be resolved with the introduction of shorter Shockwave IVL balloons.

This is the first reported case of renal artery revascularization facilitated by Shockwave IVL with successful outcomes. In our opinion, this is a simpler, safer, and cost-effective modality to successfully treat complex calcified RAS. Further studies are warranted to establish this modality as a first-line treatment for renal artery revascularization.

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AUTHOR DISCLOSURES

Dr. Kasi is a speaker for Shockwave Medical. All other authors have reported that they have no relationships relevant to the contents of this paper to disclose.

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KEY WORDS hypertension, peripheral vascular disease, stents

APPENDIX For supplemental videos, please see the online version of this paper.