Cardiovasc Intervent Radiol
https://doi.org/10.1007/s00270-022-03287-9

Case Report: Intravascular Lithotripsy Creates an Arterial Bypass Target

Simon Arian Zakeri[1] · Parminder Chandhok[1] · Ian Civil[1] · Andrew Holden[1]

Received: 20 June 2022 / Accepted: 14 September 2022

To the Editor,

We describe an application of Shockwave intravascular lithotripsy (IVL) (Shockwave Medical TM, Santa Clara, California) in the preparation of a calcified distal popliteal artery and tibio-peroneal trunk (TPT) prior to surgical bypass to exclude an above-knee popliteal aneurysm.

An 86-year-old male ex-smoker presented with one-month of right leg rest pain and dry gangrene in the lateral fifth toe. He was Buerger's positive, with absent pedal pulses and ankle-brachial-pressure-index of 0.57 (vs. 1.40 on the left). Comorbidities included hypertension, dyslipidaemia, and atrial fibrillation anticoagulated with warfarin.

Admission international-normalised-ratio (INR) was 2.5 (2–3), and he was switched to intravenous unfractionated heparin whilst hospitalised. Sars-CoV-2 antigen was negative.

A Computed-Tomogram-Angiogram (CTA) confirmed a 36 mm partially thrombosed above-knee-joint popliteal aneurysm, with severe calcific disease in the distal popliteal artery and TPT (Fig. 1), and marked crural disease with a dominant peroneal artery.

He was taken to theatre with the intention of performing distal superficial femoral to below-knee popliteal artery bypass to exclude the pro-embolic aneurysm. However, on exposure of the distal popliteal and TPT, both had a 'leadpipe' configuration prohibiting clamping and anastomosis. Thus, surgery was abandoned and the decision taken to attempt optimisation of the calcified vessels with IVL.

The P3 popliteal and TPT were percutaneously treated with a 5 × 60 mm Shockwave^{TM} M5 balloon with 10 cycles at 2 atmospheres. Satisfactory luminal gain was confirmed angiographically with no dissection or other complications. In the same session, the peroneal artery was also optimised to restore in-line flow to the foot, including 3 mm plain balloon angioplasty and 3 and 2.5 mm balloon-mounted drug-eluting stenting (Xience Prime, Abbott Vascular) in the proximal to mid-vessel (Fig. 2A-C).

Four weeks later the patient returned to theatre and following cutdown the distal popliteal and TPT walls were notably softer and more pliable, facilitating clamping of the below-knee popliteal and TPT, arteriotomy and end-to-end anastomosis of the P3 popliteal artery with the ipsilateral reversed greater saphenous vein (Fig. 2D).

The patient recovered well but re-presented within three weeks with acute limb ischaemia. CTA showed re-occlusion in the proximal peroneal artery, treated successfully with 3 mm plain balloon angioplasty, with additional recanalization of the anterior tibial artery (ATA) using 3 mm plain balloon angioplasty and 3 mm Xience Prime stenting proximally, to improve foot end-perfusion.

A duplex study at 2 months showed ongoing ATA and peroneal patency. The patient was pain-free and the ulcer almost completely healed. 6-months of clopidogrel 75 mg OD was prescribed alongside his warfarin to protect patency of the revascularization.

IVL utilises a semi-compliant angioplasty balloon with integrated emitters of sonic pressure waves to induce micro-fracturing of intimo-medial calcified plaque. It has been proven effective in treating highly calcified occlusive

✉ Simon Arian Zakeri
zakeri@doctors.org.uk

[1] Division of Vascular Interventional Radiology and Vascular Surgery, Auckland City University Hospital, Auckland, New Zealand

Published online: 29 September 2022

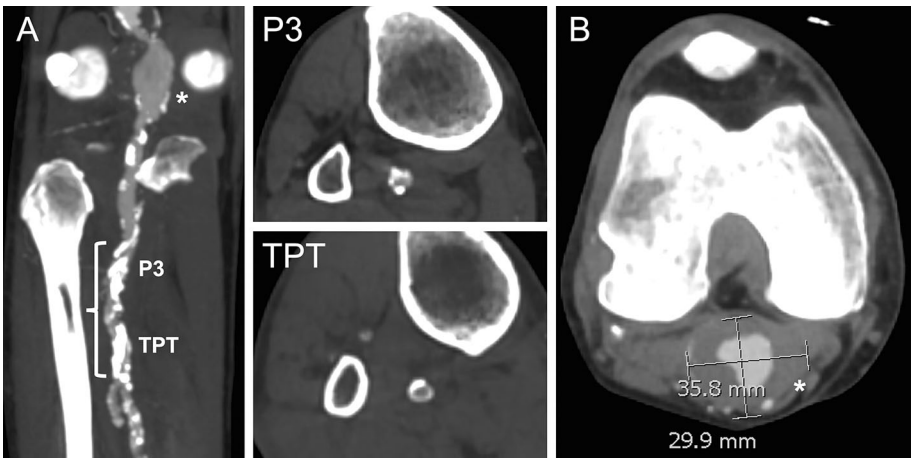

Fig. 1 **A, B** Baseline CT angiogram right leg. **A** is a coronal maximum intensity projection image depicting the P2 popliteal aneurysm (Asterix), heavily calcified P3 popliteal and TPT (Bracket). **P3** and **TPT** are axial slices at the level of P3 and TPT, respectively, showing heavy almost circumferential calcified plaque burden in both. **B** is an axial slice showing the P2 aneurysm (Asterix) measurements, with circumferential pro-embolic thrombus present

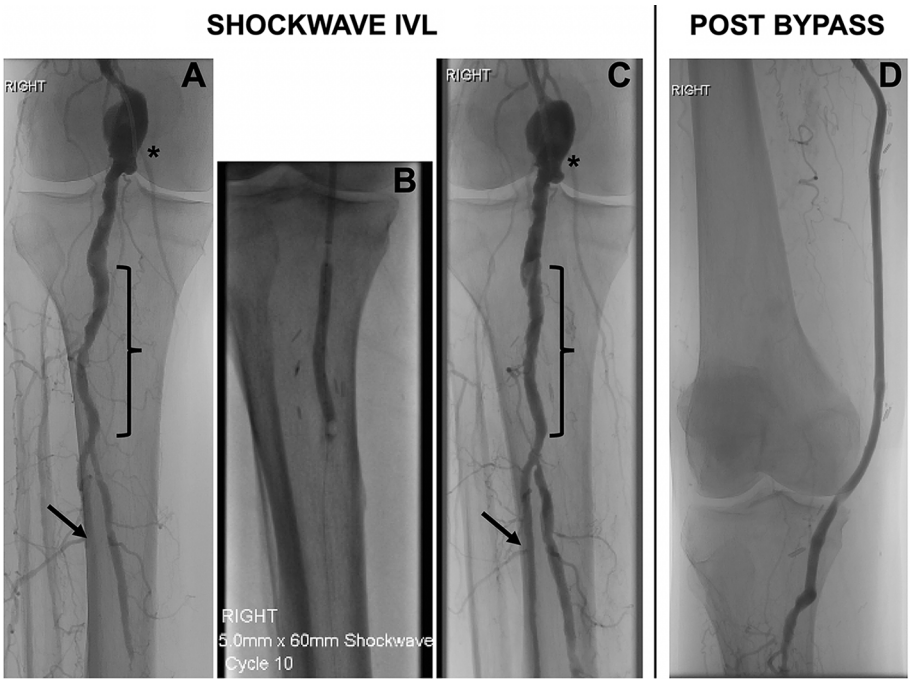

Fig. 2 **A–D** Below-knee popliteal artery and tibio-peroneal trunk (TPT) Shockwave intravascular lithotripsy (IVL) treatment and peroneal angioplasty, and post bypass angiogram. **A** is the baseline angiogram, showing the P2 popliteal aneurysm (Asterix), calcific disease particularly in the distal popliteal artery and TPT (Bracket), and peroneal artery focal occlusion proximally (arrow). **B** is the inflated Shockwave 5 × 60 mm balloon at 2 atmospheres during the last IVL cycle. **C** shows improved calibre and flow through the distal popliteal and TPT (Bracket) and recanalized peroneal artery (arrow) following IVL and angioplasty, respectively. **D** is a post bypass angiogram showing patent vein and exclusion of the P2 aneurysm

disease in the aorta and ilio-femoral arteries to facilitate large-bore sheath access for endovascular aneurysm repair and transcatheter aortic valve replacement [1, 2]. IVL was extensively studied in the largest randomized controlled trial (DISRUPT PAD III) of calcified femoropopliteal arteries [3], which showed significantly greater luminal gain at lower pressure compared to conventional angioplasty, indicating IVL enhances vessel compliance. There were also significantly lower dissection and provisional stenting rates with IVL. Such advantages have recently extended to mid-term follow-up [4].

Distal bypass grafting to unclampable calcified outflow arteries carries lower primary patency than uncalcified arteries [5]. Whilst techniques are available to optimise anastomosis, the amputation threat remains when severe calcification is insurmountable.

This case study demonstrates a novel strategy of applying IVL to increase vessel compliance and pliability in calcified below-knee arteries, ultimately facilitating

arterial clamping and surgical anastomosis to bypass a pro-embolic aneurysm. Further studies are recommended to validate the utility of IVL in optimisation of calcified vessels pre-bypass surgery.

Funding No funding was provided for the production of this case report.

Declarations

Conflict of interest Andrew Holden is a clinical investigator for Shockwave Medical. There are no other conflicts of interest.

Consent for Publication Consent for publication was obtained for the individual person data included in the study.**Ethical Approval**This article does not contain any studies with human participants or animals performed by any of the authors. IRB approval for this type of study is not required.

Informed Consent This was obtained from the individual participant included in the study.

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