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Pneumatic Compression for Embolic Protection During Upper Extremity Endovascular Intervention

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Abstract

Embolic protection devices are occasionally employed during endovascular interventions to prevent complications caused by embolic debris. However, these devices have imperfect efficacy, confer risk of endovascular trauma, and are expensive. We report a patient with giant cell arteritis and symptomatic axillary artery stenosis, with a perceived elevated risk of distal embolization during endovascular intervention. We describe a straightforward embolic protection technique of brachial pressure cuff inflation during endovascular intervention and aspiration of displaced thrombotic material from the static column of blood. This novel, effective, and cost-free technique could also be employed in other vascular beds during endovascular intervention.

Keywords

axillary stenosis, subclavian stenosis, peripheral stent, embolic protection, giant cell arteritis

Case Report

We present a 79-year-old female with a history of polymyalgia rheumatica diagnosed 13 years prior, who had been in remission following a 1-year course of prednisone. An incidental ascending and proximal aortic arch aneurysm was identified on routine chest x-ray. Computed tomography (CT) angiography measured a maximum diameter of 67 mm in the ascending aorta without dissection (Figure 1A and B). There were no risk factors for atherosclerotic disease aside from age. Transthoracic echocardiography excluded aortic valve pathology, but coronary angiography demonstrated a significant stenosis in mid-left anterior descending artery. Given the risk of aneurysm rupture, she was referred for elective open ascending and proximal aortic arch replacement and single-vessel coronary artery bypass grafting.

During right axillary artery incision for cannulation for cardiopulmonary bypass, the artery was found to be friable, and separation of the intima occurred. The damaged segment was resected, and a Dacron interposition graft was placed, with an 8-mm end-to-side chimney extension to be used for cannulation for bypass. The aortic reconstruction was uneventful, but upon discontinuation of cardiopulmonary bypass, there was concern that the right upper extremity arterial blood flow was impaired, with no recordable waveform from the radial arterial line and no Doppler signal from the brachial artery. Thrombectomy of the brachial artery was attempted with multiple passes of Fogarty balloon catheters. Papaverine was injected through the chimney graft into the right upper extremity. No thrombus was retrieved, but blood flow was restored after these maneuvers, with triphasic Doppler signals in the brachial artery and good blood flow in the hand. The chimney graft was taken down. Postoperatively, upper extremity pulses were symmetric and normal, and CT angiography confirmed a patent axillary artery graft with a moderate stenosis at the distal edge. Pathology of the resected aortic aneurysm revealed both medial degeneration (Figure 1C) and active giant cell arteritis (Figure 1D), with focal moderate calcific atherosclerosis. Prednisone was commenced because of these pathologic findings, despite normal systemic inflammatory markers (sedimentation rate 24 mm/h, C-reactive protein < 3mg/L).

The patient returned for follow-up at 6 weeks, complaining of a 2-week history of progressively worsening right upper extremity exertional fatigue. The right brachial, radial, and ulnar pulses were only weakly palpable, and the brachial

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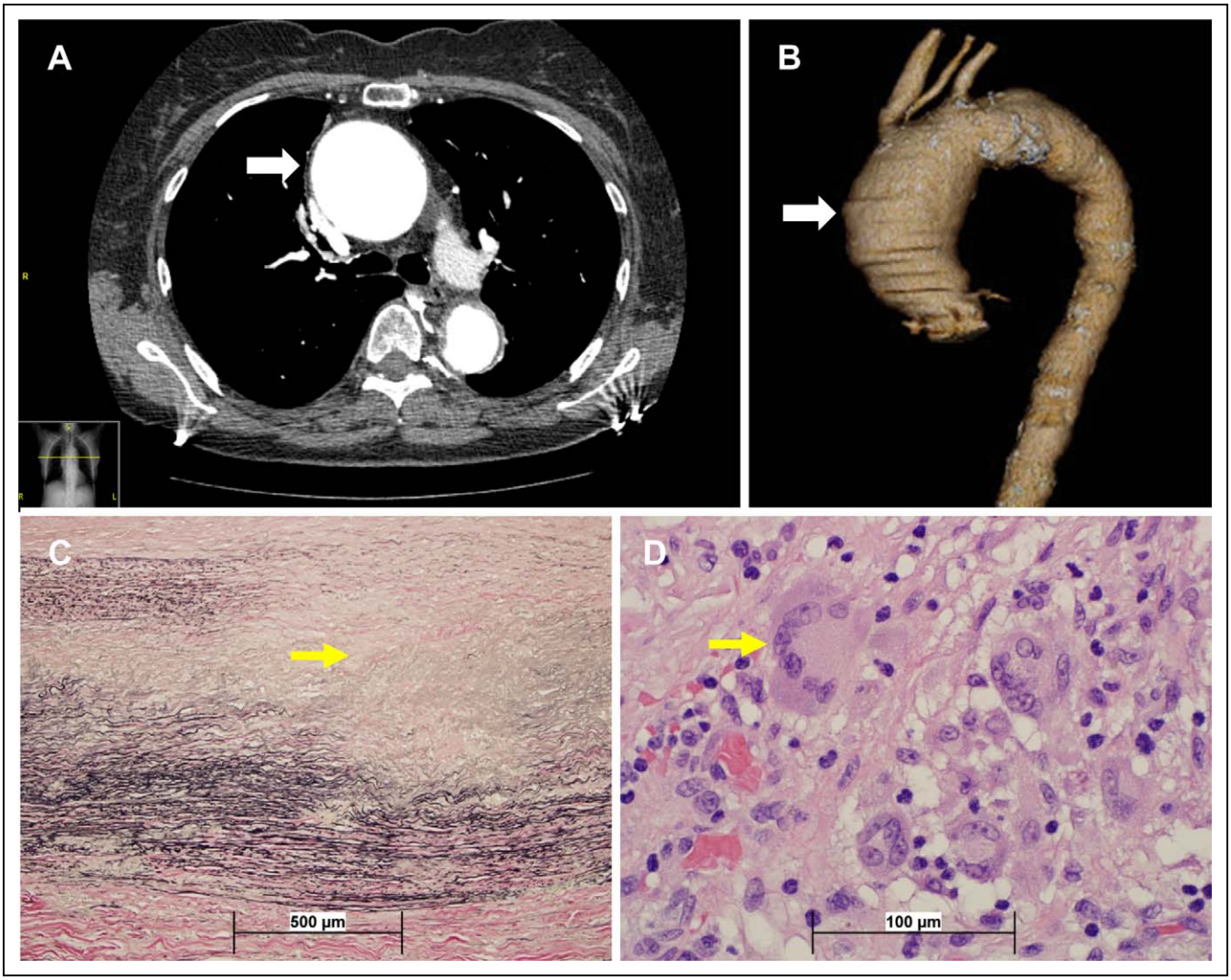

Figure 1. A and B, Computed tomography (CT) angiography with 3-dimensional reconstruction demonstrating a 67-mm ascending and proximal arch aortic aneurysm (arrows). C, Histopathology of ascending aorta aneurysm showing marked medial degeneration with disruption and loss of elastic fibers (arrow; Verhoeff-van Gieson stain). D, Medial collection of multinucleated giant cells (arrow) and other inflammatory cells, indicative of giant cell aortitis (hematoxylin–eosin stain).

systolic cuff pressure was 40 mm Hg lower than the left arm. A high-pitched bruit was heard over the right axillary artery, and arterial Doppler signals were monophasic. The CT angiography confirmed a high-grade stenosis in the right axillary artery at the distal edge of the interposition graft (Figure 2A). Given the severely limiting and progressive symptoms and the recent operation, endovascular intervention was offered. Since the etiology of the stenosis was uncertain but possibly iatrogenic, inflammatory, atherosclerotic, or thrombotic, an embolic protection strategy was planned. Intervention was deferred for 2 weeks to lengthen immunosuppressive therapy.

Arterial Access and Diagnostic Angiography

A right common femoral artery approach was used. The origin of the innominate artery was engaged with a 6F H1 catheter (Cook, Bloomington, Indiana) over a 0.035-inch angled Glidewire and advanced a 6F shuttle sheath (Cook) to the proximal right subclavian artery. Selective angiography through the sheath confirmed a critical focal stenosis in the right axillary artery at the distal edge of the prior Dacron interposition graft, with bridging collaterals (Figure 2B).

Embolic Protection Strategy and Endovascular Intervention

We elected to proceed with predilation and self-expanding stent placement to the right axillary artery using a novel "occlusive external pneumatic compression" upper extremity embolic protection strategy. After systemic anticoagulation with heparin, the lesion was crossed with a 0.035-inch Glidewire and then a 4.0- × 30-mm^2 EverCross balloon (ev3, Plymouth, Minnesota) was advanced over the Glidewire to the

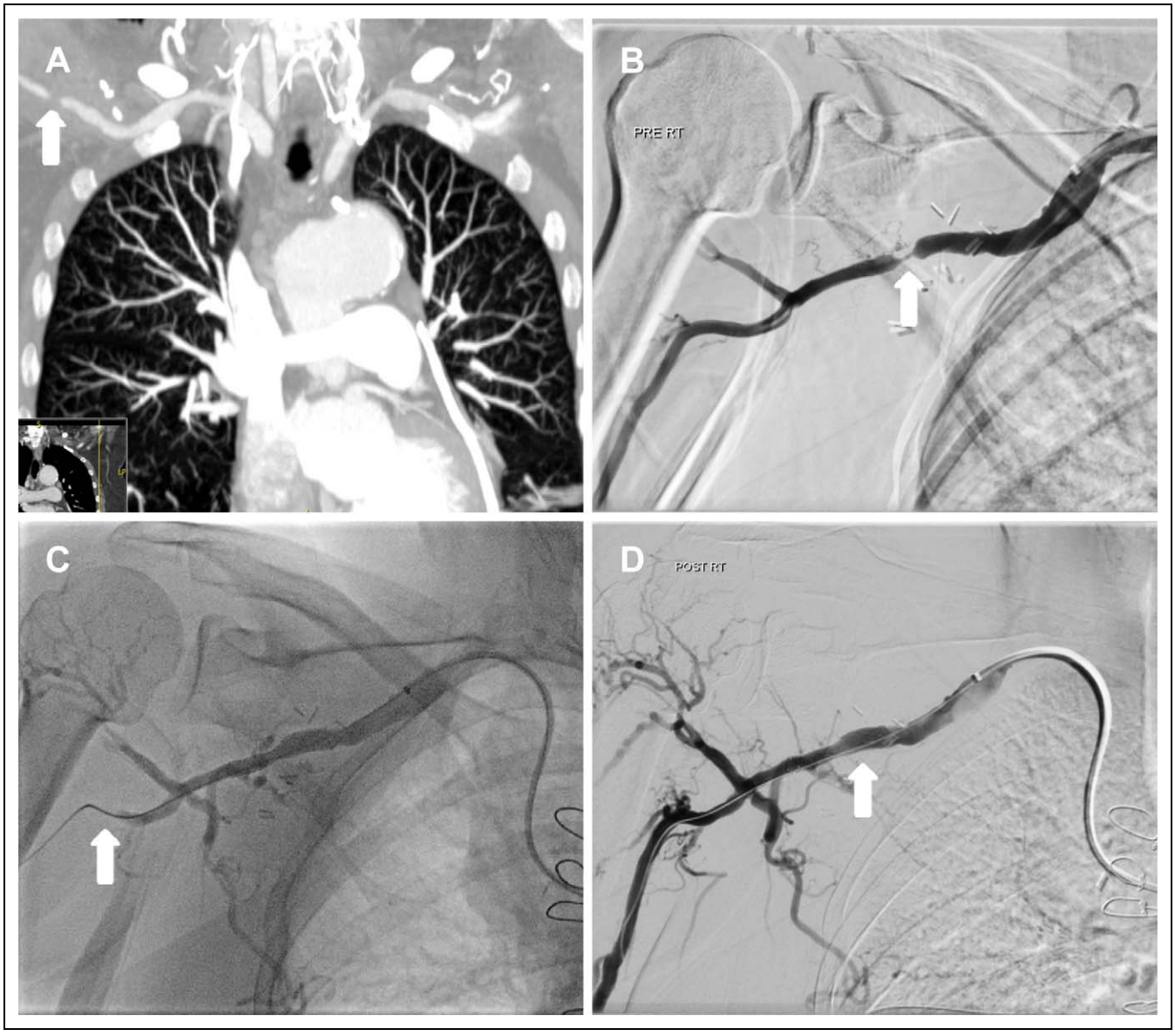

Figure 2. A, Coronal computed tomography (CT) angiography demonstrating a high-grade lesion in the right axillary artery. B, Selective angiography demonstrating critical focal stenosis in the right axillary artery at the distal edge of the prior Dacron interposition graft. Bridging collaterals are present. C, Angiographic still frame demonstrating interruption of antegrade arterial flow with right arm suprasystolic blood pressure cuff inflation. D, Selective subclavian angiography indicating excellent final result after placement of self-expanding stent and postdilation.

stenotic lesion. A right brachial blood pressure cuff was inflated to suprasystolic pressure to occlude the brachial artery. After test angiography confirmed complete cessation of antegrade flow, low-pressure balloon predilation was performed. Immediately following balloon deflation, aspiration of the static column of blood with a 50-cm^3 syringe through the sidearm of the sheath was performed followed by release of the brachial pressure cuff. A similar cuff-occlusion strategy was employed for subsequent placement of a 7- $\times$ 40-mm^2 EverFlex Protege self-expanding stent (ev3; Figure 2C) and postdilation with a 5- $\times$ 30-mm^2 EverCross balloon. Macroscopic material liberated from the lesion was identified in the aspirate (Figure 3A), with subsequent pathologic evaluation indicating this to be thrombus (Figure 3B). There was an excellent final angiographic result without angiographic or clinical evidence of distal embolization. There was immediate resolution of upper extremity symptoms, and the patient remains asymptomatic at 6 weeks.

Discussion

This report describes for the first time the use of a simple, effective, and no-cost technique for upper extremity embolic protection during endovascular intervention. Embolic protection devices are routinely employed during carotid artery and vein graft coronary interventions. They are however infrequently used in other vascular beds due to uncertain clinical

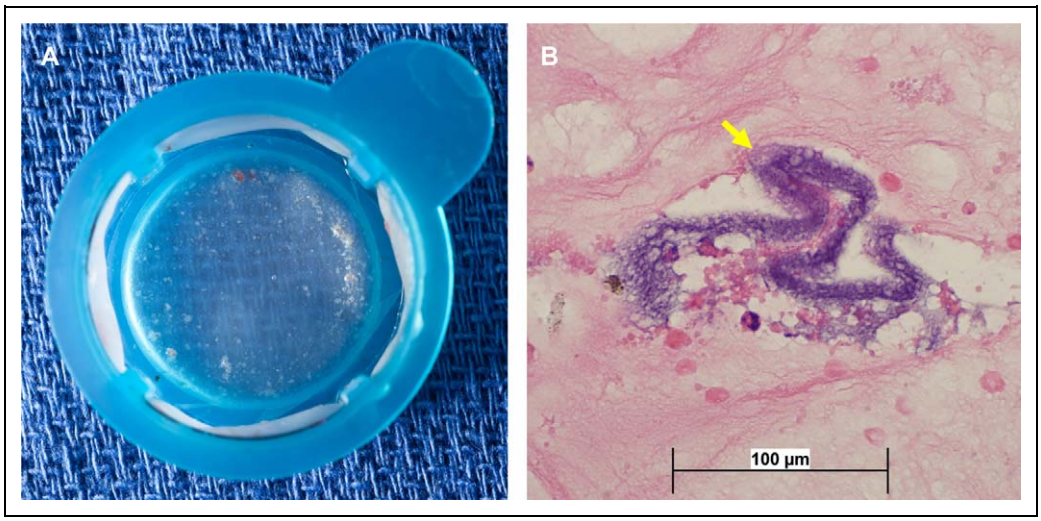

Figure 3. A, Macroscopic white and red material liberated from axillary stenosis and aspirated from static column of blood after endovascular intervention. B, Histological preparation of embolic material shows fibrin strands, red blood cells, and granular purple-blue material (arrow), indicative of hydrophilic polymer used to coat some intravascular devices (hematoxylin–eosin stain).

benefits, risks of device deployment, and cost. For example, filter devices such as FilterWire (Boston Scientific, Natick, Massachusetts) and Spider (ev3) provide incomplete distal protection by allowing particles of small size to pass through device pores or of larger size to pass around the device that seldom apposes circumferentially to the vessel wall.[1] Use of such devices confers additional risks of endovascular injury during deployment such as dissection[2] or of difficulties during retrieval.[3] Proximal protection devices (eg, MO.MA; Invatec, Inc, Bethlehem, Pennsylvania) involve the use of occlusion balloons proximal to the stenosis and in large side branches in order to suspend antegrade flow during intervention. Following intervention, the column of blood containing the displaced stenotic components is then removed through aspiration. While this technique offers improved embolic protection efficacy, the devices require large-bore sheaths and are technically challenging to use.[4]

In the cuff-occlusion technique we describe here, we address disadvantages of available distal and proximal devices, by achieving embolic protection, without endovascular manipulation, at no cost. A theoretical risk of external compression with an intravascular wire is trauma-induced arterial wall injury, but in the current case, the postprocedural angiogram was negative for complications despite a surgically proven "fragility" of the arterial wall. The aspiration of displaced thrombus following stent placement additionally confirms efficacy of this approach. This strategy could also be employed in the thigh, with superficial femoral artery occlusion during antegrade proximal intervention.

Declaration of Conflicting Interests

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