Spike the PCHA! Overuse injury of the Posterior Circumflex Humeral Artery in elite volleyball
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CHAPTER 10

Conservative management of a vascular shoulder overuse injury in a professional volleyball player: use of novel MR Angiography in diagnosis and treatment follow-up

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Submitted
**ABSTRACT**

We report on a 34-year-old elite male elite volleyball player with symptomatic emboli in the spiking hand from a partially thrombosed aneurysm of the posterior circumflex humeral artery (PCHA) in his dominant shoulder. At initial diagnosis and follow-up, a combination of time-resolved and high-resolution steady state Contrast-Enhanced Magnetic Resonance Angiography (CE-MRA) enabled detailed visualization of: (1) emboli that were not detectable by vascular ultrasound; and (2) the PCHA aneurysm, including compression during abduction and external rotation (ABER provocation). At 15-month follow-up, including forced cessation of volleyball activities over the preceding nine months, the PCHA aneurysm remained unchanged. Central filling defects in the palmar arch and digital arteries resolved over time and affected arterial vessel segments showed post-thrombotic changes. Digital blood pressure values improved substantially and almost normalized during follow-up. In conclusion, this case report is the first to show promising results of conservative management for a vascular shoulder overuse injury in a professional volleyball player as an alternative to more invasive clinical modalities.
INTRODUCTION

We present a case of a 34-year-old elite volleyball player with symptomatic emboli in the spiking hand and a partially thrombosed aneurysm of the posterior circumflex humeral artery (PCHA) in his dominant shoulder, who was selected in the context of an on-site ultrasound surveillance study. He was advised about follow-up and referred to our tertiary medical center for state-of-the-art non-invasive and invasive vascular imaging. Fifteen months later, he was re-evaluated.

CASE REPORT

Initial presentation
At the end of the national volleyball play-offs, the 34-year-old right-hand-dominant male volleyball player was referred to a vascular surgeon at our medical center. He reported a two-year history of ischemic symptoms of his spiking hand, e.g. cold, pale and painful digits, which initiated in the second and third digits and had recently expanded to the fourth and fifth digits. Since the start of the play-off season, with increased match frequency (up to three a week), he continuously experienced cold, discoloration and numbness. The athlete is a middle blocker, has played volleyball for 28 years at semi-professional level, and for 10 hours a week. He has a part-time office job, is a non-smoker with no medical history and no medication use, and reports no cardiovascular disease in first-degree family. Physical examination confirmed cold and discoloured digits and abnormal capillary refill (digit II, III, IV, and V). Subungual petechiae were present in the fourth digit. The Allen’s test was positive, and radial artery and ulnar artery pulsations were normal. No clinical abnormalities were present in the left hand. State-of-the-art vascular ultrasound examination using the standardized and accurate SPI-US protocol revealed a partially thrombosed proximal PCHA aneurysm in his right/spiking shoulder (Figure 1). The palmar arch and digital arteries could not be depicted during ultrasound assessment, and therefore neither the presence nor the absence of digital emboli could be demonstrated. Non-invasive digital arterial blood pressure evaluation revealed abnormal pressure values at the level of the proximal phalanx (digit I-V: 159, 144, 149, 159, 0 mmHg) and middle phalanx (digits II-IV: 85, 97, 81 mmHg), and photoplethysmographic curves were non-triphasic in digits II-V of the right hand, both indicative of inadequate perfusion of digits II to V (Figure 2 left panel). To assess the presence of digital emboli, a combined MR protocol consisting of time-resolved – and high-resolution steady state – Contrast-Enhanced Magnetic Resonance Angiography (CE-MRA) was performed. Filling defects and multiple emboli were detected in the distal radial artery, palmar arch, common palmar artery, and digital arteries (Figure 3), which corresponded to the abnormal non-invasive digital arterial pressure values. Moreover, the PCHA aneurysm was assessed and depicted in two positions: (1) supine anatomic
position (diameter 8mm, length 25mm, at 8 mm from the PCHA origin); and (2) during abduction and external rotation (ABER provocation), to simulate spiking and serving during volleyball, which showed compression of the distal part of the aneurysm (Figure 4). The remaining arterial run-off down to the hand showed no abnormalities.

After careful consideration in a shared decision, it was decided not to perform surgery nor undergo drug therapy. The athlete was discharged without oral anti-thrombotic medication.

15-month follow-up
After 15 months, follow-up was performed. Complete cessation of volleyball activities over the preceding nine months caused us to wonder what anamnestic and imaging changes had occurred: the discoloration, numbness and pain in the spiking hand had disappeared, and he only reported cold – not warm – digits in the right hand while playing outdoor tennis in the winter time, which disappeared instantly in warm circumstances. Physical examination revealed no clinical abnormalities in the right hand, and the subungal petechiae were resolved. Radial artery and ulnar artery pulsations were normal. Vascular ultrasound examination revealed a PCHA aneurysm in his right/ spiking shoulder without intravascular thrombus. Non-invasive digital arterial blood pressure evaluation revealed normal pressure values at the level of the middle phalanx (digits II-V: 151, 151, 141, 154 mmHg). Photoplethysmographic curves were triphasic in all digits of the right hand, but remained flattened in digits II and III (Figure 2 right panel). CE-MRA showed improved vascular patency in the right hand and resolution of central filling defects in the distal radial artery, palmar arch, and digital arteries (Figure 3). Affected digital artery vessel segments showed post-thrombotic changes with decreased diameters and occlusion of some affected segments (Figure 3). The PCHA aneurysm remained unchanged compared to baseline (Figure 4).
Figure 1 Upper panel: longitudinal B-mode ultrasound image of the aneurysmatic proximal PCHA with intravascular thrombus in a 29-year-old professional volleyball player. Lower panel: colour Doppler ultrasound image of the aneurysmatic proximal PCHA, note there is no colour flow in the thrombus region (arrowhead). Key: PCHA, posterior circumflex humeral artery
Figure 2 Left panel (initial presentation): abnormal digital arterial blood pressure values at the level of the proximal phalanx (digits I-V: 159, 144, 149, 159, 0 mmHg) and middle phalanx (digits II-IV: 85, 97, 81 mmHg). Photoplethysmographic waveform patterns were non-triphasic in all digits of the right hand. The left hand shows no abnormalities. Right panel (follow-up): Normal digital arterial blood pressures and photoplethysmographic waveform patterns in both hands on follow-up.
Figure 3 Contrast-Enhanced MR Angiography using a 1.5T MR system (Siemens MAGNETOM Avanto, Siemens Healthcare 2009) after infusion of a blood pool contrast agent (Ablavar, Lantheus Medical Imaging 2009). Resolution 0.3x0.3x0.3 mm using a 15-element knee coil. A) initial diagnosis scan: maximum intensity projection of time-resolved CE-MRA at initial diagnosis shows filling defects in the distal radial artery, palmar arch, common palmar arteries, and digital arteries (arrowheads); B) initial diagnosis scan: cross-sectional multi-planar reconstruction of digital arteries with a central filling defect in digits IV and V (arrowheads); C) initial diagnosis scan: longitudinal multi-planer reconstruction of the hand with a central filling defect in the common palmar artery (arrowhead); D) follow-up scan: resolution of thrombus and decreased artery diameters in digits IV and V (arrowheads); E) follow-up scan: resolution of thrombus in the common palmar artery (arrowhead).
Figure 4 Contrast-Enhanced MR Angiography using a 1.5T MR system (Siemens MAGNETOM Avanto, Siemens Healthcare 2009) after infusion of a blood pool contrast agent (Ablavar, Lantheus Medical Imaging 2009). Resolution 0.6x0.6x0.6 mm using a 6-element body matrix coil. Volume-rendered images of the axillary artery, branching of the PCHA and proximal PCHA aneurysm (arrowhead) in ABER position (A) and anatomic position during diagnosis (B), and follow-up (C). The proximal PCHA aneurysm (arrowhead) is largely compressed in the ABER position. Thick slab maximum intensity projections (9 mm) of the PCHA aneurysm (arrowheads) at initial diagnosis (D), and follow-up (E).
DISCUSSION

Although conservative treatment has been suggested for PCHA pathology\textsuperscript{88,127}, to our knowledge, this patient (n=1) study is the first to report on successful conservative management for this severe vascular shoulder overuse injury with digital emboli in an elite volleyball player.

After 15 months without anti-thrombotic medication, and with cessation of volleyball activities over the previous nine months, the PCHA aneurysm did not show changes compared to baseline. However, distal radial artery, palmar arch, and digital artery intravascular thrombus dissolved. Digital arteries showed post-thrombotic changes including narrowing of luminal diameters and some distal occlusions. However, symptoms dissolved and physical examination measurements as well as brachial artery and finger pressure measurements almost normalized. The residual symptoms – cold digits during outdoor tennis in the winter – might be the result of demand-ischemia as a result of inadequate vasodilation during outdoor leisure activities in cold circumstances due to post-thrombotic vessel changes.

Moreover, this case report is the first to show that a novel combined MR protocol consisting of time-resolved – and high-resolution steady state – CE-MRA enables detailed visualization of symptomatic emboli in the spiking arm and hand, which are not detectable by vascular ultrasound, and that are in agreement with symptoms and non-invasive hemodynamic measurements. Additionally, this protocol enables visualization of the PCHA aneurysm during ABER provocation, which is of added value to simulate the positional traction and compression of the proximal PCHA during the spiking and serving motion in volleyball. The assumption is that these repetitive powerful overhead movements cause chronic PCHA vessel wall injury\textsuperscript{3,17,95}, which can be assessed by the CE-MRA protocol.

Aneurysmal degeneration, thrombosis and distal occlusion of the PCHA is a rare sport-related overuse injury mostly found among elite volleyball players\textsuperscript{89}, with a prevalence of 4.6\%.\textsuperscript{92} PCHA thrombosis might lead to distal embolization to the circulation of the forearm, hand, and digits in the ipsilateral limb during the spiking or serving motion in volleyball, when the humeral head acts to compress the aneurysmal PCHA and the intraluminal thrombus, causing retrograde embolism into the axillary artery.\textsuperscript{3,49,89} Invasive treatment options for thrombosed PCHA aneurysms include surgical ligation and endovascular coiling\textsuperscript{3}, and are likely to completely reduce the recurrence emboli. However, this type of therapy does not affect the symptomatic emboli and associated symptoms. It seems that conservative management can be considered a valuable alternative for invasive therapeutic options for – partially – thrombosed PCHA aneurysms.
However, the cessation of the provoking factor, repetitive powerful overhead movements such as spiking and serving in volleyball, might be key for success and for the feasibility of conservative management.

In conclusion, for a vascular shoulder overuse injury with symptomatic embolization in the spiking arm in a professional volleyball player, this case report is the first to show promising results of conservative management as an alternative to more invasive clinical modalities such as surgery or percutaneous interventional techniques.