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Radial Artery Pseudoaneurysm With Individualized Non-Operative Management: A 4-Case Series

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Statistical Analysis C
Data Interpretation D
Manuscript Preparation E
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Case series

Patients: Female, 78-year-old • Female, 70-year-old • Female, 59-year-old • Female, 80-year-old

Final Diagnosis: Pseudoaneurysm

Symptoms: Painful swelling over arterial puncture site

Clinical Procedure: —

Specialty: Radiology

Objective: Management of emergency care

Background: Radial artery pseudoaneurysm (RAP) is an uncommon complication of radial arterial access. Although rarely life-threatening, it can cause significant morbidity. With the increasing use of radial access for coronary and endovascular procedures, arterial blood gas sampling, and invasive hemodynamic monitoring, RAP remains a potential access-site complication. Given its rarity, the literature on its management is limited and consists mainly of case reports and small case series. We report 4 cases of iatrogenic RAP with different non-operative management.

Case Reports: Four patients developed RAP following radial arterial access for intra-arterial blood pressure monitoring or coronary angiography. In Case 1, ultrasound-guided compression (UGC) was chosen because of poor collateral hand circulation and concerns for hand ischemia with thrombin injection, resulting in successful thrombosis of the pseudoaneurysm. Cases 2 and 3 underwent ultrasound-guided thrombin injection (UGTI), with Case 3 requiring repeat injection following recanalization. Case 4 had a large, flat-appearing pseudoaneurysm that was unsuitable for direct thrombin injection; balloon-assisted thrombin injection was attempted to preserve the radial artery but was unsuccessful, and a covered stent was deployed for exclusion of the pseudoaneurysm.

Conclusions: A range of non-operative approaches can be used in the management of RAP, depending on the clinical and anatomical circumstances. UGC and UGTI can achieve successful thrombosis, while endovascular techniques can provide an alternative when initial treatment is unsuccessful or the anatomy is challenging. Further studies are needed to better define the outcomes of these approaches and to establish a standardized treatment algorithm for RAP.

Keywords: Endovascular Procedures • Pseudoaneurysm • Radial Artery • Ultrasonography

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Introduction

Radial artery pseudoaneurysm (RAP) is an uncommon complication but is an increasingly recognized complication of transradial arterial access, reflecting the growing use of the radial approach for coronary and endovascular procedures, arterial blood gas sampling, and invasive hemodynamic sampling [1]. The increasing use of radial access reflects its favorable safety profile; an early landmark meta-analysis study demonstrated a significantly lower incidence of major bleeding with radial compared with femoral access for endovascular procedures (0.05% vs 2.3%) [2]. Despite these advances, RAP remains a potential access-site complication, although its incidence is low. Population-based data from a high-volume cardiovascular center estimates a RAP prevalence of approximately 0.05% [3].

RAP results from disruption of the arterial wall at the puncture site, with subsequent extravasation of blood into the surrounding soft tissues while maintaining communication with the arterial lumen [4]. Unlike a true aneurysm, a pseudoaneurysm does not contain all 3 layers of the arterial wall. Instead, it is a contained arterial rupture, in which blood leaks through the defect in the intima and media and is contained by the surrounding soft tissues and residual adventitia, resulting in a pulsatile hematoma [1]. Although rarely life-threatening, RAP can result in significant morbidity, including distal embolization, local ischemia, paresthesia from nerve compression, delayed wound healing, skin breakdown, secondary infection, and, in rare cases, spontaneous rupture [5]. Risk factors include multiple puncture attempts, systemic anticoagulation, inadequate haemostasis, and larger sheath sizes [6,7].

Previous reports have described a range of treatment approaches for RAP, including ultrasound-guided compression (UGC), ultrasound-guided thrombin injection (UGTI), percutaneous and endovascular interventions and surgical repair [8-19]. UGTI has increasingly been reported as a minimally invasive treatment option [8], while balloon-assisted thrombin injection and covered stent placement have been described for anatomically challenging pseudoaneurysms or when the initial treatment is unsuccessful [16,17,20,21]. However, given the rarity of RAP, the available literature remains limited and consists predominantly of individual case reports and small case series, with management guided largely by individual case characteristics rather than consensus recommendations [8].

We thus describe 4 cases of iatrogenic RAP following radial artery access with individualized non-operative approaches. This case series aims to highlight the varied clinical and anatomical considerations encountered in each case and the different treatment approaches employed.

Case Reports

We report 4 cases of iatrogenic RAP managed at 2 centers over a 3-year period. The patients were referred to the Interventional Radiology service by Vascular Surgery or the primary clinical team for assessment and non-operative management of RAP.

Case 1

A 78-year-old woman underwent emergency coronary angiography for non-ST-elevation myocardial infarction via distal right radial artery access using a 6-Fr sheath. Radial access was obtained with a single puncture attempt. Following sheath removal, manual compression was applied for 5 minutes followed by application of a NICHIBAN STEPTY™ P (NICHIBAN Co., Ltd., Tokyo, Japan) dressing for 2 hours. She was then started on dual antiplatelet therapy.

Within 24 hours, she developed painful swelling over the radial access site. Duplex ultrasound confirmed the presence of a RAP (2.6 × 0.9 cm, neck diameter: 1 mm) (Figure 1A). Given the poor collateral circulation (Barbeau Type D) with additional potential risks of finger ischemia during thrombin injection, UGC was performed for 30 minutes with intermittent release with partial thrombosis in the pseudoaneurysm sac achieved (Figure 1B). Follow-up ultrasound the next day demonstrated complete thrombosis of the pseudoaneurysm neck and patent flow in the parent artery (Figure 1C).

Case 2

A 70-year-old woman on long-term warfarin for chronic atrial fibrillation presented with a painful swelling over her left distal forearm 2 months after radial arterial line placement during admission for mechanical aortic valve replacement. The arterial line was inserted with a single puncture using a 22-G introducer needle, followed by placement of a 20-G arterial catheter using the Seldinger technique. Following catheter removal, manual compression was applied for 5-10 minutes to achieve haemostasis; the type of dressing subsequently applied was not documented.

Duplex ultrasound showed a partially thrombosed RAP (2.6 × 2.1 cm, neck diameter: 1 mm) (Figure 2A). Clinical examination demonstrated good palmar arch circulation (Barbeau Type A).

UGTI was performed using a 21-G needle, whereby a total of 1000 units of thrombin was injected into the pseudoaneurysm neck (diluted to 1000 IU/cc) until there was cessation of flow into the pseudoaneurysm, with resulting thrombosis of the pseudoaneurysm neck and sac (Figure 2B). Follow-up

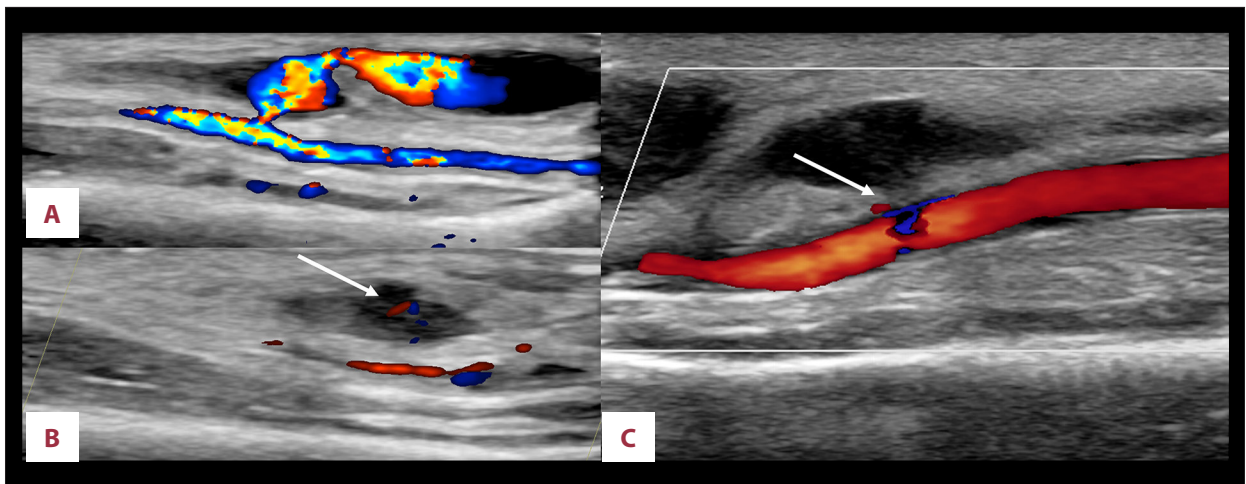


Figure 1. Case 1: Ultrasound-guided compression of radial artery pseudoaneurysm (RAP). (A) Distal RAP with a narrow neck width (1 mm width). (B) After 30 minutes of compression with intermittent release, partial thrombosis was achieved with mild residual flow in the RAP (white arrow). The reduced flow in the distal radial artery was attributed to vasospasm. (C) Follow-up ultrasound performed the next day demonstrated complete thrombosis of the RAP neck (white arrow) with patent flow in the distal radial artery.

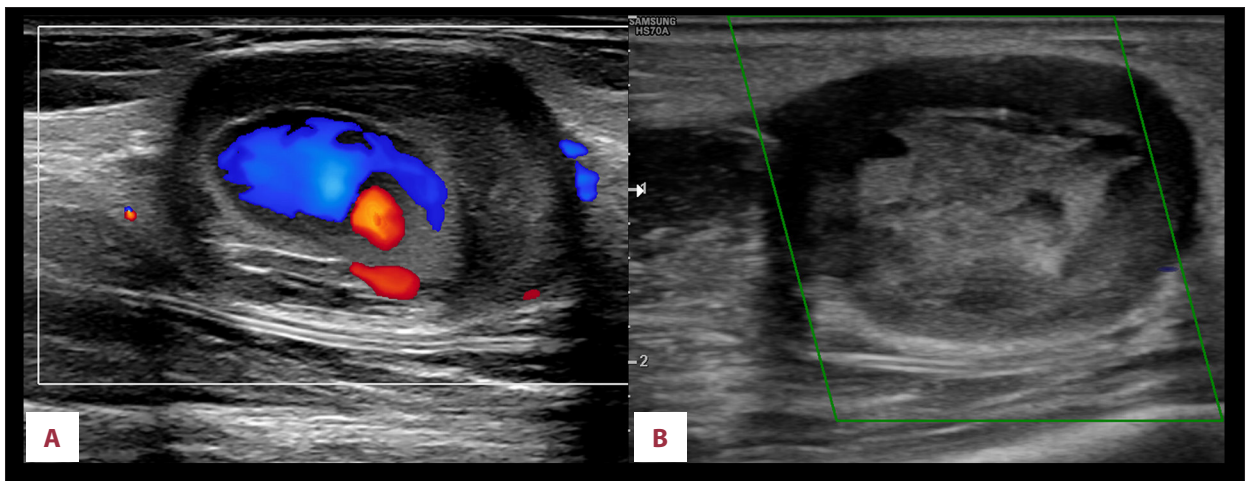


Figure 2. Case 2: Ultrasound-guided thrombin injection (UGTI) of radial artery pseudoaneurysm (RAP). (A) Partially thrombosed large RAP with the classical yin-yang sign. (B) UGTI was performed with complete thrombosis of the RAP sac and neck.

ultrasound confirmed sustained thrombosis of the RAP with preserved patency in the parent artery.

Case 3

A 59-year-old woman with a prolonged complex hospital stay developed painless swelling over her left distal forearm several days after removal of her left arterial line. The line had been inserted with a single puncture using a 22-G introducer needle, followed by placement of a 20-G arterial catheter using the Seldinger technique. Manual compression was applied for 5-10 minutes following catheter removal to achieve hemostasis; the type of dressing subsequently applied was not documented.

Duplex ultrasound demonstrated a large left RAP (4.1 × 1.6 cm, neck diameter 2 mm) (Figure 3A). This was re-demonstrated during direct-stick angiography (Figure 3B). She was not on antiplatelet or anticoagulation therapy and had good palmar arch collateral circulation (Barbeau Type A). Initial UGTI performed using a 23-G needle and 100 units of thrombin (diluted to 1000 IU/cc) achieved complete thrombosis of the pseudoaneurysm neck and sac. However, there was recurrence of symptoms after 3 weeks, with ultrasound confirming recanalization of the pseudoaneurysm sac (Figure 3C). Repeat UGTI performed using 23-G needle and 200 units of thrombin (diluted to 1000 IU/cc) again resulted in complete thrombosis.

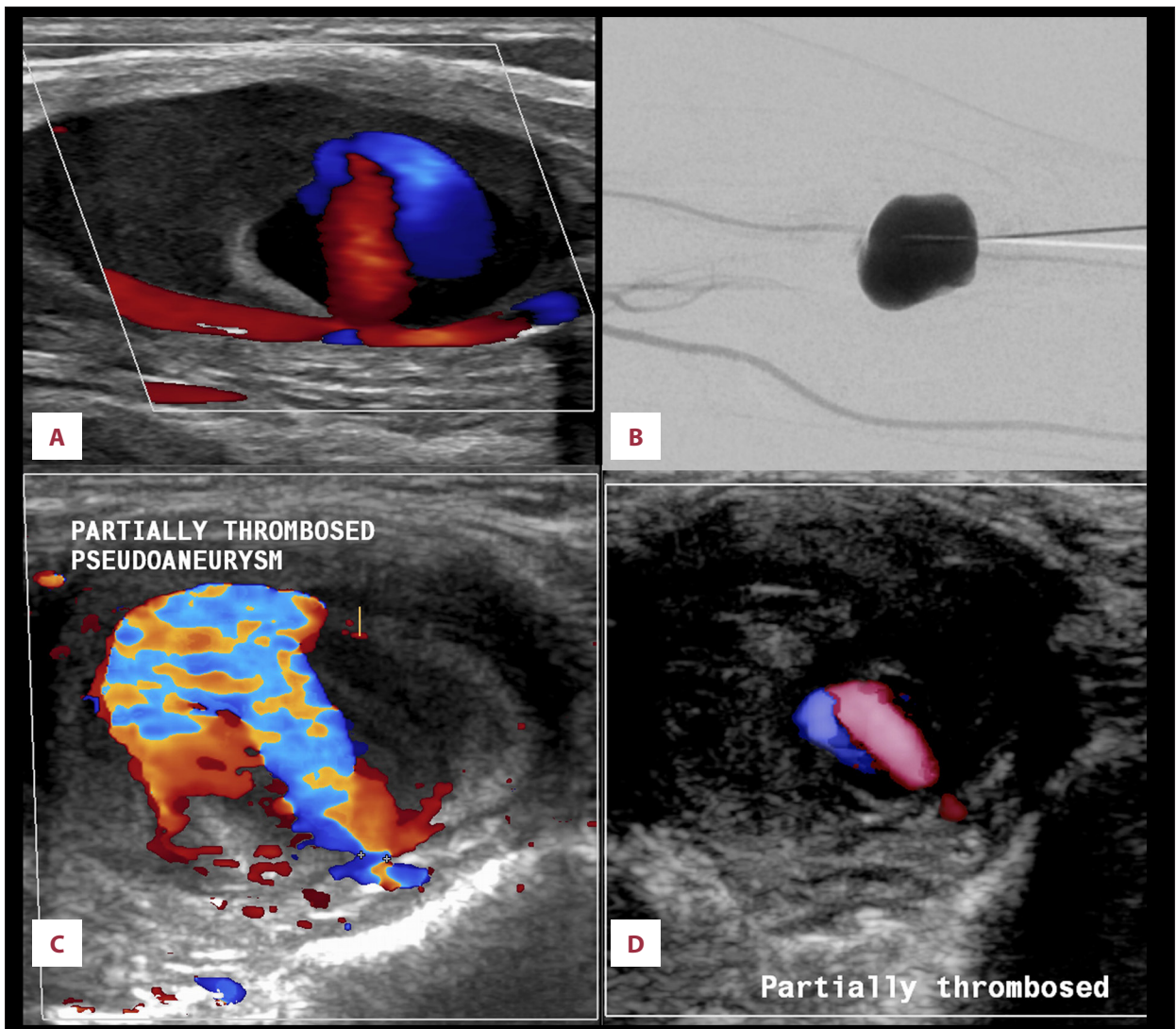


Figure 3. Case 3: Two sessions of ultrasound-guided thrombin injection (UGTI) for recurrent radial artery pseudoaneurysm (RAP). (A) Partially thrombosed large RAP with the classical yin–yang sign. (B) Direct-stick angiography re-demonstrated the large RAP at the mid-forearm. UGTI achieved complete thrombosis of the pseudoaneurysm. (C) Follow-up ultrasound at 3 weeks demonstrated recanalization of the RAP sac; repeat UGTI again resulted in complete thrombosis. (D) Subsequent ultrasound showed marked reduction in the residual patent component of the RAP.

Follow-up ultrasound demonstrated a partially thrombosed pseudoaneurysm sac, with marked reduction in the residual patent component, now measuring 0.5×0.6 cm, with a persistent 2-mm neck (Figure 3D). As the patient was asymptomatic, she was managed conservatively in the anticipation of eventual complete thrombosis.

Case 4

An 80-year-old woman presented with a painful swelling over the right mid-distal forearm following diagnostic coronary angiography, attributed to RAP on ultrasound (9.0×1.4 cm, neck diameter: 1 mm). The procedure was performed at a separate

institution; details regarding the radial puncture technique, including the number of puncture attempts and subsequent post-procedural haemostasis, were not available in the records.

She required urgent coronary artery bypass grafting (CABG) for newly diagnosed severe triple-vessel disease and was on aspirin and subcutaneous enoxaparin. The initial attempt at UGC was unsuccessful. The collateral flow of the palmar arch remained favorable (Barbeau Type B). Given the impending need for systemic anticoagulation in the peri-procedural period and thus the need for definitive exclusion of the RAP, the patient was urgently referred to Interventional Radiology.



Figure 4. Case 4: Endovascular balloon-assisted thrombin injection followed by covered vascular stent for radial artery pseudoaneurysm (RAP). (A) Angiography demonstrates a flattened, partially thrombosed radial artery pseudoaneurysm (RAP) arising from the mid- to distal forearm (white arrow). (B) Balloon-assisted thrombin injection was performed but failed to achieve complete exclusion of the RAP (white arrow). (C) Deployment of a covered vascular stent resulted in complete exclusion of the RAP. (D) Final angiography demonstrates patent antegrade flow through the stent and distal artery.

On repeat ultrasound evaluation, the RAP appeared flat and was not suitable for direct thrombin injection. Due to the potential considerations for radial artery harvesting during CABG, balloon-assisted thrombin injection was initially attempted to preserve the radial artery. This was performed via a distal radial access using a 3 × 40 mm Sterling™ balloon catheter (Boston Scientific, Marlborough, MA, USA) and 3 × 40 mm Coyote™ balloon catheter (Boston Scientific, Marlborough, MA, USA), but this was unsuccessful in excluding the RAP due to balloon rupture (Figure 4A, 4B). Thereafter, a 3 × 24 mm BeGraft® covered stent (Bentley InnoMed, Hechingen, Germany) was deployed to cover the arteriotomy site and achieved complete exclusion of the pseudoaneurysm (Figure 4C, 4D).

She proceeded to urgent CABG without complication. While early duplex ultrasound confirmed stent patency, a 3-month follow-up ultrasound demonstrated stent occlusion with distal perfusion via retrograde collateral flow from the ulnar artery. The patient remained asymptomatic.

Discussion

These 4 cases demonstrated variable clinical presentations and pseudoaneurysm characteristics, with individualized non-operative approaches used in each case. Differences in collateral circulation, anticoagulation status, response to initial treatment plan, pseudoaneurysm morphology, and clinical course provided the clinical contexts for the differing options.

Mechanical compression, either manual or device-based, is a widely used initial method because it is non-invasive and can be easily applied [10]. UGC involves applying intermittent compression to the pseudoaneurysm neck with the ultrasound probe to obliterate flow. Its principle is to achieve patent hemostasis, whereby sufficient pressure is applied to prevent flow through the arteriotomy defect while maintaining perfusion in the parent artery. This can concurrently be accessed using color flow Doppler imaging [12]. Compressive techniques are particularly applicable for RAP, which overly the radius that serves as a firm underlying surface [13]. However, the duration of compression is lengthy and the procedures are often painful [14], and is less reliably effective in obese or anticoagulated patients [15], with a reported efficacy rate of up to 58.5% [8]. Device-based compression techniques, including compression bandages and radial compression devices such as the TR Band® (Terumo Medical Corporation) that were originally designed for post-procedural hemostasis have also been reported [10,11]. Case 1 in this series is consistent with these previous reports in demonstrating successful thrombosis following UGC, while also illustrating its feasibility in patients with poor collateral hand circulation.

UGTI is a minimally invasive procedure extrapolated from its established efficacy in treating femoral artery pseudoaneurysms [7], and is increasingly applied to treating RAP. Recent studies involving larger cohorts of RAP have reported success rates of 82% to 100% [8,16]. It involves the controlled delivery of thrombin into the pseudoaneurysm sac, prompting rapid

clot formation even in patients on anticoagulation and/or antiplatelet therapy [15]. Complications are rare (1.3%) and include thromboembolism/finger ischemia and allergic reactions [15]. Factors associated with successful UGTI include a longer neck (> 3 mm), smaller arteriotomy diameter (< 5 mm), superficially located pseudoaneurysms, and appropriate expertise [8]. In our series, Case 2 achieved sustained thrombosis after a single session, while Case 3 required repeat UGTI following subsequent recanalization. This highlights the variable clinical course following UGTI and the possibility for recurrence.

Endovascular treatment provides useful alternatives for RAP in patients who are unsuitable or unfit for surgery or with hostile local anatomy [10]. Balloon-assisted thrombin injection has previously been described as an endovascular modification of UGTI, with the balloon used to protect the parent artery during thrombin delivery. A large retrospective review of 17 publications with a total of 62 cases reported a 100% technical success rate, although recurrence was reported in 2 cases [17]. Covered stenting can be performed via antegrade brachial, retrograde ipsilateral ulnar, or distal radial access [6].

In our series, the flat-appearing RAP was deemed to be morphologically challenging, and a combined endoluminal-percutaneous approach was used. Following an unsuccessful attempt at balloon-assisted thrombin injection to preserve the radial artery, we proceeded to covered stent placement in the same surgery. While previous reports have described stent restenosis and occlusion in the small-caliber radial artery, the literature on their long-term patency remains limited [10]. In our case, covered stent placement achieved successful initial exclusion of the pseudoaneurysm, although longer-term patency was not maintained.

Transcatheter coil embolization using coils and even vascular plugs have also been reported in case studies [1]. However, this treatment option is limited in practice due to potential permanent hemostasis of the parent artery [19].

Surgical intervention can be used as a primary therapeutic option or as a bailout strategy after failure of the non-operative managements as described. Option includes bypass procedure, radial artery ligation, and partial or complete removal of the RAP segment [18]. However, these surgeries typically require general anesthesia and increase the burden on patients who already have multiple comorbidities [6].

Duplex ultrasonography is critical for evaluating pseudoaneurysm morphology, particularly the neck width. The ESC and SCAI guidelines both recommend the use of 5-Fr or 6-Fr introducer sheaths for transradial coronary angiograms to minimize access-site trauma [22,23], effectively limiting the expected defect size to < 3 mm based on the sheath's outer diameter [24].

Radial arterial cannulation for intra-arterial pressure monitoring is commonly performed using a 20G arterial catheter (outer diameter of 1.1 mm) [25]. These access tools favor the development of narrow neck pseudoaneurysm amenable to compression or thrombin injection (Cases 1, 2, and 3). Other patient-specific circumstances are also important, such as the ongoing anticoagulation in Case 2 as well as the anticipated need for systemic anticoagulation and urgent coronary artery bypass grafting in Case 4.

This report has several limitations. First, the number of cases is small and therefore does not allow comparison of the effectiveness of the different treatment approaches. Second, the clinical and anatomical characteristics of the cases are heterogeneous, making direct comparison between treatment modalities inappropriate. Finally, the available literature is predominantly composed of case reports and small case series, with potential publication and reporting bias [8]. Thus, these cases are not intended to establish a treatment algorithm but rather to illustrate the varied presentations and treatment experiences that may be encountered in this uncommon complication of radial artery access.

Conclusions

RAP is a rare complication of radial artery access that can be managed effectively using a range of non-operative approaches. UGC, UGTI, and endovascular techniques were successfully used in different clinical contexts, although recurrence and loss of radial artery patency were observed in some cases. Further studies are required to better define the outcomes and long-term patency associated with these approaches and to establish a standardized approach to the management of RAP.

Institution Where Work Was Done

Changi General Hospital and Singapore General Hospital, Singapore.

Declaration of Informed Consent

All patients provided verbal informed consent to participate and agreed to publication of this manuscript and any accompanying images.

AI Disclosure

The authors used ChatGPT (OpenAI, San Francisco, CA, USA) to assist with language refinement and grammatical editing during manuscript preparation, and OpenEvidence (Miami, FL, USA) to assist with literature review. All clinical content, interpretation of the literature, and final manuscript revisions

were reviewed and approved by the authors. The authors independently located and verified each cited reference against the primary source. The authors take full responsibility for the accuracy and integrity of the manuscript.

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