Radial Pseudoaneurysms — Are They Becoming More Prevalent?

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Abstract: Radial pseudoaneurysm is a complication of radial route angioplasty that is slowly increasing as the number of radial angioplasties increases. A determined effort is required to prevent and treat pseudoaneurysms. A literature search revealed that advanced age, repeated attempts at radial puncture, more proximal punctures, the presence of diabetes mellitus, infection at the local site, and use of anticoagulation seem to be the most common causes of radial pseudoaneurysm. Proper compression or graded compression using a special sheath, or a TR Band (Terumo) assisted by pulse oximetry or corrective surgery appear the most feasible methods of treatment. Here we describe a case of radial pseudoaneurysm that developed in an elderly woman, in whom radial puncture was only attempted, the angioplasty was done from the femoral route. She was treated with surgery. We also discuss other options for the treatment and prevention of radial pseudoaneurysms.

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Introduction

Studies have shown that radial route angioplasty is associated with a lower mortality than femoral angioplasty and has become the default route for most coronary interventions. Radial interventions are on the rise, hence, more radial pseudoaneurysms will be reported in the future. Here we describe an elderly woman who developed a pseudoaneurysm after a primary angioplasty even though the radial artery puncture was only attempted. After the operator failed to get a radial puncture, the primary angioplasty was successfully done from the femoral route. While conducting a review of the literature we found most of the reported cases occurred in octogenarians and patients above the age of 75 years. Hence, we thought it would be useful to report this now common complication and to describe the various types of management options available to provide other operators and ourselves a guide to prevent and treat radial pseudoaneurysms.[1-18]

Figure 1. The clinical photograph of the pulsatile swelling in the wrist.

Case Description

Our patient was an 85-year-old woman who presented with coronary artery disease, acute coronary syndrome, acute inferior wall myocardial infarction, in Killip class 1. Her heart rate at admission was 64 beats/min and her blood pressure was 170/110 mm Hg. On clinical examination she had no cardiomegaly, her heart sounds were normal, and she had no murmurs. As per our departmental policy, she was taken up for primary angioplasty. An attempt was made to access her heart from the right radial route, but since this was not successful her right femoral route was punctured and her coronary angiogram was performed. Her right coronary artery had a 90% discrete eccentric lesion proximally. This was crossed with a Versaturn wire and the lesion was predilated with a 2x8 Mini Trek semi-compliant balloon (Abbott) at 10 atmospheres for 10 seconds two times and then the lesion was stented with a 3.5 x 13 mm everolimus (DES) stent deployed at 10 atmospheres into 10 seconds. The stent was well deployed and the patient had a TIMI 3 flow post procedure, and a TIMI perfusion grade of 3. Her left coronary injection showed a 70% lesion in the left anterior descending coronary artery that was planned

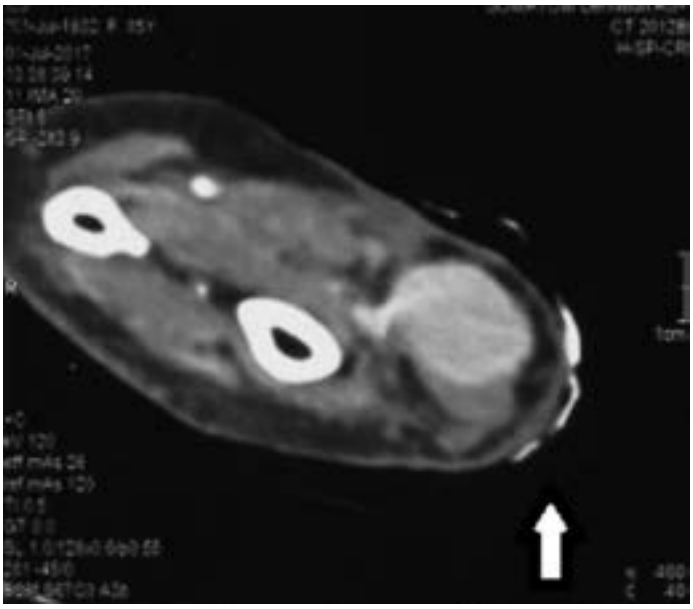

Figure 2. The CT angiogram showing the radial pseudoaneurysm.

Figure 3. The cut section of the forearm seen on CT angiogram. Note the dilated structure filled with contrast; this was the pseudoaneurysm. A clot is seen in this section outlining the pseudoaneurysm.

for intervention later. She was already preloaded with ticagrelor and aspirin and was later discharged on ramipril, atorvastatin, and subcutaneous insulin (long acting). She was discharged 3 days after this procedure. Three days after discharge she reappeared with a pulsatile swelling along the right forearm (**Figure 1**). Since this was fairly large she was sent for a Doppler evaluation and for a CT angiogram (**Figure 2, Figure 3, Figure 4**). A large radial pseudoaneurysm was discovered, and she was referred to our cardiovascular thoracic surgeons who immediately operated (**Figure 5**). We were worried that the surgeon would request stoppage of the dual antiplatelets, but they did not.

Investigations

Doppler of the right radial artery revealed a 1.4 x 4 cm mass from the distal end of the right radial artery with a typical yin yang pattern of color flow suggestive of a radial pseudoaneurysm. CT angiogram of the radial artery showed that the right radial artery was normal in course and caliber. Contrast filled an outpouching measuring 1.7 x 2 x 3.3 cm seen about 5 cm proximal to the radial styloid process. The neck of the pseudoaneurysm measured 2.3 mm. No extravasation or filling defects or thrombus were noted (as per the radiologist). In Figure 3, a thrombus can be seen outside the pseudoaneurysm. The right superficial and deep palmar arches were normal, as were the right ulnar and right brachial arteries.

Figure 4. A reconstructed CT angiogram of the pseudoaneurysm.

What is the indication for a CT angiogram in a patient with a radial pseudoaneurysm?

Unlike femoral pseudoaneurysms that have a thick covering of tissue, radial pseudoaneurysms are very thin. It has also been found at surgery that some pseudoaneurysms have an active bleeding point directly on the swollen area. A CT angiogram

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can detect active bleeding points so the surgeon can be prepared for the same. Therefore, performing a CT angiogram may be both useful and prognostic.

Differential Diagnosis

1. *An abscess.* This would have fluctuation but would not have either transillumination or pulsations. This mass was pulsatile and did not have fluctuation. An abscess would have a local rise of temperature and the patient would be febrile. Our patient had none of these features.
2. *A radial pseudoaneurysm.* A radial pseudoaneurysm would be pulsatile, and show expansile pulsations in the line of the radial artery. This swelling had pulsations and was in the line of the radial artery. Further, this swelling usually appears de novo after an attempted radial puncture, and is of short duration. A vascular tumor would have predated the radial puncture attempt. So, in this patient it was suggestive of a radial pseudoaneurysm and confirmed on Doppler evaluation.
3. *Vascular anomalies.* These can be classified into two categories: Vascular tumors and vascular malformations. A vascular tumor: This would have an external feeding artery, and an irregular appearance. Usually it would not be in the line of the radial artery and would not be related to a radial puncture. It would have existed before the radial puncture and would not appear within 48 hours of the attempted radial puncture. Vascular tumors are not present from birth. These tend to grow rapidly and then involute.
4. *Vascular malformation:* In 1982, Mulliken and Glowacki divided vascular malformations into two, tumors and malformation. This classification was modified by the ISSVA or the International Society for the Study of Vascular Anomalies in 1996, 2014, and 2018.[19,20] Malformations are an error in vascular development. Sometimes they are believed to be birthmarks. These are present at birth and do not have a rapid cell turnover. Vascular malformations can be either a high flow or a low flow. Vascular malformations can be benign or locally invasive or malignant.[21,22]

Course of Treatment

Surgery was performed. A linear incision was made parallel to the radial artery. A dilated pseudoaneurysm filled with blood was seen, measuring 7x4 mm, tense and filled with blood clots. Fresh bleeding was observed from a 1 mm defect on the radial wall. An Allen's test was performed. No distal vascular compromise to hand was observed. The incision was deepened, and proximal and distal vascular control was achieved. The pseudoaneurysm was opened and the clots were evacuated. The radial artery was repaired and both ends of the radial artery were ligated. The pseudoaneurysm was excised. Complete hemostasis was achieved, and the wound was closed in layers with a drain in situ. The skin was closed by staples.

Figure 5. The wrist of the patient after surgery. Note the fingers are not ischemic.

Follow-up

The patient had surgery for the pseudoaneurysm and improved and was discharged. She still comes for follow-up.

Why do pseudoaneurysms occur in the radial artery?

Literature has shown that radial puncture in the elderly, in patients with a latent infection, incomplete or inadequate compression, or those in whom oversized radial sheaths were used, or performing the angiogram on oral anticoagulants like coumadin are all causes for radial pseudoaneurysms.[1] Since the radial route angiography is perceived to be safer, operators prefer this route whenever the chances of bleeding are high, for example, after intravenous thrombolysis for rescue angioplasty, or, for a patient on oral anticoagulants for valvular heart disease awaiting a preoperative coronary angiogram. Since anticoagulation is a risk factor for radial pseudoaneurysm, special care should be taken both during and after the procedure. In another large series, only 20% of the patients who developed pseudoaneurysms were on oral anticoagulants.[2] The incidence of pseudoaneurysm was the same whether angioplasty was performed, or merely radial route coronary angiography was performed (0.08%). This was less than the reported incidence of femoral pseudoaneurysm (1.4%) from the

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Table 1. Literature reports of the profile of patients with radial pseudoaneurysms.

Mean age in years	Number of patients	Reference
75.8 ±11.12	5/16,808 (3/10,0000)	[1] Zegri
77 years	10/6242 (0.08%)	[2] Din
68 years old	1	[8] Babunashvili
81.5 years	2	[9] Hamid
3 years	1	[12] Cozzi
43 years	1	[13] Sinha
78 years	1	[14] Bachani
54 years	1	[15] Kumar.
81 years	1	[16] Petersen
73 years	1	[17] Truong
45 years	1	[18] Cauchi

same center. There are several individual case reports about radial pseudoaneurysms.[3,4,5] Harper and McDonald reported two elderly patient with diabetes.[9] Their first patient was on fondaparinux and heparin. This pseudoaneurysm developed early, within 24 hours of the procedure. Doppler evaluation revealed a pseudoaneurysm with a thrombus inside that was surgically repaired. Their second patient was also an elderly, diabetic, hypertensive (as was our patient) (**Table 1**) and received fondaparinux. Her pulsatile swelling developed within 48 hours of the procedure. The surgeon found that the right radial artery had a small puncture wound on the anterior surface that was causing the hematoma. The radial artery was then debrided and reconstructed with a cephalic vein patch. In both cases hemostasis was achieved using a TR Band. We observe, however, that these bands were placed for only 4 to 5 hours. We routinely occlude our radial arteries with a bandage overnight.

What exactly is a radial pseudoaneurysm?[9]

A radial pseudoaneurysm is basically a tear in the outer wall of the radial artery that has been contained by the surrounding tissue. It is possible, like a femoral pseudoaneurysm, that it occurs in higher, more proximal radial punctures, where the radial artery no longer overlies the radius bone, but instead lies on the interosseous ligament. Here, even adequate pressure will not cause compression of the radial artery and will allow it to expand in all directions. In these instances, the systemic blood pressure is high, and tissues are friable (as in the elderly patient, and in those on anticoagulants). We observed that most of the pseudoaneurysms in literature show the sites of pseudoaneurysm formation are slightly more proximal to the recommended radial puncture site.

How can the radial artery be prone to pseudoaneurysm formation?[10]

The radial artery usually ends as the deep palmar arch and the ulnar artery at the superficial palmar arch. In about 67%-100% of individuals, the deep palmar arch is complete. In 43% to 97% the superficial palmar arch is complete. Generally, this is why ischemia to the hand does not develop after radial artery punctures. As age advances, the intima of the radial artery thickens. Atherosclerosis of the radial artery progresses, though this progression is less than the thickening routinely found on screening of the carotid intima-media. Using ultrasound, radial artery thickening and calcification has been found in 7%-9% of non-diabetic patients. But in diabetics, radial artery calcification has been seen in 82% of patients. This could be the predisposing factor for the frequent radial pseudoaneurysms observed in diabetics.

Table 2. Important messages for the treatment of pseudoaneurysms.

1. Radial pseudoaneurysms often occur in the elderly so while using this route in the above 75 years special attention to hygiene, proper compression of the puncture site and avoiding excessive anticoagulation should be given.
2. The site should be observed for a new onset discoloration which means a pseudoaneurysm may develop.
3. Never directly compress the pseudoaneurysm as this may rupture – it doesn't truly have a capsule, is is a pseudo bulge.
4. Ulnar artery compression or compression proximal to the pseudoaneurysm of radial artery is more useful in occluding the pseudoaneurysm than direct compression.

The timing of development of pseudoaneurysms:

Radial pseudoaneurysms usually develop as early as 1-2 days after the radial puncture or as late as 2-3 weeks after the radial puncture.

Pseudoaneurysms after intra-arterial monitoring:[11]

Some ICCU patients receive indwelling radial artery catheters over a period of time. In a large series this was associated with radial pseudoaneurysms, and those who went for surgery for the same had a high mortality. One of the major risk factors for pseudoaneurysm in this series was radial site infection with serious pathogens. Standard sterile practice would prevent many of these complications. These authors also found that sheath sizes of less than 2 cm had more complications than those with sheaths longer than 2 cm.[11]

Prevention of radial pseudoaneurysms:

Proper compression after a radial puncture is important. Proper cleaning of the puncture site before performing the puncture is important. Avoiding excessive anticoagulation is important.

How to recognize that a pseudoaneurysm may occur:

In published case reports, many have described a new onset bluish discoloration of the radial site. These patients may go on to develop pseudoaneurysms. On examination the swelling is usually painful tender and pulsatile. A thrill may be felt over the aneurysm.

Investigations

The first investigation is a color Doppler scan of the swelling that usually shows an aneurysm. Doppler can be used to measure

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the neck of the aneurysm. Typical swirling inside the sac has been observed by various authors. Puncturing the swelling with a needle should be avoided.

A computed tomography (CT) angiogram can also be performed. This imaging will reveal the extent of the pseudoaneurysm, and the associated thrombus and hematoma can be correctly seen before planning further treatment. For example, when the pseudoaneurysm is totally thrombosed no further treatment may be required. Or, if the bleeding spot is visualized, special care should be taken if surgery is planned and dissection of the artery is being performed.

MRI and MR angiograms

This investigation is not needed in a pseudoaneurysm where a Doppler or a CT scan may suffice. But, this is indicated if a subcutaneous vascular tumor or anomaly is suspected.[21,22]

What are the imaging features of a radial or ulnar pseudoaneurysm?

Anderson et al reviewed the pseudoaneurysms of the hand that had presented to their department.[23] They collected 6 radial and 19 ulnar pseudoaneurysms, most of them had previous history of trauma to the limb. They describe the typical features of the pseudoaneurysm as (1) anatomic site near the artery; (2) a saccular mass originating at the artery with flow into the artery; (3) a flow void or a phase encoding artifact; (4) indirect evidence of thrombosis, for example, exhibited by lack of arterial flow. These authors recommend magnetic resonance (MR) angiography as it shows the status of the local and peripheral vessels.

How to treat pseudoaneurysms

Pseudoaneurysms can be treated both conservatively (mentioned later) or with surgery (**Table 2**).

Surgery

Most radial pseudoaneurysms are treated by surgery.[2]

When is surgery the preferred modality?

In instances where pseudoaneurysms are large or expanding, or associated with infection, conservative management would not help. When preparing for surgery, inspect the radial site first. Very often a bleeding point can be discovered, or a partially thrombosed hematoma sealing a gradual bleeding point can be seen. Compress the ulnar artery and note whether the bleeding stops and the integrity of the superficial palmar is present. Test the deep palmar arteries. If the circulation to the thumb and index finger are adequate, in spite of radial artery compression, the radial artery is ligated and the bleeding point is resected. If the arches are not properly perfusing the palm, then a vein is anastomosed to the radial artery, like a bypass graft.

Different surgical approaches to radial pseudoaneurysms[3]

Before performing surgery, the patency of the palmar arches should be tested by either Doppler ultrasound or CT coronary angiography.

Open surgical resection with end-to-end repair:

The bleeding from the radial artery is first controlled with a tourniquet. After that, a linear incision is made along the length of the radial artery, along the anatomical snuff box. With sharp dissection, the pseudoaneurysm can be dissected out, and the tourniquet released. The patient is heparinized. A proximal and a distal control is made, and the pseudoaneurysm sac is incised, letting out all clots. In large pseudoaneurysms the aneurysm is resected and end-to-end anastomosis of the radial artery performed. In the above reported case, 7-0 prolene sutures were used.[4] Restoration of the radial pulse was made and confirmed by manual palpation of the distal radial pulse. Later, a Doppler evaluation was made. The patient was supported with a splint for 2 weeks.

Sinha et al[13] also treated a patient with a pseudoaneurysm by surgery. They also found an open bleeding point when they exposed the surgical site after having tried a conservative management that had failed.

Repair of a true aneurysm of the radial artery is similar.[6] Al-Zoubi describes repair of a spontaneous true aneurysm of the distal radial artery. The procedure involved making a 4 cm long incision above the aneurysm in order to expose it. The proximal and distal and superficial palmar arches were controlled with a tourniquet. The aneurysm was then excised, and the vessel was repaired by an end-to-end anastomosis.

Technique of end-to-end arterial repair:

Ball and Feliciano describe a simple technique for end-to-end suturing of arteries.[7]

One technique recommended is called the "parachuting" of the graft or the vessel. This was first described for repairing an injured or torn femoral artery. Here a non-absorbable monofilament suture material (6-0 polypropyline) is used. Small bites 1 mm apart are taken on the vessel starting from the posterior wall of the artery. Once the suturing is almost complete, de-airing and flushing of the artery is performed before the final anterior sutures are placed.

Various other surgical procedures have been described.[11-14] Primary repair of the pseudoaneurysm with monofilament sutures, radial artery ligation and vein patch angioplasty have all been described. Infected radial arteries require excision and ligation of the infected radial artery. Assessment of the collateral flow from the ulnar artery helps ensure that the surgery, including radial pseudoaneurysm resection, is safe and unlikely to cause ischemia to the hand.[15] Surgery appears to be safe even in the elderly.[16,17]

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Non-surgical techniques:

Intra-aneurysm injection of thrombin, ultrasonically guided compression, and some novel interventional techniques have been used. Unlike femoral pseudoaneurysms, radial pseudoaneurysms are thin-walled and friable. There have been instances of rupture and bleeding of the RA during compression. Therefore, we recommend that if compression is being used, it should be given proximal to the radial pseudoaneurysm to prevent pressure induced rupture. Covered stents are not recommended as the radial artery is considered too small for a covered stent.

Endovascular closure of a radial pseudoaneurysm:

Babunashvili et al describe a patient who after a radial route angiogram had a successful occlusion of the radial artery leading to adequate hemostasis and discharge.[8] One month later the patient appeared with a pseudoaneurysm a little lower in the forearm. The operators performed an ipsilateral radial puncture distal to the pseudoaneurysm, and inserted a long sheath (21 cm 6 Fr) into the radial artery over a guidewire. This sheath was left in the forearm for 8 hours during which time the radial artery was kept patent with a heparin infusion. The pseudoaneurysm was compressed with a transradial band (TR Band). This procedure caused reduction in the pseudoaneurysm which originally measured 49 x 38 mm and was filled with thrombus. On follow-up ultrasound, the pseudoaneurysm had collapsed adequately and the radial artery flow had been preserved.[8]

Pressure application:

Pseudoaneurysms are friable, so, if pressure is applied it should be applied only proximal to the pseudoaneurysm. This may then occlude the pseudoaneurysm. There have been instances where even using the arm has led to rupture of the pseudoaneurysm. Some pseudoaneurysms are fed by the ulnar artery via the superficial palmar arch, in these, radial artery compression will not help.

Pseudoaneurysms in children:

Surgery for radial pseudoaneurysms in children may be associated with growth retardation of the hand due to inadequate blood flow. Therefore, surgery is not the ideal method for treatment of the pseudoaneurysms in children. Many of the pseudoaneurysms in children are traumatic. These have been treated by applying an elastic bandage for 72 hours. After checking the position of the band and the radial flow by Doppler ultrasound the band was kept for 3 weeks, after which the pulsatile mass with a thrill subsided.[12]

One caveat: when applying pressure proximally on the radial artery, the pressure should be occlusive.[13] In some instances, due to adequate collaterals from the ulnar artery, the pseudoaneurysm will continue to get blood supply and not get obliterated. A Doppler should always be taken during compression of the pseudoaneurysm to rule out increasing flow from the ulnar artery via the superficial palmar arch.

Ultrasound-guided thrombin injection:

Some authors recommend thrombin injection into the pseudoaneurysm. Thrombin injection may be associated with embolization to the hand and this may cause gangrene or loss of the limb.[14] Therefore, this method is not recommended for radial pseudoaneurysms.

Another simple method for treating a pseudoaneurysm:

Using a TR band and ulnar artery compression: Cauchi and coworkers describe a simple method to treat radial pseudoaneurysms.[18] Their 45-year-old male patient was on prasugrel and aspirin. After his TR Band was removed as per the usual protocol he developed a sharp pain in the wrist. Color flow mapping revealed a radial pseudoaneurysm with back and forth movement, and the size was 1.1 cm. The neck was 0.5 mm in size. They decided to compress the pseudoaneurysm using the TR Band. For this, they placed a pulse oximeter on the thumb supplied by the radial artery and compressed the ulnar artery of the same side by manual compression proximal to the TR Band. The TR band was inflated until the plethysmographic wave form of the radial artery disappeared. The workers noted how much air was required to completely occlude the TR Band. In this case it was 17.5 ml of air. They slowly removed small amounts of air from the TR Band until the radial pulse oximeter wave form reappeared, even while compressing the ulnar artery. A continuous compression was given for 45 minutes following which the nurses released 1 ml of air every 15 minutes. After 4.5 hours, the entire air had been removed, and a repeat Doppler showed that the pseudoaneurysm had collapsed and the radial artery flow was normal. These authors utilized the connection of the ulnar artery and radial artery via the superficial palmar arch to occlude the feeding artery to the radial artery and occlude the pseudoaneurysm, a neat technique. This method indeed may be the ideal method in the future. In our patient, we only applied pressure proximal to the radial artery as we had not yet read this article. Since the patient had severe pain on this maneuver, we had to send her immediately for surgery. Her pseudoaneurysm appeared swollen and painful, similar to an abscess but was not infected and was pulsatile. Hence, time was an important consideration.

Preventing radial pseudoaneurysms / Points to remember

We will now try to prevent radial pseudoaneurysms.

1. Reduce the radial punctures in patients on anticoagulation, or stop the anticoagulation 24 hours before the planned puncture;
2. Control the patient's diabetes carefully;
3. Prompt and correct hemostasis with the radial bandage applied for at least overnight to enable proper sealing of the defect through which the radial sheath was introduced.
4. Avoid radial puncture if the area is infected.
5. In the elderly, do not make too many attempts to puncture the radial artery. If one or two attempts fail, an alternative route like the right ulnar artery or right femoral artery can be chosen. The left snuff box puncture may be an additional option. ■

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