

A narrative review of history, advantages, future developments of the distal radial access

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Abstract

This article presents a historical excursus and a review of modern literature on distal radial access for interventional surgery, discussing the anatomical and physiological substantiation of the use of this access point in endovascular surgery, its advantages and disadvantages. The main considerations directly related to distal puncture, choice of instrumentation, hemostasis, possible complications, and prevention are analyzed. The major areas of interventional surgery (coronary, vascular, oncological, and neurointerventional), where the distal radial approach is actively used, are reflected and their characteristics are highlighted. In general, it has been shown that with the development of technology, improved manual skills, the widespread use of hydrophilic introducers, and modern sheathless guiding catheters, the vessel diameter, and puncture site are not decisive factors when choosing access for any type of intervention.

Keywords

Access, radial artery, literature review, distal radial access

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Introduction

Access is the first component when initiating any surgery and is one of the fundamental stages contributing to its success. Moreover, access has certain qualitative and quantitative requirements. In endovascular surgery, these are latitude (of adequate size to ensure free movement of instruments), optimal distance to the main surgical site, minimal vessel trauma, simplicity, and reusability. Over the past decades, radial access (RA) for coronary angiography or percutaneous coronary intervention (PCI) has become the standard for most interventional cardiologists worldwide¹ and, according to the European Society of Cardiology/European Association for Cardiothoracic Surgery recommendations for myocardial revascularization, it is the preferred approach for any PCI regardless of clinical conditions.² RA currently meets all the requirements and has advantages over the femoral approach in terms of lower frequency of bleeding from the puncture site, early activation of movement for the patient, possible discharge on the day of the procedure, patient comfort, and a decrease in mortality from acute myocardial infarction

(AMI) with ST segment elevation.^{3–6} RA also has advantages over ulnar access (UA).⁷ However, some researchers still consider the ulnar artery a possible alternative to the radial artery (RadA) because of the relationship between the diameter of the artery and the weakening of the hand compressive force according to dynamometry data.⁸ For the last 10 years, due to improvements in endovascular instrumentation and an increase in the manual skills of surgeons, RA has been actively used to treat pathologies in the peripheral arteries⁹ and pelvic organs¹⁰ and in neurointervention.¹¹

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Nevertheless, the use of RA has certain limitations. The RadA, due to its small diameter, is prone to spasm and has pronounced tortuosity, more so than other arteries, and this may require conversion of the access point, thereby increasing procedure time and the risk of adverse events.¹² With a frequency varying from 0.8% to 30%, early and late RadA occlusions are the most frequent complications and may prevent further use of an occluded RadA in repeated endovascular interventions for the formation of hemodialysis fistulas or as a conduit for a coronary artery bypass graft.^{13,14} Moreover, procedures conducted through the left RadA are not entirely ergonomic, causing significant inconvenience to patients and surgeons.^{15,16}

In theory, access through the distal RadA segment can reduce the incidence of complications thus increasing patient and surgeon comfort. Since 1977, individual anesthesiologists have used a puncture site in the anatomical snuffbox (AS) for perioperative blood pressure monitoring in children.¹⁷ Babunashvili, in Amsterdam in 2003, reported on the interventional use of this access point for the first time, for recanalization of late RadA occlusions after transradial procedures and early occlusions.¹⁸ The first publications on the use of distal radial access (DRA) as the primary access point for diagnostic and therapeutic procedures, in comparison with classic ones, appeared in 2014 and 2015.^{16,19,20} Since 2017, the use of DRA in various endovascular procedures has rapidly increased worldwide. According to the “Best Practices for the Prevention of Radial Artery Occlusion after Transradial Diagnostic Angiography and Intervention” consensus of 2019, the routine use of DRA can reduce the number of RadA occlusions. However, large, randomized trials are needed to test this theory.²¹ In 2017, a multicenter, open, randomized (1:1) “Comparison between Traditional ENtry point and Distal puncturE of Radial Artery” (TENDERA) study (no. NCT04211584 at <https://clinicaltrials.gov>) was organized to answer this question.

The goal of this review is to analyze the literature (WoS, Scopus, EMBASE, eLIBRARY) on DRA for interventional surgery.

Anatomy and physiology of DRA

The RadA provides blood supply to the forearm and hand and is located between the brachioradialis muscle, the radial flexor of the wrist, and the superficial flexor of the fingers distally. It is located on the anterior surface of the radius and is easily palpated. At the distal end of the radius, the RadA divides into the following branches: the palmar carpal branch, which separates at the level of the wrist joint, supplies it and the skin with blood, and connects with a similar branch from the UA, the superficial palmar branch, which enters the hand at the level of the styloid process of the radius, connects to a similar branch from the UA, and participates in the formation of the superficial palmar arterial arch from the anterior surface of the forearm, the deep

palmar branch of the RadA (DPBRadA), the dorsal carpal branch, which passes inferior to the tendons of the muscles of the long and short extensors of the first finger and the long muscle that deflects this finger to the first interdigital space where it passes into the deep arterial arch of the hand and the artery of the thumb (Figure 1).

Distal RadA puncture is possible in the radial fossa (AS) or the first interdigital space. With such a puncture, in the case of vessel occlusion at the puncture site, the RadA should remain passable because of the presence of previously deflecting branches.²² Interruption of blood flow plays a major role in the complex interaction of factors leading to RadA blockage.²² In prospective studies, the absence of blood flow during hemostasis significantly increased the risk of RadA occlusion,²³ while in a retrospective analysis comparing the shortest and longest times of puncture site compression, complete interruption of blood flow during hemostasis was the only significant predictor.²⁴

Another retrospective analysis examined the diameter of the RadA and its branches, including diameters <2.1 mm, with a mean value of 1.6 mm. Technically, the puncture was more difficult to perform, took longer, and had a statistically significantly lower success rate in the DRA group, but the number of complications, including RadA occlusions, were not statistically significant on the 1st and 30th days.²⁵

Most doctors are right-handed; therefore, after puncture of the left RadA, the endovascular surgeon moves to the right side of the patient, and the hand is placed on the latter's stomach with the palm turned upward, which is non-anatomical and inconvenient for the patient. Therefore, during the procedure, the patient tries to place his left hand in a more natural and comfortable position, thereby lengthening the duration of the examination or surgery and partly interfering with the surgical procedure. This problem is solved by using the maneuver, in which the left hand is placed with the palm on the stomach (Figure 2). It does not cause discomfort to the patient and remains static throughout. This is especially important when the procedure is delayed for several hours.^{16,26}

DRA procedure

The DRA procedure has certain difficulties. They are overcome when the learning stage is passed, which normally takes 30–50 punctures on average.^{16,27} Even if the authors' criteria for success were different, a review of 25 studies with a sample size of more than 20 cases, the success rate of DRA ranging from 70% to 100%.²⁸ In some publications, success was determined by a needle in the lumen of the vessel, while others used an installed introducer.²⁸ For example, Kim et al.²⁹ reported that the rate of successful arterial puncture was 93.3%, but the introducer was successfully installed in only 88.0% of cases. To perform DPBRadA puncture, it is necessary to clearly perceive its pulsation in the AS or the

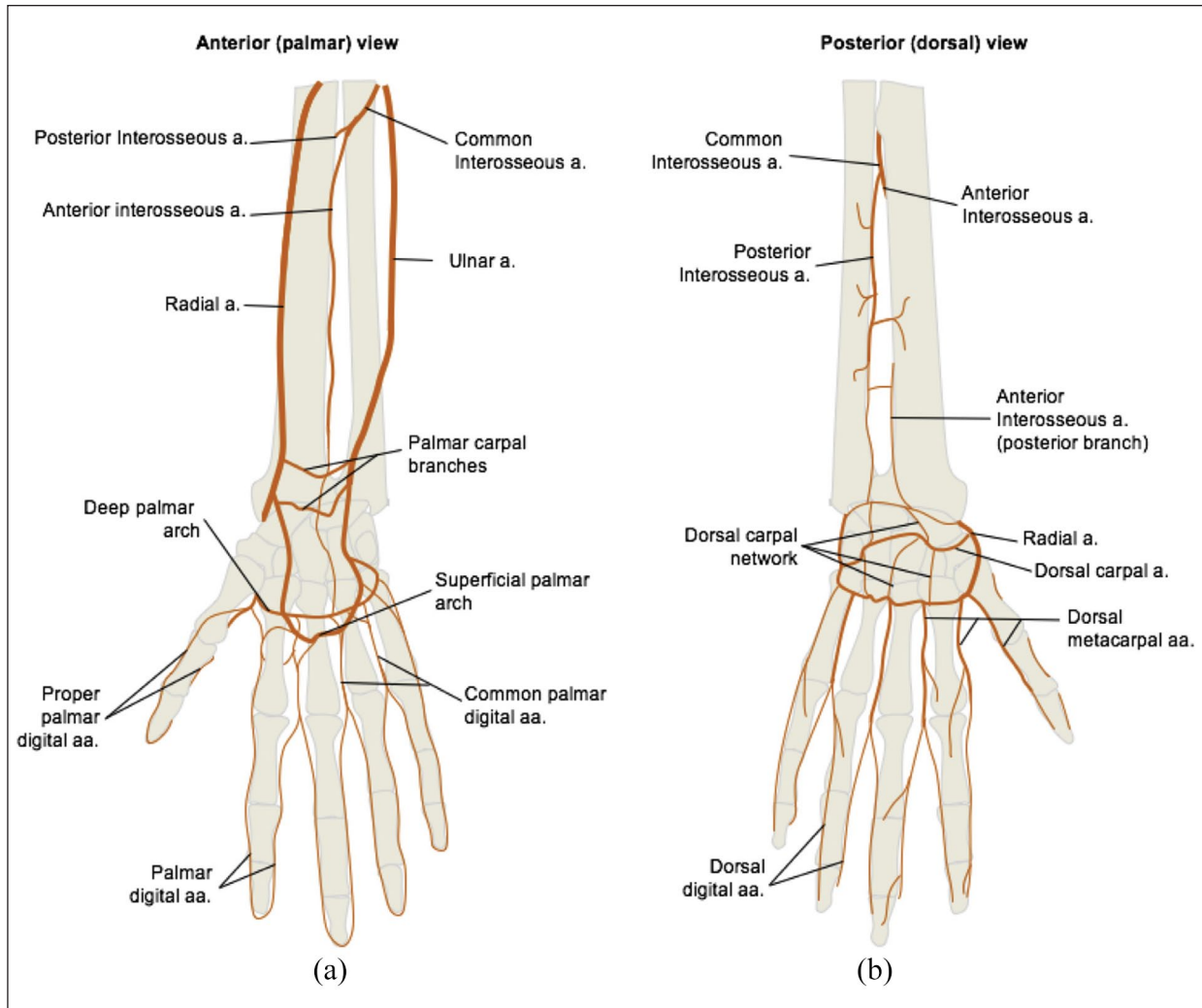


Figure 1 (a) and (b). Anatomy of forearm and hand arterial circulation.



Figure 2. Coronary angiography with left distal radial access.

first interdigital space. Ultrasound navigation can be used for more accurate identification of anatomical landmarks and more accurate access to the vessel, increasing the number of successful catheterizations in DRA.^{22,28,30} Correct

forearm position and support are important for facilitating DRA. Some surgeons ask the patient to squeeze the thumb under the other four fingers or to hold a cylindrical object in the hand to bring the artery closer to the surface of the radial fossa.³¹ The puncture technique also affects the success rate. Some surgeons prefer “to puncture of the anterior wall¹⁶,” while others incline “to puncture of both walls²⁹.” Because the wrist bones are located deeper than the artery and the periosteal puncture causes significant pain, which can cause the patient to move the arm, the authors do not recommend the “both-wall puncture” technique. After a successful puncture, a 0.018-in, 0.021-in, or 0.025-in guidewire from the kit is inserted. With pronounced tortuosity of the vessel it is not always possible to start with a standard conductor and inserting it with effort can lead to inner vessel wall trauma and, as a result, loss of access. In such cases, the authors recommend the use of a workhorse 0.014-in coronary guidewire because the tip can be adjusted at the surgeon’s discretion and fluoroscopy can be performed to ensure that the guidewire is located in the RadA and not in

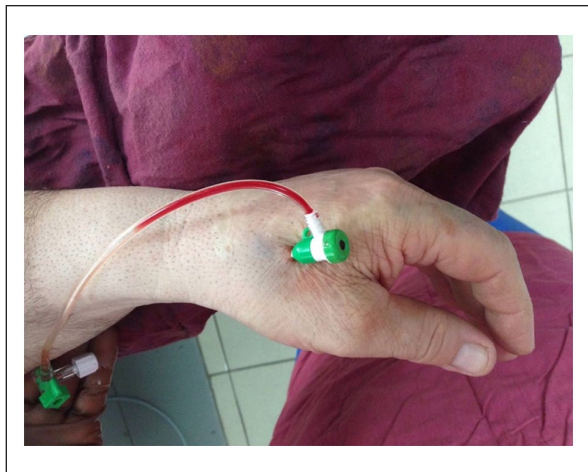


Figure 3. DRA with introducer 6Fr.

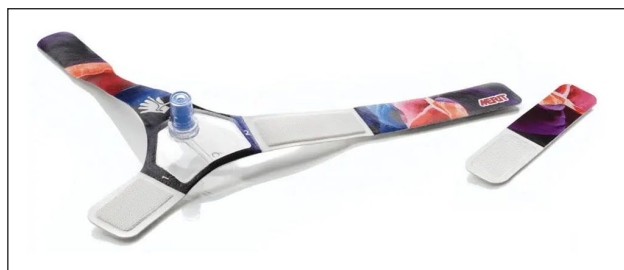


Figure 4. PreludeSYNC DISTAL® (Merit Medical), the patented device for DRA hemostasis.

the hand arteries. Although the diameter of the DPBRadA is smaller than that of the RadA, a 6-French (Fr) sheathless guiding catheter can be inserted in most patients (Figure 3). Gasparini et al.³² shared their successful experience of using the left DRA for interventions in chronic complete occlusion of the coronary arteries in 41 patients using the 7-Fr Glidesheath Slender («Terumo», Tokyo, Japan). A patented device, namely PreludeSYNC DISTAL («Merit Medical», South Jordan, Utah, USA) (Figure 4), is used for DRA hemostasis. It is possible to apply the SafeGuard Compression Device («Merit Medical», South Jordan, Utah, USA) using the Kiemeneij F. technique by injecting 3.0 mL of air before removing the introducer and 2.0 mL after,³³ followed by manual compression for 10–15 min and the application of a light bandage for 1–3 h,³¹ or a pressure bandage for 2–3 h,^{16,29} until complete hemostasis. Before the patient is discharged, it is necessary to check the compression site and the RadA pulse (Figure 5). Doppler ultrasound, although not essential, can be used to confirm arterial patency.³³

DRA usage in various pathologies

Currently, DRA is successfully used in vascular surgery for the treatment of carotid artery stenosis. Kühn et al.³⁴ carried out 20 carotid stentings using 7-Fr Glidesheath



Figure 5. DRA puncture site 24h later.

Slender and Wahoo Access Catheters («Q'apel Medical», Fremont, California, USA) or 6-Fr Fubuki («Asahi Intecc», Seto, Aichi, Japan) and Benchmark («Penumbra Inc», Alameda, California, USA) as guiding catheters, with removal of the introducer and additional skin incisions for successful implementation, without significant differences in efficacy and safety compared with RA. Ruzsa et al.³⁵ described 34 cases with a high success rate in the treatment of occlusive-stenotic lesions of the superficial femoral artery, including recanalization of chronic occlusions, with no differences in the combined primary endpoint (technical success, major adverse cardiovascular events, and complications) and transitions to the femoral artery, with significant differences only in the use of the double (distal radial + transpedal) approach not in favor of DRA. Considering the treatment of stenoses of arteriovenous fistulas for hemodialysis, Watanabe and Usui described 12 clinical cases of balloon angioplasty of the anastomoses, when access through a vein was not possible. They found RadA access to be extremely difficult, but with 100% efficiency and without complications.³⁶ Individual clinical cases of DRA application in stenting of the subclavian, upper mesenteric, common iliac, celiac, and renal arteries, and in embolization of bleeding bronchial and renal arteries, and renal artery aneurysm have been described.^{37,38}

DRA has been used in interventional oncology for liver chemoembolization, selective radiation therapy and I-90 mapping, diagnostic angiography, embolization of the uterine arteries, and mesenteric, pelvic, and oncological bleeding (gastric, hepatic, renal, and pulmonary) with technical success in almost 100% of cases.^{37,38} Investigators noted statistically significant differences in the diameter of the RadA and DPBRadA (0.2 ± 0.16 mm) in all age groups in cancer patients; analysis of subgroups by sex showed a difference in men 0.21 ± 0.17 mm ($p < 0.001$) and women 0.17 ± 0.16 mm ($p < 0.001$).³⁸

RA has been used by neurointerventional surgeons relatively recently,¹¹ but there are individual clinical cases, studies, and one meta-analysis on DRA in their practice.



Figure 6. DPBRadA occlusion.

Srinivasan et al.³⁹ described successful use of DRA in 11 out of 12 cases to treat posterior circulation pathology with a coaxial technique, of which seven cases covered emergency mechanical thromboextraction in stroke. Goldman et al.⁴⁰ conducted a single-center comparison of RA and DRA in various neurointerventional procedures, reporting no statistically significant differences between the groups; the overall rate of technical success was 92.1%, and in 7.6% (26 cases) a transition to access through the femoral artery was required. The authors believe that 7.6% is a high level of access change, especially if it occurs in an emergency patient with stroke. Therefore, the operating surgeon should know the side when the procedure cannot be performed immediately through an upper limb artery, and it is necessary to puncture the common femoral artery. In a meta-analysis, the overall success rate was 95% (91%–98%).⁴¹ However, seven studies included only 24.2% of direct surgeries, most of which were cerebral angiographies.⁴¹ Therefore, accumulation of experience and prospective studies are needed to assess effectiveness, safety, and patient selection to conduct neurointerventional procedures, both through DRA and RA.

Most studies related to DRA have been performed in cardiac patients undergoing coronary angiography or coronary stenting. In their review, Cai et al.²⁸ analyzed 25 studies between 2017 and 2020, including case series, nonrandomized, and randomized studies after removal of duplicate data and found 6672 cases of DRA use. It should be noted that, according to this review, the highest experience of DRA use in Russia was 60.2% of all cases. During the same period, Babunashvili⁴² and Kaledin et al.'s⁴³ data were given, although other authors from Russia also had good results.^{16,27} According to one study, 12.5% of cases

required more than one attempt to achieve successful DRA.⁴³ In almost half of the cases included in the review, stenting of the coronary arteries was performed, including recanalization of chronic coronary occlusions. In 78.2% of cases a 6-Fr introducer was used; there was no significant difference in contrast-medium volume, radiation dose, or procedure duration in the study groups, but a significantly shorter compression time was required for DRA hemostasis, almost 30% shorter than that required for RA. Currently, DRA is rarely used for the treatment of patients with acute coronary syndrome (ACS), especially in the presence of cardiogenic shock (6.0% of patients reviewed by Cai et al. were ACS). Timing is extremely important in ST-elevation myocardial infarction (STEMI) patients, and fast puncture and door-to-balloon time are critical. According to Soydan and Akin,⁴⁴ the average time to puncture of the DPBRadA was 1.2 min, with more than a third of patients having ACS. Flores and Todd⁴⁵ reported that the mean time from door to balloon in STEMI patients, when using DRA, was 46 min, which was within the recommended 90 min.⁴⁵ According to the literature, the authors believe that it is possible to safely use DRA in STEMI patients since PCI performed in the DRA cohort was technically successful.²⁸ However, further prospective data are necessary to ascertain the effect of DRA on mortality and morbidity in ACS and to directly compare its use with RA. A randomized controlled trial comparing DRA and RA in patients with STEMI is currently underway. Additional information will be provided at no. NCT036117254 at <https://clinicaltrials.gov>.

Complications

DRA has a higher level of safety, but complications associated with access, such as RadA occlusion, arterial spasm, bleeding, and hematoma must be considered.

RadA stenosis or occlusion after catheterization is common and is associated with several factors, including female sex, age, manual compression, and RadA diameter.⁴⁶ Kaledin et al.⁴³ observed post-catheterization disorders of the RadA, including intimal dissection, medial calcification, intimal injury, medial hypertrophy, and adventitial neovascularization, using optical coherence tomography.⁴³ The incidence of DPBRadA occlusions in large retrospective studies was 0.12%–2.2%, while the frequency of occlusion with direct DRA use was reduced by 90%, when compared with RA use (0.4% vs 4.2%) (Figure 6).^{42,43} According to another prospective randomized study, comparing the frequency of RadA occlusion according to Doppler ultrasound data in the DRA and RA groups 24 h and 30 days after the coronary procedure, RadA occlusion after 24 h and 30 days was 8.8% and 6.4% in the RA group and 1.2% and 0.6% in the DRA group, respectively (24 h: odds ratio (OR)=7.4, 95% confidence interval (CI)=1.6–34.3, $p=0.003$; 30 days: OR=10.6, 95% CI=1.3–86.4, $p=0.007$).⁴⁷ It is also noteworthy that the frequency of

Table 1. Complications after DRA.

Type	Frequency (%)	Authors	Study design
DPBRadA occlusion	0.12	Babunashvili ⁴²	Retrospective
RadA occlusion	0.48	Babunashvili ⁴²	Retrospective
RadA occlusion after 24 h	1.2	Eid-Lidt et al. ⁵²	Prospective
RadA occlusion after 24 h	0.6	Eid-Lidt et al. ⁵²	Prospective
Hematomas >10.0 cm	0.2	Babunashvili ⁴²	Retrospective
False aneurysms		Prejean et al. ⁴⁹	Case
False aneurysms		Boumezrag et al. ⁵⁰	Case
Arteriovenous fistula		Shah et al. ⁵¹	Case
Numbness of the fingers	2.0	Korotkikh and Bondar ¹⁶	Retrospective

RadA occlusion may increase with time after the intervention. Therefore, Gasparini et al.³² found that the incidence of occlusion might be slightly higher at 1 month than at 24 h after the procedure, and this may be related to vascular remodeling. In the ongoing TENDERA study, arterial patency is monitored at 24 h; 7 days; and 3, 6, and 12 months, which is of practical and scientific interest.

Cases of severe bleeding, false aneurysms, and hematomas are rare because of the structure of the AS with a bony base surrounded by tendons. In the case of a more distal puncture, the artery is surrounded by dense structures in the form of the metacarpal bones. Faster hemostasis in this area can reduce the patient's hospital stay and the burden on nurses. After coronary angiography, hemostasis can be achieved by manual compression of the puncture site for 15 min, and even after PCI, manual compression can provide hemostasis in patients with activated clotting time (ACT) <250 s at the end of the procedure.⁴⁷ A small hematoma of <5.0 cm sometimes occurs at the DRA site, and does not require treatment. Hematomas larger than 10.0 cm were described in 0.2% of cases in a large retrospective study.⁴² A large hematoma can be caused by improper application of a compression device, a combination of dual antiplatelet therapy with an anticoagulant, old age, flabby skin, and multiple puncture attempts. A clinical case was described in a 63-year-old woman who underwent PCI: after successful hemostasis at the DRA site, the patient developed a serious hematoma, accompanied by edema, pain in the arm, and limited finger movement. After alternating application of the tonometer, the hematoma gradually stabilized and disappeared, with complete restoration of all hand functions.⁴⁸

The occurrence of false aneurysms at a distal puncture site are extremely rare. Prejean et al.⁴⁹ reported a case of pseudoaneurysm after left DRA occurred 20 h after removal of the introducer and healed by repeated compression. In 2019, Boumezrag et al. reported a case of a pseudoaneurysm at a left distal puncture site, which arose 48 h after successful PCI and required endovascular treatment with the Onyx adhesive composition. The vasculature of the palmar arch was completely preserved on control angiography.⁵⁰

Shah et al.⁵¹ presented a clinical case of DRA complications, including a left arteriovenous fistula (AVF) in a 71-year-old man after a long recanalization of chronic coronary occlusion. The patient presented mild signs (slight swelling and discomfort in the wrist) 7 days after the procedure with AVF was confirmed using ultrasound. Since repeated compression hemostasis was unsuccessful, the vascular surgeon recommended conservative follow-up treatment with dynamic observation because of minimal symptoms. After 8 months, deterioration in arm function or strength and an increase in fistula size were not observed. The authors associated the complication with simultaneous puncture of the artery and the head vein, which in this anatomical area is closer to the artery, as well as a large dose of heparin administered during the procedure.

Theoretically, the space between the AS and the first interdigital space is narrow, and the superficial branch of the radial nerve approaches the RadA. Repeated puncture in the AS area and prolonged compression can damage the superficial branch of the radial nerve, resulting in numbness of the fingers. However, clinical reports of numbness are rare with one study reporting a 2.0% the incidence of this complication.¹⁶

A brief description of the complications is presented in Table 1.

Conclusion

In terms of RadA preservation and patient and surgeon comfort, DRA is undoubtedly the best alternative to traditional RA. However, there are outstanding issues to be addressed in clinical practice such as the possibility of using DRA in all patients with a palpable pulse in the AS or first interdigital space during interventional procedures and the feasibility of using DRA in patients with AMI or stroke. Additionally, the length of the catheter may be insufficient for tall patients or patients with tortuous arteries at different levels, leading to a change in the access site.

Nevertheless, at present, it cannot be denied that DRA may gradually become preferable when performing certain planned procedures, in combination with the development

of material technology and the widespread use of hydrophilic introducers and modern sheathless guiding catheters. DRA use for coronary and non-coronary interventions has become routine.


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