Review

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The distal radial artery: Versatile vascular access for transcatheter interventions

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Abstract

Conventional transradial access has been established as the gold standard for invasive coronary angiography and percutaneous interventions by the current European and American guidelines. The distal or snuffbox radial artery access represents an alternative transradial access site that allows radial sheath insertion with the patient's hand pronated. Firstly described 40 years ago, it exploded in popularity only recently. Promising additional benefits, the distal radial access is increasingly being adopted in various types of percutaneous interventions, being preferred by many interventional cardiologists and radiologists for its reduced vascular complications and time to hemostasis, and improvement of patient and operator comfort. Other centers consider it a fad, waiting for solid clear evidence and benefits. The evidence is dynamic and discrepant, depending on the center, the operator, and how it was collected (randomized controlled vs observational studies). Another essential aspect raised by "skeptics" was whether distal radial access, by its smaller diameter and more angled course, can support all types of interventions. The aim of this review is to gather all the scenarios where distal radial access has been utilized and to conclude whether this vascular access is feasible across all transcatheter interventions.

Keywords

Distal radial access, snuffbox access, transradial, vascular access, vascular complication, percutaneous coronary intervention

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Introduction

Vascular access for coronary procedures is of paramount importance, not only for a successful procedure but also to prevent complications. Of all, the transradial approach (TRA) is universally accepted and is recommended as the default approach for cardiac catheterization by current European and American guidelines,[1,2] based on solid evidence demonstrating benefits in terms of major bleeding, vascular complications, and all-cause mortality in patients undergoing percutaneous procedures.[3,4] The widespread adoption of TRA, prompted by technical improvements and the steady increase in operators' expertise with that access site,[5,6] paved the way forward to new approaches for cardiac catheterization with the ambitious aim of maintaining the benefits of TRA and further mitigating potential access site–related complications, such as forearm radial artery occlusion (RAO), major bleeding, pseudoaneurysms, or arteriovenous fistulas.

In the last few years, the growing "radial-first" strategy gained increased attention, particularly on social media, pushing the limits of TRA in the anatomical snuffbox or the dorsal hand for both coronary[7] and noncoronary procedures.[8] Distal radial access (DRA) gained impressive popularity, despite the lack of solid, immediate data. The benefits

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quickly became clear and the nursing staff began to prefer it for obvious reasons: the burden of patient supervision was eased and a better throughput in the recovery room was observed. From a theoretical standpoint, distal TRA offers some potential advantages over conventional TRA for physiological and anatomical reasons[9] (Figure 1). First, a puncture distal to the superficial palmar arch allows maintaining anterograde flow in the forearm radial artery during hemostatic compression or in case of occlusion at the puncture site, thereby reducing the risk of RAO. Flow interruption during the hemostasis process has been recognized as one of the main players in the development of RAO.[10] Second, shorter hemostasis time due to a more superficial position of the distal radial artery might further mitigate the risk of RAO. Finally, distal TRA is associated with improved patient and operator comfort during the procedure, especially in case of left distal TRA. Available studies, although small in nature or restricted to registry data, are multiplying and provide homogeneous results for a safe and effective DRA practice. The aim of this review is to deliver an in-depth analysis of DRA rationale and its role, performance, and limitation in various endovascular interventions.

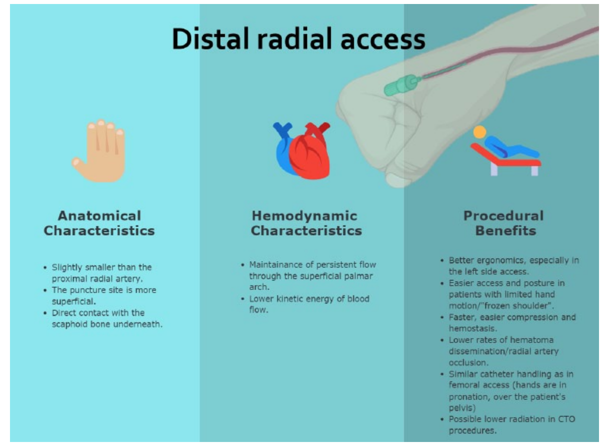

Figure 1. Advantages of DRA.

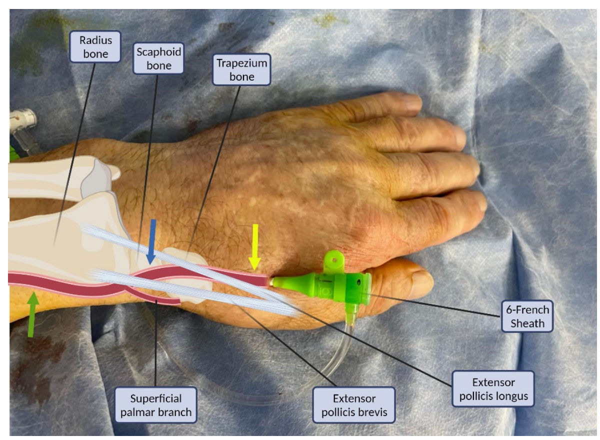

Figure 2. Insertion of the sheath in the distal radial artery: location and anatomy.

Current landscape of distal radial access

The radial artery runs from the forearm to the base of the thumb and continues into the superficial and deep palmar arch.[9] In the 70s, the access to the radial artery via the anatomical snuffbox (fovea radialis) has been described as an alternative access point for blood pressure monitoring in children and adults,[11] but it took several decades until the DRA started to be used for coronary angiogram and interventions. It was then adopted in interventional radiology and interestingly, revived in intensive care units, for perioperative monitoring.[12,13] The distal radial technique consists of canalizing the radial artery through the anatomical structure called snuffbox (anatomical snuffbox, radial fossa, fovea radialis) which represents a hollow space on the radial side of the wrist that becomes evident when the thumb is extended; it is limited by the extensor pollicis longus tendon of the thumb, the extensor pollicis brevis and the abductor pollicis longus tendons of the thumb. The scaphoid and trapezium bones form the floor of this triangular anatomical space (Figure 2). Patients with an easily palpable pulse in the area of the snuffbox and/or slightly more distally on the dorsal surface of the hand are suitable for the DRA. The details of puncture technique has been described elsewhere.[7,9,14] The preparation does not differ from proximal radial access. The same boards or extension rails can be used to position the patient's arm. Overall, the distal access does not require any significant changes in the processes of a cardiac catheter laboratory.

The learning curve with distal radial access is navigable, but there are nuances to the technique that should be appreciated in the interest of patients' safety. At least 100 cases are needed to consistently maintain a high success rate of >96%.[14,15] This is of particular importance if the aim is to push DRA in more difficult scenarios such as STEMI cases or Complex High-Risk Indicated Procedure/Patients. Marked improvement can be felt within the 50 cases, which is encouraging for a novice operator.[16] Being more distal, the artery is slightly smaller in diameter (−0.2 to 0.3 mm) but the difference showed no impact on 6–7-French sheaths.[17,18] However, as mentioned above, it may make the technique a little harder to master, along with its angled trajectory throughout the carpal bones. A 6-French sheath has an outer diameter of approximately 2.4–2.6 mm while the mean distal radial artery diameter is around the same (smaller in women),[19,20] meaning that in most cases, the sheath occupies the whole arterial lumen. Although this theoretically raises concern about flow-mediated dilatation and long-lasting functional impairment at the access site,[21] it has been shown that DRA, in fact, is associated with significantly less influenced vasomotor functions the day after the procedure, compared to the conventional TRA.[22,23] Moreover, the recent RATATOUILLE study showed that DRA was not associated with hand function impairment at 1-year follow-up.[24] As with permanent occlusion, there is no real clinical effect, forearm vascularization being quickly compensated by the rich collaterals of the ulnar and interosseous artery; rarely the patient complains of pain or numbness after RAO.[25,26]

Default DRA can be accessed by palpation alone in most cases with some practice, and this can be improved further with ultrasound guidance. There is a subset of patients, especially in the elderly, where DRA access can be particularly challenging. The anatomical positioning of the distal radial segment varies more than the proximal segment, which is always rectilinear. Here the use of imaging would bring some benefits. While the use of ultrasound is standard of care for many transvascular interventions, its use in DRA remains at the discretion of the operator and the center's expertise, although there are signals for a higher patient satisfaction and success rate (multiple through-and-through attempts and inadvertent needle injury of underlying periosteum causes severe pain and predisposes to arterial spasm).[27] The same RATATOUILLE study used ultrasound-guided DRA for approximatively 85% of participants which highlights the effectiveness of US use in both DRA and TRA.[24] In relation to hemostasis, DRA showed significantly shorter times.[28] The same study showed a very low complication rate in the DRA group (partial occlusions 1.0% and arteriovenous fistula 0.5%), consistent with other reports that followed.[29–31]

Of all, perhaps the most important is the low occlusion rate, which anyway, in case of occlusion, it was proven that it remains localized at that level, the flow through the superficial palmar arch remaining preserved and the distal radial artery patent.[18,28] This has been confirmed by various recent meta-analyses.[32–34] Moreover, the shorter compression time was clear amongst all three studies and no differences in the risk of developing hematomas or spasm at the access site were observed when comparing with conventional TRA.[32–34] Recently, different methods shown to minimize the risk for RAO were reviewed in an international consensus document that supports their systematic implementation in everyday interventional practice and DRA has been proposed as a potential approach for RAO avoidance given its anatomic basis and physiological rationale.[10] This fact becomes even more relevant after the publication of two recent studies which showed that RAO is not influenced either by the low dose of rivaroxaban (10 mg) administered short-term after the procedure nor by the systematic administration of nitroglycerin at the beginning and end of the procedure.[35,36] Of note, in an experimental study involving healthy subjects, simulated occlusion of the distal radial artery in the anatomic snuffbox did not cause significant flow reduction in the forearm radial artery compared with simulated occlusion of the radial artery at the wrist.[37] This detail explains the asymptomatic occlusion and emphasizes more the importance of preserving the artery as a medical investment rather than having an immediate clinical impact.

To promote a homogenous diffusion of DRA and allow meaningful comparisons between conventional TRA and DRA, several randomized trials have been completed or are still ongoing (Table 1). One of the largest of all, the DISCO Radial trial[38] recently announced its results regarding RAO: the rates were strikingly low, and similar between TRA and DRA groups (0.91% vs 0.31%; $p = 0.29$); moreover, there were no differences in bleeding and vascular complications across the two groups (bleeding 5.5% vs 6.8%; $p = 0.33$; vascular complications 1.2% vs 1.1%; $p = 0.81$). These findings resulted from the implementation of a rigorous hemostasis protocol following current best practice recommendations. The fact that RAO rates after DRA remain low even when compared to the best practice TRA protocols is noteworthy. As per other complications, it is worthy to mention that bleeding or vascular complications were comparable between conventional TRA and DRA (5.5% vs 6.8%; $p = 0.33$; 1.2% vs 1.1%; $p = 0.81$ respectively).[38] Crossover rates (7.4%) were still much lower than in DAPRAO,[39] where crossover to TRA was 13.3%, and ANGIE,[31] where it was as high as 22.3%. This speaks about the importance of the learning curve and the expertise of the operator (which was substantial in the DISCO Radial), but also shows one of the limitations of adopting DRA in regular clinical practice where variously skilled operators intersect. Post-DRA care is shorter and more practical for both the patient and the nursing staff. Moreover, from the patient's perspective, leaving hospital earlier and without a bruise represents a significant benefit. DRA appears to combine the advantages of conventional TRA with additional benefits to patients. On a closer look, the DAPRAO trial also used patent hemostasis and prevention strategies in both groups (pneumatic band, gradual deflation, slender sheaths, arterial cocktail with heparin, nitroglycerine, verapamil) and still, the RAO rates were lower in patients receiving DRA; but this was a relatively small, single center study with first- and second-year fellows performing the access, therefore its external validity should be perceived as limited.[39] The incidence of other complications (bleeding, arterial spasm, access time) remained consistently similar in both groups.[39] Other randomized clinical trials comparing DRA with conventional TRA are expected to definitively establish its role in interventional cardiology and radiology. Nonetheless, available data highlight that DRA may allow the very same procedures as conventional TRA, including intervention for left main coronary artery and complex bifurcation lesion; intravascular imaging; calcium debulking devices; chronic

Table 1. Baseline characteristics of the main randomized clinical trials comparing distal radial access with proximal radial access.

Trial	Registration	Year (completed)	Country	*N*	Endpoint	Follow-up
Mokbel et al.[68]	–	2018	Romania	114	RAO	In-hospital
Koutouzis et al.[69]	–	2019	Greece	200	Cross-over rate	Not prespecified
Vefali et al.[70]	–	2020	Turkey	205	Not prespecified	Not prespecified
DAPRAO	NCT04238026	2021	Mexico	282	RAO	1 month
ANGIE	NCT03986151	2021	Greece	1042	RAO	2 months
CORRECT	NCT04194606	Ongoing	Germany	500	RAO	1 month
DISCO Radial	NCT04171570	2022	Europe	1330	RAO	In-hospital
DIPRA	NCT04318990	Ongoing	USA	300	Motor hand function	1 month
DRAMI	NCT03611725	Ongoing	South Korea	352	Puncture success in STEMI	–
TENDERA	NCT04211584	Ongoing	Russia	1500	RAO	1 year
DC Radial	NCT04784078	Ongoing	China	938	RAO	In-hospital
RESERVE	NCT04861389	Ongoing	China	414	RAO	In-hospital
TunDRA	NCT05311111	Ongoing	Tunisia	250	Puncture success	–

total occlusion intervention; peripheral intervention for the carotid, lower extremity, and radial artery itself; and even balloon aortic valvuloplasty (BAV).[8,40–44] These will be discussed in more detail in the next section.

Distal radial access for coronary interventions

DRA feasibility is supported by an overall high rate of success in all reported studies. Our review of the literature found a cannulation success rate using DRA between 76.3% and 100%.[18,45–48] Moreover, no major safety issue has been reported so far among published registries, pointing out a very low incidence of radial artery spasm, shorter time to hemostasis, and a substantial absence of forearm RAO despite no mention of any dedicated strategy to favor vessel patency. In a large registry, the mean time to achieve DRA was also comparable to that of conventional TRA.[14] Access site crossover was performed in 2.58% of the patients, mainly via the contralateral DRA. Distal and proximal radial artery pulses were palpable in 99.68% of all patients at hospital discharge. The rate of minor vascular complications was low (1.5%)[14]; minor vascular complications were considered prolonged postprocedural hand numbness or pain, limited forearm hematomas (classification EASY I-II[49]) or postprocedural bleeding that as not actionable and did not case the patient to seek unscheduled performance of tests, hospitalization, or treatment by a health care professional. Ultrasound guidance can increase the success of DRA, either if implemented systematically or as a rescue after failure of tactile-guided approach. In the only study comparing both approaches, ultrasound guidance shifted DRA success from 87% to 97%.[50] The main advantages of ultrasound guidance are accurate identification of the puncture site and careful assessment of the size and curvilinear course of the distal radial artery. An in-depth guide to ultrasound guidance in DRA has been recently published, providing valuable technical advice.[51] Interestingly, ultrasound examination during DRA would have another advantage besides guidance, because the detection of calcifications in the radial artery wall was correlated with that in the coronary wall[52]; arterial media calcification is mostly found in patients with high smoking index, chronic renal failure, and diabetes mellitus and its presence is associated with higher mortality rates.[52,53] All catheters commonly used for the proximal radial access can be used for coronary diagnosis and intervention. For patients taller than 185 cm, the usual catheter length of 100 cm may not be sufficient. It is recommended to use diagnostic and guide catheters with a length of 110 cm in such patients. Patients with a height of more than 200 cm over DRA can also be examined successfully. The distal radial artery, cephalic vein, and superficial branches of the radial nerve are all contained within the snuffbox.

In addition to the usual coronary interventions, the role of DRA has proved to be even more important during chronic total occlusion (CTO) recanalization. In these arduous procedures, dual arterial access is required in most instances. While conventional TRA access is possible, the patient's position quickly becomes uncomfortable due to forced supination of the hand. Moreover, the operator must bend over the patient's abdomen. For this reason, most CTO operators prefer radial-femoral right ipsilateral arterial access. This issue could be solved by adopting dual DRA, which would bring the left hand close to the right and provide increased comfort for both the operator and the patient. This attractive theory has been described in recent studies.[54,55] Moreover, one comparative study also measured the radiation dose across two groups and not surprisingly, the dose area product received was lower in the DRA group compared to the traditional TRA.[56]

Another concern was the performance of DRA in acute coronary syndromes (ACS), where time-to-access is paramount; the higher procedural time and crossover rate with DRA raise some concerns, hampering prompt reperfusion, and potentially affecting clinical outcomes. Therefore, upfront selection of the access site should balance the benefit coming from forearm RAO avoidance with the operator's proficiency to successfully perform diagnostic procedures and percutaneous coronary interventions (PCI) with that access site. This concern, however, was more theoretical because the 2017 ESC guidelines declared TRA as the first choice for coronary angiography or PCI in patients with STEMI, reflecting the maturity of this vascular access.[56] A similar situation happens with DRA which has comparable access times. Sgueglia et al. studied 176 patients with ACS (DRA 88 and TRA 88). The results showed that dTRA and TRA have similar puncture success rates (97% vs 99%), operation times, fluoroscopy times, and surgery success rates, and the incidences of RAO by DRA were significantly lower than TRA (1% vs 4.5%).[57] Soydan and Akın compared 30 patients with acute STEMI undergoing DRA and 61 patients undergoing transfemoral (TF) PCI. The success rate of PCI in both groups was very high (90% vs 91.8%, $p=0.795$), and the puncture time of the two groups was similar (28.63 s vs 28.93 s, $p=0.767$). However, patients in the DRA group had shorter fluoroscopy times, total radiation doses, and hospitalization days, and patients in the TF group had a higher mortality rate during hospitalization (0% in the dTRA group and 18% in the TF group, $p=0.013$).[58] Cao et al.'s review showed that the puncture time for coronary angiography or PCI using the DRA path for ACS is 28.63 s to 162 ± 96 s.[59] As a perspective, the option of using large bore catheters in complex high-risk coronary cases remains open and must be tested with DRA[60]; for example, a 2.0 mm rotablation burr requires an 8-French catheter and not all arterial lumens support such a size. In this case, the role of ultrasound becomes relevant again by means of preoperative assessment of arterial diameter because the incidence of RAO is directly related to the ratio between the sheath and artery size.[61,62]

Distal radial for peripheral interventions

As the experience with such approach increases, other potential fields of application are rising, including patients with occluded radial artery, carotid, femoral, and in general endovascular extracardiac interventions. Practically, DRA can take the role of access to any intervention and extracardiac procedures that are classically performed by femoral approach, such as carotid or limb ischemia.[43,44] For example, a hybrid approach has been proposed for superficial femoral artery interventions, utilizing the radial and the pedal access.[43] Interventional oncologists are beginning to use this access for embolization of pathologies of the pelvic organs.[63] The neuroradiology field has also adopted this approach.[64] A special role is played by the recanalization of the radial forearm artery (post-PCI RAO) and the continuation of the coronary procedure through the same ipsilateral approach. DRA can therefore reopen the jeopardized radial artery.[65]

Distal radial for structural interventions

Perhaps most impressive, DRA has proven its versatility in structural interventions where the insertion of large sheaths (7–8F) has led to very low rates of cross-over or RAO, with high procedural and clinical success. Indeed, hardware originally made for large-bore accesses is now accessible for the radial approach as well, and the newer balloons for BAV are flexible and feasible via DRA.[42] An additional advantage offered by DRA in BAV procedures is the maintenance of the radial artery patent, compared to the increased rate of postprocedural RAO by classical TRA approach, in the context of endothelial injury and immediate thrombosis secondary to large sheaths.[66] Another useful role of the DRA is as a secondary access in transcatheter aortic valve implantations, where the left hand can be brought close to the primary, large-bore access, thus optimizing the workspace and avoiding the puncture of both femoral arteries.[67]

Conclusion

DRA proves its versatile abilities in all percutaneous interventions. Emerging data, although most observational studies, show the same efficacy as conventional TRA, with some net benefits such as low RAO rate, shorter hemostasis, and better intraprocedural ergonomics. Randomized studies would elucidate the impact of DRA on hard clinical endpoints such as severe bleeding or mortality.

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