Distal Radial Artery Access in Noncoronary Procedures

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Abstract: Since the beginning of interventional cardiology and for decades, the femoral artery has been the access of choice for both diagnostic and interventional endovascular procedures. Due to an extensive evidence base accumulated over the last 20 years, the majority of interventional cardiologists around the world prefer classical radial artery access for both elective and emergency procedures. A similar trend has been observed for distal radial artery access over the last 5 years. Noncoronary endovascular surgery undergoes the same stages of improvement and optimization of access, but in a more accelerated way. The goal of this review is to analyze the literature on distal radial artery access in noncoronary procedures. (Curr Probl Cardiol 2022;00:101207.)

Introduction

Since the beginning of interventional cardiology and for decades, the femoral artery (FA) has been the main, and one might even say the only, access of choice for diagnostic and interventional

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endovascular procedures. At the same time, the number of coronary angiography (CAG), and subsequent percutaneous coronary interventions (PCI), increased annually. There was also an increase in the number of clinics where coronary interventional procedures were performed, which led to an increase in the number of access-related complications.[1-3] In our opinion they were primarily associated with endovascular tools, which were far from perfect; however, today there are rare cases of very serious complications of FA puncture for CAG.[4]

After Lucien Campeau introduced proximal radial artery access (PRA) in 1989,[5] and Ferdinand Kiemeneij performed the first PCI via radial artery (RA) in 1992,[6] the beginning of new era ensued, not only in interventional cardiology, but also in other areas of endovascular surgery. However, it took more than 2 decades to establish the reliable evidence base of efficiency and safety of transradial access (TRA), so it could be implemented as a reliable access for any PCI independent of the clinical picture, according to the European Society of Cardiology (ESC)/European Association for Cardio-Thoracic Surgery (EACTS) recommendations for myocardial revascularization.[7] But at first, not everyone believed in the success of TRA and they improved FA access methods. In particular, patented devices for hemostasis from resorbable collagen plugs were developed, and after that, randomized trials were conducted and showed the effectiveness of the plug, especially in patients with a high risk of developing hemorrhages.[8,9] Both trials revealed that these new devices contributed to a faster hemostasis with a statistically significant degree. There was also a statistically significant decrease in post-procedure bleeding and hematomas[8]; however, the number of infectious complications at the access site increased.[9] The PRA was used only when the FA was impossible or contraindicated.[10]

Currently, TRA has significant advantages over femoral access in the form of a lower incidence of bleeding from the puncture site, possible discharge on the day of the procedure, patient comfort, and reduced mortality in acute myocardial infarction with ST segment elevation.[11-14]

Due to its small diameter, however, the RA is prone to spasm and has anatomical variations much more often than other arteries, which can lead to perioperative complications, access conversion, and an increase in the duration of the procedure.[15] But the most common complication of the PRA is still early and late RA occlusion, the frequency of which can reach 30%.[16,17] The presence of an occluded RA after CAG or PCI rarely leads to severe ischemic consequences on its own, which has led to the complete rejection of the Allen test before puncture, although the literature describes isolated cases of acute hand ischemia.[18] In the future, RA

occlusion can cause insurmountable difficulties for repeated endovascular intervention through the involved arm, the formation of an arteriovenous fistula, or the collection of a conduit for coronary artery bypass grafting.[19] Moreover, some authors emphasize the lack of ergonomics when working through the left PRA, especially during long procedures, causing inconvenience to both the patient and the surgeon.[20,21]

During the last 10 years, the PRA has been actively used by vascular surgeons in the treatment of peripheral artery pathologies of various basins,[22] by interventional neuroradiologists for cerebral angiography (CAG) and operations,[23] interventional oncologists for embolization of pathologies of the pelvic organs.[24]

The goal of this review is to analyze the literature (PubMed, Scopus, EMBASE, eLIBRARY) on distal radial artery access (DRA) in noncoronary procedures.

Development of the Distal Radial Artery Access

The first publications about the use of the DRA as a primary access for diagnostic and interventional procedures in comparison with the PRA appeared in 2014 and 2015.[25,26] Since 2017, the DRA has become very popular among interventional surgeons around the world in their daily practice. According to the 2019 consensus "Best Practices for the Prevention of Radial Artery Occlusion After Transradial Diagnostic Angiography and Intervention", the routine use of the DRA can reduce the number of RA occlusions, but large randomized trials are needed to test this hypothesis.[27] In December 2017, a multicenter, open, randomized (1:1) TENDERA (Comparison between Traditional ENtry point and Distal puncturE of RA) trial, NCT04211584, was initiated on https://clinicaltrials.gov. Interim data of the trial were published in 2021, and showed fewer local complications of the DRA in coronary practice.[28]

Distal Radial Artery Access in Anesthetic Practice

It was anesthesiologists who first began to perform a puncture distal to the traditional point for certain types of manipulations. In 1977, JJ Amato et al. presented a method of puncture in the anatomical snuffbox (AS) area for perioperative blood pressure monitoring in pediatrics.[29] In 2019 Maltra S. et al. reported 55 cases of performing a puncture of the distal RA for perioperative management of patients after the induction of general anesthesia in major cardiovascular and other operations. Access was performed under the direct control of ultrasound navigation or just in the presence of pulsation of the distal RA in the AS area. At the same time,

the authors themselves did not report any difference in the number of successful punctures with or without ultrasound assistance.[30]

Distal Radial Artery Access in Interventional Oncology

It was just 5 to 7 years ago when the PRA began to be actively introduced in interventional oncology, and primarily into the most frequent and simple operations, such as uterine artery embolization (UAE). According to one of the latest studies, UAE via RA or FA access in women up to 178 cm height has similar technical and clinical results with a low incidence of local complications.[24] However, there are clinical observations of UAE via the DRA, which report good results.[31] Moreover, the DRA is at present a possible access site for liver chemoembolization (more than 200 cases), selective radiation therapy and Y-90 mapping (more than 120 cases), embolization of mesenteric and small pelvic arteries (more than 60 cases), embolization in oncological bleeding: hepatic, renal, gastric, pulmonary (5 cases), as well as for a large number of diagnostic angiographies in oncology.[31-33] Anastasia Hadjivassiliou et al. noted statistically significant differences in the diameter of the RA in its proximal and distal sections (0.2 mm $\pm$ 0.16 mm) in all age groups in cancer patients; subgroup analysis by sex showed that in male patients the difference was 0.21 $\pm$ 0.17 mm ($P < 0.001$), while in women it was 0.17 $\pm$ 0.16 mm ($P < 0.001$).[33] At the same time, all operations were performed by surgeons via the left distal radial artery access.[33] Lievay van Dam et al. during their observation note 97.6% success in using DRA with access conversion in just 2 patients; all patients underwent ultrasound control in the postoperative period, in which RA occlusion or other serious complications were not observed.[32]

Uei Pua et al. describe their experience of surgical interventions on visceral arteries in oncological practice which were performed via RA in the AS area. Before the procedure, the authors performed a modified Barbeau test for all patients, according to the results of which only patients with A-C wave type were included in the study. A total of 50 successful punctures were performed in 31 patients using ultrasound navigation and a modern hydrophilic introducer GLIDESHEATH SLENDER (Terumo, Tokyo, Japan). After the insertion of the introducer, 3000 IU of heparin and an antispasmodic cocktail were administered, and at the end of the operation a patented device for hemostasis was applied. The maximum follow-up period was 7 months, and the early and late complications included only 1 asymptomatic false aneurysm of the access zone, which was treated conservatively. The interest of this work lies in 13 cases of

repeated successful puncture in the AS area after a short period of time, which was not described in earlier and later works. In addition, the authors note positive feedback from the patients themselves about the new access as a more comfortable one. All these points are very important for oncological patients, since they often must undergo procedures repeatedly to achieve the desired clinical effect.[34]

Distal Radial Artery Access in Interventional Neuroradiology

The introduction of the DRA into interventional neuroradiology almost coincided with the active introduction of the DRA. Currently, there are already retrospective studies on the DRA in neuroradiological practice, as well as 1 meta-analysis. According to the inclusion criteria, the meta-analysis included 7 retrospective studies with a total of 459 interventions.[35] In the meta-analysis the overall success rate was 95% (95% CI, 91%-98%; I2 = 74.33), the minor complication rate was 2% (95% CI, 1%-4%; I2 = 0), and there were no major complications.[35] At the same time only 24.2% of all procedures were direct surgeries; therefore, neuroradiological interventions both via the DRA and the RA still require the accumulation of experience.

The authors of 2 studies with a total of 94 patients reported that each attempt to perform the procedure via the DRA was successful, while the number of accesses via the FA was significantly reduced. It also became possible to use the proximal part of the RA after unsuccessful DRA without immediately resorting to the femoral access.[36,37] Srinivasan VM. et al. reported 11 successful cases of the DRA in the treatment of posterior circulation pathology; 7 of them were emergency mechanical thrombus extraction in stroke.[38] In a 2-center retrospective analysis of the database from 2018 to 2020 Kuhn AL. et al. identified 74 patients, who underwent surgical treatment of intracranial aneurysms using flow-diverter devices via AS access.[39] In all 74 clinical cases, it was possible to successfully catheterize the RA in its distal part, but 3 times the surgeons had to change the access to the femoral one due to severe tortuosity, lack of instrumentation, and aberrant lesion of the right subclavian artery. The authors note the absence of local complications and 1 early asymptomatic RA occlusion.[39] A study by Cyril Chivot et al. presents a retrospective review of a prospective database of cerebral aneurysm embolization that describes the experience of using the DRA by 1 surgeon and 30-day patency of the target RA was assessed as an endpoint.[40] Access conversion was required in 1 clinical case. There was no RA occlusion or hand

ischemia observed, and the DRA itself was described as safe for endovascular treatment of this pathology.[40]

Goldman DT et al. conducted a one-center comparison of the PRA and the DRA during various neurointerventional procedures and did not obtain statistically significant differences between the groups. The overall percentage of technical success was 92.1%, and in 7.6% (26 cases), a transition to access via the FA was required.[41] A number of other neurointerventional radiologists used DRA or AS access only for CAG,[42] or only for the surgical treatment of different pathologies: aneurysms, arteriovenous malformations, arteriovenous fistulas, intracranial stenoses, etc.,[42] as well as for the treatment of strokes such as local thrombolysis or thrombextraction.[43,44] All authors note high patient satisfaction with the new access, the reduction in the number of major local complications associated with the FA, the great potential for the DRA in the future, and the need for further large prospective studies on DRA in interventional neuroradiology.

Distal Radial Artery Access in Vascular Surgery

Vascular surgeons describe isolated successful clinical cases of using the DRA or access via AS in the following surgical interventions: stenting of the subclavian artery (5 cases), stenting of the superior mesenteric artery (1 case), stenting of the celiac trunk (1 case), stenting of the renal artery (1 case), bronchial artery embolization due to bleeding (7 cases), renal artery embolization due to bleeding (1 case), and renal artery aneurysm embolization (1 case).[31,32]

The investigated area of the hand is used on a much larger scale by vascular surgeons for dialysis arteriovenous fistulas (AVF). Krzysztof Letachowicz et al. suggest use of a part of the RA in the area of AS to create primary dialysis AVFs, especially in young patients without concomitant diseases.[45] According to their data, primary patency after 18 months and secondary patency were not statistically different between the AVF groups in the AS area and in the wrist area - 72% and 65%, $P = 0.48$; 93% and 94%, $P = 0.89$.[45] Three publications present 39 cases of using the DRA to restore patency (balloon angioplasty) of dialysis AVFs with 100% efficiency and the absence of any early or late complications.[31,46,47] It should be noted that the authors did not use this access in routine cases, but only in difficult cases, when the access through a vein was not possible, and through the RA was extremely difficult.

Zoltán Ruzsa et al. described 38 clinical cases of the treatment of occlusive-stenotic lesions of the superficial femoral artery (SFA)

(including recanalization of extensive calcified chronic occlusions) via the DRA and compared them with the PRA. The authors did not receive any statistically significant differences in the combined endpoint (technical success, MACE) and access conversion to the FA. Chronic total occlusions were recanalized in 25 of 26 patients with the DRA (96.1%) and in 79 of 81 patients with the PRA (92.6%) ($P = 0.57$). Dual (transradial and transpedal) access was used in 14 patients (36.8%) in the DRA group and 28 patients (18.9%) in the PRA group ($P < 0.01$). Contrast volume, fluoroscopy time, irradiation dose, and procedure time were not statistically different between the DRA and PRA groups, nor were access site complication rates (2.6% vs 7.0%).[48]

Norihiko Shinozaki et al. published 42 cases of successful use of the DRA in the treatment of atherosclerotic lesions of the SFA (4 cases) and iliac arteries (38 cases), 8 patients of all had chronic total occlusion of the target vessel. The surgeons always used guide catheters, 7 Fr in 67% of cases and 5-6 Fr in the rest. In 100% of cases a good angiographic and clinical result was achieved (a statistically significant increase in the ankle-brachial index), without any periprocedural (including access-related) complications. Additional punctures were not required. There were no RA occlusions, revascularizations of the treated artery, or complications after 1 month.[49]

The DRA is successfully used in the treatment of carotid stenosis. In a retrospective review, Anna Luisa Kühn et al. described 22 carotid stentings (CAS) using 7 Fr Glidesheath Slender and Wahoo Access Catheter (Q'apel Medical) or 6Fr Fubuki (Asahi Intecc) and Benchmark (Penumbra) as guiding catheters with removal of the introducer and additional skin incision for their successful implementation.[50] The average diameter of the RA in the study was 2.1 mm (1.6-2.8 mm), and access conversion to the FA was required in 9.1% of cases due to vasospasm or tortuosity of vessels in type III aortic arch.[50]

In a pilot retrospective study, RADCAR-DISTAL, the authors assessed the feasibility of the DRA for carotid endovascular intervention. A total of 58 DRA and 151 PRA procedures were performed. All operations were performed by 3 experienced interventional surgeons. The study assessed major adverse cardiac and cerebral events, as well as major and minor local complications. All punctures were performed under ultrasound guidance. Only 6.5 Fr JR5 (Asahi Intecc, Aichi, Japan) was used as a guide catheter, and for complex anatomy a coaxial technique was used with a 125 diagnostic catheter. CAS were performed only with a distal embolism protection system. In the DRA group, modern double-mash stents were statistically significantly more frequently implanted (48.28%

and 30.46%, $P = 0.023$). The success of the procedure from the primary access was achieved in all patients in the DRA group and in 94% of the PRA group ($P = 0.065$). Total procedure duration ($P < 0.001$) and fluoroscopy time ($P = 0.005$) were higher in the DRA group, while contrast consumption ($P = 0.912$), cumulative x-ray dose ($P = 0.811$), and hospital stay were not statistically significantly different. There were no statistically significant differences for the primary endpoint. In the DRA group, 1 complication was noted in the form of the AVF, which required surgical treatment. In the PRA group, only asymptomatic RA occlusions occurred in 3.1% of cases.[51]

Discussion

Currently the DRA has proven to be an equal or perhaps even safer access for diagnostic and therapeutic coronary interventions. However, like any other approach, it requires a learning process. Even in the hands of an experienced interventional cardiologist, questions remain about its routine use, particularly in patients with acute coronary syndrome, when it is necessary to minimize the time of puncture and catheterization of the access artery. We will receive a partial answer to this question when a randomized controlled trial comparing the DRA and the PRA in patients with STEMI (number NCT036117254 at https://clinicaltrials.gov) is completed.

A similar situation exists in non-coronary practice. In interventional neuroradiology, the main question is "Can we use the DRA in patients with acute cerebrovascular accident?" Indeed, in such patients, minutes count to save more neurons and minimize neurological deficit, and the difficulties associated with the DRA and/or its subsequent conversion to the FA can negatively affect the patient. In our opinion, in vascular surgery, the main difficulties are associated with the working length of the tools (guide catheters, guide wires, balloon catheters, stents, and micro instruments) and support when working on the femoral-popliteal segment. In addition, using the DRA or the PRA for the treatment of atherosclerotic pathology below the inguinal fold, debulking devices (Jetstream from Boston Scientific, Rotarex from Bard, etc.) cannot be used. While working on the iliac segment and brachiocephalic arteries, it is important to match the diameter of the guide catheter or introducer to the diameter of the artery in the DRA area. In interventional oncology and in bleeding control, it is highly important to deliver the drug or embolizing agent as accurately and/or distally as possible. The absence of significant tortuosity, good support, and sufficient instrumentation length are also important.

In our opinion, at present, the DRA has undeniable advantages and does not require special evidence for this in anesthesiological practice, especially when used for puncture under ultrasound navigation, as well as for the treatment of dialysis AVF stenoses. Anesthesiologists use somewhat thin catheters to monitor invasive blood pressure, which minimally injure the target vessel. And in the treatment of dialysis AVFs, the DRA is as close as possible, which provides good support and, at the same time, the RA itself is not directly involved, which reduces the risk of its occlusion.

Thierry Corcos wrote in 2019: "Radial is better, smaller is better, distal radial is even better!,"[52] and one cannot but agree with him. One cannot deny that at present, the DRA is gradually becoming the preferred access in some elective procedures, and the development of material technology makes routine use of the DRA no longer a dream.

Conclusion

Currently, observational and retrospective data indicate a significant clinical benefit of the DRA for both the surgeon and the patient. Reducing the number of early and late RA occlusions, nerve damage, local hematomas, and major bleeding are clear advantages of the DRA over the PRA. Large prospective studies will help to evaluate the long-term outcomes of the DRA in both coronary and non-coronary practice.

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