How to Improve the Success Rate of Distal Transradial Access Puncture, “A Winding Path Leads to Seclusion”? An Experience Summary Based on Over 2000 Cases (Post-print)

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Abstract

Distal transradial artery access for coronary intervention is currently one of the research hotspots in the field of coronary intervention. Compared with conventional transradial artery access, distal transradial artery access offers advantages such as higher patient comfort and fewer related complications; however, due to radial artery tortuosity and the relatively small caliber of the distal radial artery, puncture via distal transradial artery access has a significant “learning curve”. Based on experience from over two thousand cases, this article analyzes and summarizes the common causes of failed puncture via distal transradial artery access (mainly including two aspects: patient-related factors and operator-related factors) and management strategies, in order to provide references for improving puncture success rates and promoting the application of distal transradial artery access.

Full Text

How to Improve the Success Puncture Rate of Distal Transradial Artery Approach, “Winding Path to the Secluded”: Summary of the Experience of More than 2,000 Cases

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Abstract

Percutaneous coronary diagnosis and intervention via distal transradial artery approach has become one of the hot research topics in the field of coronary angiography and intervention. Compared with the transradial approach, the distal transradial artery approach offers advantages such as higher patient comfort and fewer related complications. However, due to the tortuosity of the radial artery and the relatively small caliber of the distal radial artery, there is a significant learning curve for distal transradial artery puncture. Based on experience from more than 2,000 cases, this paper analyzes and summarizes the common causes of distal transradial artery approach puncture failure (mainly including patient-related and operator-related factors) and management strategies, aiming to provide references for improving puncture success rates and promoting the application of distal transradial artery approach.

Keywords: Coronary disease; Coronary artery disease; Percutaneous coronary intervention; Coronary angiography; Radial artery; Distal radial artery; Problem-based learning

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What Are the Main Challenges in Distal Transradial Artery Approach Puncture?

The radial artery originates from the brachial artery and descends along the radial side of the forearm. At the radial styloid process, it gives off the superficial palmar arch branch, then turns toward the dorsal hand, passes through the space between the first and second metacarpal bones, and forms the deep palmar arch with the distal ulnar artery. The distal radial artery is the continuation of the radial artery at the wrist, traversing the triangular region on the dorsal hand (anatomical snuffbox). This region is bounded laterally by the tendons of the abductor pollicis longus and extensor pollicis brevis, medially by the extensor pollicis longus tendon, inferiorly by the radial styloid process, and its floor is the bony platform formed by the trapezium and scaphoid bones. In this region, the distal radial artery is more superficial, making its pulse easily palpable. However, because the distal transradial approach is farther than the conventional radial approach and the vessel is relatively small and tortuous, puncture and catheterization difficulty increases, and interventional cardiologists face a significant learning curve.

Currently, large coronary intervention centers in China commonly have high procedure volumes and "fast-paced" workflows. Throughout history, the emergence of new technologies has always driven learning enthusiasm, but it is undeniable that due to the learning curve, beginners in interventional cardiology spend more time on puncture and encounter higher failure rates, leading to a sense of frustration. Previous studies have reported distal transradial artery puncture success rates of 70%-100%, while early randomized controlled studies showed lower success rates for distal transradial approach compared with conventional radial approach (70% vs. 100%). However, most researchers now believe that the puncture success rate for coronary intervention via distal transradial approach is similar to that of the conventional radial approach. Therefore, whether beginners can overcome the learning curve quickly, shorten puncture time, and increase puncture success rate has become an important factor in whether distal transradial approach can be promoted and popularized clinically.

How to Choose the Puncture Needle for Distal Transradial Artery Approach?

Currently, several types of transradial puncture kits are commonly used in China. Based on whether they have a sheath, puncture needles can be divided into bare steel needles and sheath needles. Needle sizes range from 22G to 20G (outer diameter 0.71-0.91 mm), with matching guidewire diameters ranging from 0.018" to 0.025" (0.46-0.63 mm). Our institution routinely uses the Terumo sheath needle (Terumo, Introducer kit II, 20G needle with 0.025" guidewire) for both conventional transradial and distal transradial puncture. The sheath needle offers a distinct advantage during distal transradial puncture: when guidewire insertion is difficult, the sheath can be used for angiography to clarify vessel course and determine the cause of guidewire insertion difficulty, facilitating resolution of many guidewire insertion problems. However, sheath needles also have certain disadvantages for distal transradial puncture: due to the superficial location of the vessel, puncture failure can occur when the needle shows blood return but the sheath is not completely within the vessel. It should be noted that some coronary intervention centers in China routinely use bare steel needles for distal transradial puncture and also achieve high success rates. Therefore, in clinical practice, needle selection should be based on the interventional cardiologist's experience and preference, and the advantages and disadvantages of bare steel needles versus sheath needles cannot be generalized.

What Are the Causes of Distal Transradial Artery Approach Puncture Failure and What Are the Management Strategies?

Most studies define successful distal transradial artery approach puncture as smooth insertion of the arterial sheath, and report that coronary intervention via distal transradial approach can be safely completed using conventional 6F and 7F sheaths. Therefore, for interventional cardiologists proficient in radial artery puncture technique, completing distal transradial puncture alone is not difficult. Our institution routinely uses the Terumo 6F conventional sheath and the Apt 7F thin-walled sheath (Apt Braidin® 7F thin-walled sheath) for distal transradial approach puncture. Through long-term clinical practice, we have found that guidewire insertion failure is the most critical factor causing distal transradial puncture failure, which is consistent with international reports. Since 2019, our institution has successfully performed more than 2,000 coronary interventions via distal transradial approach, with a puncture success rate of approximately 95% and sheath insertion success rate of approximately 93%. We preferentially use the right distal radial artery approach for puncture, switching to conventional radial approach when puncture fails. We have summarized and categorized the causes of distal transradial puncture failure into patient-related and operator-related factors. Using sheath needles as an example, we analyze the causes and management strategies for distal transradial puncture failure as follows.

Patient-Related Factors Patient-related factors, particularly vascular characteristics, are the main causes of guidewire insertion failure during distal transradial puncture, which can be summarized as the following four aspects: (1) radial artery tortuosity; (2) physiological bend at the transition segment; (3) radial artery stenosis, occlusion, or spasm; and (4) small distal radial artery.

Radial Artery Tortuosity (Figure 1A): Radial artery tortuosity is a common cause of distal transradial puncture failure. The puncture kits generally contain straight guidewires that are relatively thick, with poor ability to pass through tortuous radial arteries. Forceful manipulation can easily cause radial artery perforation or dissection, forcing the operator to abandon distal radial puncture. **Management Strategy:** Shape the puncture guidewire by creating a small "J" curve 3-5 mm from the tip. When inserting the guidewire, coordinate with gentle rotation. Care should be taken not to apply excessive force during shaping to avoid damaging the protective structure at the guidewire tip. When the radial artery tortuosity angle is too large and the shaped guidewire cannot pass, consider using a percutaneous transluminal coronary angioplasty (PTCA) guidewire to assist passage through the tortuous segment. Lee et al. reported that when straight guidewire insertion is difficult, switching to a thinner 0.014" PTCA guidewire helps improve puncture success rate. It should be noted that PTCA guidewires are thin with poor support, but their shaft has greater support than the distal segment. Therefore, when advancing the sheath along a PTCA guidewire, consider inserting more of the PTCA guidewire and keeping it coaxial with the vessel as much as possible.

Physiological Bend at the Transition Segment (Figure 1B): The transition segment refers to the portion where the distal radial artery curves around the radial styloid process from the anatomical snuffbox to join the radial artery. This segment has a physiological bend that sometimes impedes straight guidewire insertion. **Management Strategy:** Generally, shaping the puncture guidewire allows it to pass the physiological bend at the transition segment. When ineffective, it can be used in combination with a PTCA guidewire, and the sheath should be advanced as far as possible under PTCA guidewire guidance to cross the transition segment bend before switching back to the straight guidewire.

Radial Artery Stenosis, Occlusion, or Spasm (Figures 1C, 1D): For patients with previous transradial coronary intervention history, when no radial pulse is palpable, radial artery stenosis or occlusion should be considered. Doppler ultrasound can be used for further confirmation. However, due to special anatomical structures, palmar arch circulation, and collateral formation from the interosseous artery, especially when the occlusion segment is short, relying solely on palpation of the radial pulse can easily miss the diagnosis of radial artery occlusion. When sheath advancement is difficult, the possibility of vascular spasm should be excluded. **Management Strategy:** For patients with previous transradial coronary intervention history, routine preoperative radial artery ultrasound can identify some patients with radial artery occlusion. For radial artery occlusion patients, if distal transradial puncture can be successfully completed, there is still an opportunity to recanalize the occluded radial artery and complete coronary intervention via the ipsilateral approach. For radial artery spasm, vasodilator drugs can be administered through the sheath.

Small Distal Radial Artery: Compared with the radial artery, the distal radial artery is relatively small (the diameter ratio at puncture sites between distal transradial and conventional radial approaches is approximately 0.8), which increases the difficulty of distal transradial puncture to some extent. Studies have shown that female sex, low body mass index, and smoking are independent predictors of small distal radial artery. **Management Strategy:** For interventional cardiologists with limited puncture experience or beginners, consider preoperative ultrasound examination and select patients with relatively large distal radial arteries for initial attempts.

Operator-Related Factors Operator-related factors are important causes of distal transradial puncture failure, which can be summarized as the following four aspects: (1) entering branch vessels; (2) excessive angle between puncture needle and vessel; (3) sheath contacting vessel wall too tightly; and (4) sheath not completely entering the vessel.

Entering Branch Vessels (Figures 1E, 1F): The distal radial artery has many branches (including deep palmar arch, superficial palmar arch, thumb artery, and dorsal hand artery) with tortuous courses, making it easy for the guidewire to enter branch vessels. **Management Strategy:** Confirm under fluoroscopy that the guidewire has entered a branch vessel without resistance, then carefully adjust the guidewire direction to advance it along the main vessel.

Excessive Angle Between Puncture Needle and Vessel (Figure 1G):

An excessive angle between the puncture needle and vessel, similar to radial artery tortuosity, can cause guidewire passage difficulty. This is mainly related to patient vascular anatomy and operator puncture angle. **Management Strategy:** Adjust the extracorporeal sheath angle to make it as coaxial with the vessel as possible, then reattempt guidewire insertion.

Sheath Contacting Vessel Wall Too Tightly (Figure 1H): When the sheath contacts the vessel wall too tightly, pushing the sheath can create an artificial angle at the posterior vessel wall, also causing guidewire passage difficulty. **Management Strategy:** Slightly withdraw the sheath and reattempt guidewire insertion.

Sheath Not Completely Entering the Vessel (Figures 1I, 1J): Incomplete sheath entry into the vessel occurs in two situations: first, the puncture needle hits the "bull's-eye" but the sheath is not completely within the vessel; second, the puncture needle misses the "bull's-eye," preventing guidewire entry into the vessel lumen. **Management Strategy:** For sheath needle puncture, the through-and-through method can be used—after blood return is seen, advance the puncture needle slightly further. For thin, small patients, since vessels lie close to bone, the puncture distance is shortened, and the puncture angle can be reduced. After blood return is seen, advance the sheath slightly along the needle. It is recommended to control the puncture angle at approximately 30° in the snuffbox area, while an even smaller angle is appropriate for the more distal Hegu acupoint area. If the puncture needle misses the "bull's-eye" and the matching guidewire cannot be inserted into the vessel, re-puncture or switch to a thinner PTCA guidewire to guide the sheath into the vessel, then replace with the puncture guidewire.

Other Factors In clinical practice, the cause of guidewire insertion failure can also be judged based on the insertion length, and corresponding management strategies can be formulated: if the guidewire has not exited the sheath, possible causes include incomplete sheath entry into the vessel or the sheath abutting the vessel wall; if the guidewire has passed beyond the sheath, possible causes include physiological bend at the transition segment, radial artery tortuosity/occlusion, or entry into branch vessels. In such cases, attempt to advance the sheath forward along the guidewire and inject a small amount of contrast through the sheath to clarify the cause of guidewire insertion failure. The causes and management strategies for distal transradial puncture failure (guidewire insertion failure) are detailed in Figure 2 [Figure 2: see original paper].

Application of Ultrasound Guidance to Improve Distal Transradial Puncture Success Rate

High-frequency ultrasound can clearly differentiate the distal radial artery, cephalic vein, superficial branch of the radial nerve, bony structures, and tendons in different parts of the anatomical snuffbox. Ultrasound guidance can effectively improve transradial puncture success rate and has high clinical value, though few studies have reported on its application in distal transradial puncture. Norimatsu et al. measured distal radial artery diameter in 142 patients undergoing coronary intervention via ultrasound to analyze sheath-to-vessel diameter ratio and assess potential radial artery injury from catheterization. They found that the intravascular diameter at the distal radial artery puncture site in the snuffbox was smaller than that at the conventional radial artery puncture site, suggesting that ultrasound examination before distal transradial coronary intervention is very necessary. Mori et al. used ultrasound-guided puncture of the distal radial artery in the anatomical snuffbox and found significantly higher puncture success rates compared with the non-ultrasound-guided group (97% vs. 87%, P=0.0384).

Although radial artery occlusion is not uncommon clinically, successful distal transradial puncture can achieve retrograde recanalization of the occluded radial artery. However, even when the distal radial artery has retrograde blood supply from the palmar arch after radial artery occlusion, it often has insufficient filling, making the distal radial pulse non-palpable. Therefore, for patients with unclear distal radial pulse or radial artery occlusion, ultrasound guidance can clarify vascular course and improve puncture success rate, demonstrating high application value. It should be noted that because the distal radial artery traverses the snuffbox with limited space, ultrasound probe placement is difficult. If interventional cardiologists are not proficient in ultrasound operation, puncture time for distal transradial approach will be significantly increased.

Conclusion

In summary, with the development and application of specialized puncture guidewires and thin-walled sheaths suitable for distal transradial approach, distal transradial coronary intervention technology will accelerate its development. Failure is common during initial attempts at distal transradial puncture, and timely identification and summary of failure causes are particularly important in the early learning stage. Only by continuously improving puncture success rates can distal transradial coronary intervention truly achieve the "winding path to the secluded" state!

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