Radial Complications: Rare But Critical

Prevention and treatment of transradial complications.

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Transradial cardiac catheterization techniques allow the practitioner essentially the same benefits of the transfemoral approach with a marked reduction in the risk of both minor and life-threatening vascular access site complications.[1] Although the risk is reduced using the transradial approach, it is not totally eliminated, and complications still occur. Although complications germane to angiography/catheterization and not related to the site of vascular entry remain no different from a transfemoral approach, there are a cluster of potential complications unique to the transradial approach that need to be recognized and respected for the radial operator to minimize their occurrence and limit any negative outcome.

A TECHNICAL APPROACH TO REDUCE COMPLICATIONS

Radial arteries are not simply small femoral arteries. Although there is always room for innovation, especially in an exciting technique such as transradial catheterization, several technical points should be emphasized to maximize success (Table 1). Attention to detail and technique in access and execution of the study can prevent most complications. First, a precise puncture and delivery of the access sheath into the radial artery is important. The use of prepackaged radial access or micropuncture kits facilitates access by providing the appropriate size-matched equipment. Successful access can only occur without resistance to passage of wires or sheaths. Second, prophylactic antispasmodic medications should be administered immediately at access and may be repeated later in the procedure if conditions suggest spasm may occur. Several "cocktails" have been suggested but commonly include nitrates and calcium blockers alone or in combination. Third, anticoagulation is needed to prevent or reduce radial thrombosis. Anticoagulation should be equivalent to a full-dose (5,000 U) heparin bolus.[2] Despite full anticoagulation, the sheath is removed from the artery immediately at the end of the procedure. Last, once central arterial access is achieved with a wire and catheter, this position should be maintained through the use of exchange wire or jet-catheter exchange techniques so that the distal arterial tree does not have to be repeatedly transversed by wires that may induce spasm.

ETIOLOGY OF COMPLICATIONS

The root of most transradial complications lies in the anatomical variations that are the rule in the forearm. The two most common situations are (1) an accessory radial artery and (2) radial loops. Accessory radial arterials occur when the radial artery does not terminate completely into the brachial artery in the antecubital fossa but rather has an extension that continues up the radial side of the upper arm and enters the brachial/axillary artery high up toward the shoulder. An accessory radial may be large enough for standard catheters but is often small in caliber and may easily entrap catheters with spasm, making manipulation difficult and painful for the patient. Radial loops represent redundancy in the vessels that allow muscle group movement or have developed due to aging changes in an individual. Radial loops tend to be most pronounced in the elderly but can be found in all age groups. Both the accessory radial and radial loop variations often herald their presence when resistance to wire passage is encountered.

TABLE 1. KEY TECHNICAL POINTS IN DEVELOPING A SUCCESSFUL APPROACH TO TRANSRADIAL CARDIAC CATHETERIZATION

These technical notes will help minimize the occurrence of complications.

- Precise puncture with micropuncture equipment
- Prophylactic antispasm medication
- Anticoagulate to prevent (or reduce) thrombosis
- Hold on to hard-won territory (exchange wire or jet-catheter exchange technique)
- Remove the sheath at the end of the case

Anatomical variability should be expected and met with a standard plan of action, such as outlined in Table 2. Once a solution to the anatomical challenge has been found, a long access sheath or exchange technique should be employed to maintain access without the need to rechallenge the vascular system.

CORONARY SPASM

Anatomic variability often results in increased vascular manipulation and stimulates vascular tone leading to spasm. It also sets the stage for the potential of equipment failure and vascular perforation. Arterial spasm must be met up front with prophylactic pharmacologic therapy and sedation that should be repeated if any concerns arise during the procedure that suggest active spasm may be occurring. Left untreated or carried to its extreme, spasm may result in abandonment of the transradial approach for another access site, enhance risk of radial thrombosis, or rarely, evulsion of the endothelium of the radial artery onto the shaft of the introducer catheter.[3] Recalcitrant spasm is often the result of continued application of force or activity in the artery, and it may respond to time (no further catheter movement) and more sedation. In very extreme cases of spasm, general anesthesia and/or nerve blocks could be considered. The use of hydrophilic-coated sheaths appears to be helpful, especially in controlling access-site spasm.[4]

EQUIPMENT FAILURE

Anatomic variability can usually be surmounted with limited angiography and the use of carefully guided wires. Within these arteries, there may be a need to manipulate catheters that stress the limits of our present catheter technology. Improvements in design have occurred, most notably in the small 4- and 5-F sizes. Catheter kinking may occur, especially in a catheter softened by time and stress of use. There is little room in the small-diameter distal arm vessels for kinked catheters. A loss of pressure waveforms, torqueability, or enhanced resistance to injection are all signs of catheter failure from kinking. The kink should be immediately undone by countering the last movement, and the catheter should be removed and replaced with a fresh device. A kinked catheter should never be withdrawn into a more peripheral location unless all attempts at remediation have failed. Persistence in trying to salvage or complete the case with failing equipment is a recipe for more serious problems, such as subclavian dissection if the catheter becomes entangled and cannot be unkinked.

TABLE 2. A STEPWISE APPROACH USED TO OVERCOME ANATOMICAL VARIATION IN THE ARM CIRCULATION

- Having a pre-existing plan maintains the flow of the procedure and helps the cardiac catheterization laboratory team anticipate the next step in the procedure.
- The wire should always pass without resistance. If not,
- Try a hydrophilic-coated .035-inch wire. If that will not pass,
- Record a limited angiogram to define the problem, then
- Retry with a .035-inch hydrophilic wire or a flexible smaller wire

ARTERIAL PERFORATION

Wire manipulation to initially gain central arterial access is a potential mode of arterial perforation. If the interventionist applies enough force to a wire in a thin-walled, distal artery in the arm, it will perforate typically through a small branch. Despite care, even the most experienced operators may be faced with vessel perforation. Although perforation is most likely to occur in the more distal vessels, small branches originating anywhere along the full length of the arm's vascular system have the potential to perforate if entered with enough force. Early recognition of perforation is paramount to preventing more serious complications, and the perforations can often be managed with little disruption to the overall performance of the procedure. One must recognize that the distal forearm has a fascial compartment that may become pressurized by an arterial bleed. A compartmental syndrome can then occur, with the potential for significant long-term damage if not rapidly diagnosed and treated. The upper arm does not contain a true compartment that could pressurize with blood loss. This prevents upper-arm compartmental syndromes but may allow extensive blood loss if also not recognized as a bleeding source.

The typical scenario for vascular perforation is the occurrence of resistance to wire passage, many times with a complaint of transient pain noted by the patient. Either a straight-tipped wire or one with a hydrophilic coating is most likely to be involved. Under this scenario, there should be a high suspicion for perforation. The anatomic location of the wire should be established for future reference. Either a limited angiogram can be obtained to inspect the site, or a prophylactic elastic bandage (Figure 1) can be applied to the area. If the wire has transversed the region successfully, the procedure can continue despite the possibility of perforation even with an elastic bandage in place. Under most situations, the elastic bandage can be removed after the procedure in the recovery area, and no further sequelae are seen.

If a perforation occurs—but was not appreciated in the catheterization laboratory—it may show up as arm

Figure 1. Example of a forearm wrapped with an elastic bandage at the site of a suspected micropuncture in the mid-portion of the forearm. The standard hemostasis device is seen in place in the foreground. There was no visible or measurable hematoma after removal of the elastic wrap that had been placed during the initial access procedure.

Figure 2. Example of a foreign-body reaction that appeared several weeks after use of a hydrophilic, gel-coated access sheath. After drainage and local wound care, this resolved without long-term sequela.

swelling in the recovery area. The potential for compartment syndrome needs to be considered and followed up. Once again, application of pressure using an elastic pressure dressing is all that is usually needed to control the situation. If there are changes that raise the potential of a compartment syndrome, a vascular surgeon should be consulted. If a true compartment syndrome develops, fasciotomy may be necessary to prevent chronic injury.[5]

HEMOSTASIS DEVICE COMPLICATIONS

Hemostasis devices and technique are another source of transradial morbidity. Transradial access sheaths are removed in the catheterization laboratory even in highly anticoagulated patients without respect to laboratory clotting times. The vascular site is then controlled with a variety of techniques ranging from a "tight" pressure dressing to a wide variety of pressure band devices. Closure devices, such as those used on the femoral artery, have not been adapted for radial use. Most of these devices used to control the access site carry the risk of a "handcuff" injury if allowed to remain too tight, which can result in local venous thrombosis, hand swelling from microvascular leakage or petechial rashes, and subcutaneous hemorrhages due to suppressed coagulation pathways. Peripheral nerve crush injuries can be seen, and, very rarely, complex regional pain syndromes have been reported.[6] Most of these injuries can be prevented with attention to device application and subsequently treated with conservative measures and time once they occur.

DELAYED INFLAMMATORY REACTIONS TO VASCULAR SHEATHS

A late complication has been reported[7] with the use of heavily coated hydrophilic sheaths, which represents a delayed foreign-body reaction. In such cases, patients initially do well but report inflammation at the access site weeks to months after the procedure. There are no systemic signs of infection, although the access site looks as if an abscess is forming, as shown in Figure 2. Such reactions appear to be from hydrophilic gel material from the introducer sheath that is retained under the skin. These sterile inflammations respond well to drainage and conservative care and do not represent chronic infection. As such, use of antibiotics has not been shown to be helpful.

ACUTE RADIAL ARTERY OCCLUSION

Radial artery occlusion does occur in some patients after transradial procedures and is almost always asymptomatic; or, if symptomatic, it presents with an arteritis of the forearm that responds well to nonsteroidal agents and warm soaks. Many of these occlusions will spontaneously resolve with time. Risk of occlusion is highly dependent on technique and has ranged from 1% to 70% in the literature.[2,8] Using full-dose heparin along with using a sheath that is not oversized for the artery reduces the risk of occlusion. Despite the use of heparin and a small sheath, radial occlusion will still at times occur. Because vascular insufficiency is essentially never seen with radial occlusion, there is no role for vascular surgical intervention for the vast majority of these situations. In many cases, radial patency will return with time.

CHRONIC ARTERIAL DAMAGE

Beyond the acute thrombotic injury seen, some injuries to the radial artery associated with transradial catheterization are more chronic and should be recognized. Endothelial function and the character of the vessel wall may be altered by passing catheters through this relatively small vessel.[8,9] Such changes may make the vessel less appropriate for use

as an arterial conduit for bypass surgery in the future. Many surgeons who use radial conduits use the left radial initially; hence, the right is available for the cardiologist. However, in some institutions, the potential for long-term changes to the radial artery may be a consideration.

MISCELLANEOUS COMPLICATIONS

Large registries have confirmed the relative safety of the transradial approach when applied by a wide variety of operators in large groups of patients, and data have been collected that show a reduction in mortality driven by a reduction in transfusion requirements in transradial patients. Despite this positive news, there have been some reports of potential neurologic events that may be related to transradial procedures. The proximity of the right carotid artery to the passage of catheters up the right arm has been implicated in increased microembolism. This risk may be cushioned by the almost universal use of anticoagulation agents during transradial procedures, which may reduce the sequela of these events. Nevertheless, there is a potential for cerebral microembolism that needs to be considered. This risk is somewhat balanced by a reduced risk of aortic embolism because the transradial catheter enters the central aortic system proximal to the atheroma found in the transverse and descending aorta that the transfemoral operator would otherwise need to transverse. A recent study supports the relative safety of the transradial approach using serial MRI scanning in aortic stenosis patients undergoing cardiac catheterization and has suggested the potential for less embolism from the transradial approach than previously reported by the transfemoral techniques.[10]

COMMENTARY ON THE ALLEN'S TEST

The Allen's test has been a topic of much discussion at transradial meetings and the source of complications when patients who are denied transradial access due to an abnormal Allen's test result subsequently suffer a complication from femoral access. The Allen's test, named for Edgar Allen, MD, from the Mayo Clinic, demonstrates the presence of an intact palmar arch and direct collateralization between the ulnar and radial circulations. Although it can be used to demonstrate a physiologic principle of collateralization, it has not been shown to be predictive of ischemic complications involving the hand.[11] Surgical literature is devoid of descriptions of hand ischemia after radial harvest during CABG, even in patients with documented abnormal Allen's test results.[12] Likewise, the transradial literature also lacks any clear-cut cases of hand ischemia, despite the fact that many operators no longer use the Allen's test as an indication to deny transradial access.[13] This is not to say that hand ischemia will never occur, but rather the risk is exceedingly small. The risk of morality and morbidity is clear and present from transfemoral puncture. This real risk from femoral puncture must be considered against a potential ischemic risk, not yet reported, when using a hand with an abnormal Allen's test result, before the transradial approach is lightly rejected.

CONCLUSION

Although transradial cardiac catheterization is less likely to result in a catastrophic vascular complication compared to the transfemoral approach, the transradial approach does present its own set of unique complications. Usually, these complications are minor and, if recognized early, can be managed without serious consequences. Most complications stem from the anatomic variability that is the rule in the peripheral circulation. Minor perforations must be recognized to prevent potentially serious hematomas. Hemostasis bands need to be applied carefully to the wrist to prevent handcuff injuries. The use of heparin and appropriate chosen sheath sizes can minimize arterial occlusion that is usually asymptomatic. Likewise anticoagulation may help avoid potential thromboembolic complications inherent in working in close proximity to the origins of the carotid arteries. Finally, the role of the Allen's test needs to be questioned. The worst outcome of an abnormal Allen's test is a femoral puncture and subsequent retroperitoneal hemorrhage—a complication that most radial operators have chosen to avoid. ■

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