Techniques for Right Heart Catheterization in Conjunction With Radial Artery Left Heart Procedures

Peripheral access for successful right heart catheterization.

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There has been significant growth in transradial catheterization around the world and in the United States. One thing that has been lacking in this shift to the radial approach has been a similarly eloquent method to achieve right heart access to complement the newer radial artery techniques. Operators may use the need for a simultaneous right heart catheterization as an indication to use the femoral artery or one of the central neck veins for access. Both of these options defeat the impetus for radial catheterization, as they add risk and discomfort to the procedure. Better options are available. The goal of this article is to describe how to complement a transradial artery procedure with a peripheral vein approach to central venous access and right heart catheterization using the forearm. In particular, the focus will be on venous access, as this is key to a successful procedure.

The most important step in central venous access from the forearm is achieving peripheral venous access, which should be done before arterial access to minimize arterial time and risk for radial artery thrombosis. Two general approaches will be considered, and both may have a role at times (Table 1). These approaches include (1) achieving venous access prior to reaching the catheterization laboratory, or (2) achieving venous access in the catheterization laboratory with ultrasound assistance or angiography to locate the position of a vein for access. Catheterization laboratory time is valuable, and achieving access prior to arrival is an efficient use of resources. In-laboratory techniques, such as ultrasound or angiography, are more resource intensive, although these are useful when access is difficult. Once successful venous access is established, the rest of the procedure typically follows in a standard course, as all veins eventually lead to the heart.

VENOUS ACCESS BEFORE THE CARDIAC CATHETERIZATION LABORATORY

It is most efficient to secure a venous entry site before the patient arrives in the cardiac catheterization laboratory. Under this approach, staff outside of the catheterization laboratory, such as the intravenous (IV) access team or nursing staff, achieves access. Due to the limited length (< 110 cm) of available right heart catheters, an access site located geographically near the antecubital fossa and above the mid-forearm will ensure the ability to reach the wedge position. The question of whether the entry site is placed more medially on the forearm (routing the ascending catheter through the basilic system) or laterally (directing the catheter up the cephalic system) is primarily a concern if larger, stiff catheters are being used. Stiffer catheters, such as those used for right

TABLE 1. ADVANTAGES AND DISADVANTAGES TO ESTABLISHING INITIAL VENOUS ACCESS BEFORE OR AFTER ARRIVAL IN THE CATHETERIZATION LABORATORY		
IV Placement	**Advantages**	**Disadvantages**
Before the patient enters the catheterization laboratory	• Most efficient approach • Access initiated in the most patient-friendly environment • IV team expertise can be used	• Access needs stabilization/protection until the patient reaches the catheterization laboratory • Potential concerns of infection if exchange techniques are not appropriate
In the catheterization laboratory	• No need to rely on noncatheterization laboratory personnel • Quality control is simpler • Vascular ultrasound may be more readily available • Levophase arteriograms or limited venograms are available	• Most access can be done prior to arrival • Routine venipuncture in a high-overhead lab is inefficient • Catheterization laboratory environment and patient anxiety may impede venous access

ventricular biopsy, may not be able to safely negotiate the junction of the cephalic and axillary vein at their proximal terminus.

The vein should appear healthy. Sites of recent IV catheters or multiple blood sampling may have underlying venous thrombosis or local inflammation. The vein should be large enough for a 20-g IV catheter in order to permit the use of a 4- to 7-F vascular access sheath. Procedures using larger devices may need larger veins. Small, tortuous superficial veins that appear to be collaterals, spider veins, or varicosities do not make good access sites.

It is important to recognize the infectious potential of this approach, and the subsequent suggested approaches are consistent with the Centers for Disease Control and Prevention's 2011 guidelines for the prevention of intravascular catheter-related infections.[1] The venous entry catheter placed by staff outside of the clean catheterization laboratory will be exchanged for a vascular access sheath in the laboratory. This access ultimately delivers catheters to the central venous system, and as such, attention to details to ensure that the catheter remains sterile are paramount.

Although the site of venous entry is recleaned in the catheterization laboratory, the presence of a foreign body (ie, heparin lock) may make complete sterilization difficult; preemptively maintaining good hygiene will minimize risk (Figure 1). Chronic indwelling intravenous lines should not be used. They may initially appear as an obvious site to convert for central venous access, but under routine hospital conditions, they become infested with pericatheter pathogens, both on the catheter itself and the skin track passing down to the vein. This contamination is resistant to attempts at routine sterilization.

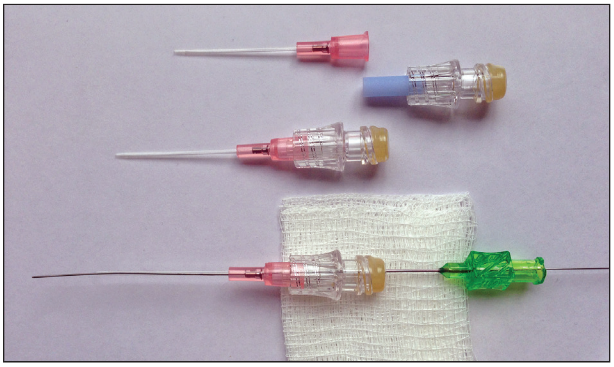

Figure 1. Plastic IV catheters (pink), latex-capped heparin lock adapter (tan), and 21-g, thin-wall needle (green) with a wire placed through both the needle and into the venous catheter ready for exchange with a vascular sheath (not shown). Sterile dressing (white) is used to grasp and slide the IV heparin lock 21-g needle en bloc off of the wire without having physical contact between the IV parts and the sterile field.

The advantage of establishing an intravenous entry site prior to arrival has several significant advantages compared to access in the catheterization laboratory. Patients are generally more relaxed, and the environment is generally warmer, factors that are more conducive to venodilation. Positioning options are flexible, and lighting may be better for routine venipuncture. Staff expertise—such as from an IV team that may be facile in advanced vein-finding techniques, such as vascular ultrasound—may also be enlisted. Most importantly, valuable catheterization laboratory time is not being used for a procedure that can be accomplished outside of that area.

ESTABLISHING VENOUS ACCESS IN THE CARDIAC CATHETERIZATION LABORATORY

Some hospitals routinely send patients to the cardiac catheterization laboratory without a pre-established venous entry site; at other hospitals, attempts may have been unsuccessful prior to arrival. A variety of in-lab techniques can be tried. Standard techniques can be employed, similar to those used for routine venipuncture, but the cool temperatures and enhanced anxiety of entering the laboratory will increase the difficulty over similar attempts outside of the laboratory.

Standard Vein Access

Inspecting both arms often results in the discovery of a vein candidate that the floor staff overlooked. Quickly finding an overlooked site that can be easily used can facilitate the in-lab process. Catheterization laboratory staff become quite adept at this task, and this can avoid further escalating the resources used to achieve access.

Ultrasound-Guided Access

If a superficial vein is not evident, there are always deep veins to use. Anatomical landmarks provide general guides to the location of these veins, but blind access is not foolproof and risks collateral damage of nearby structures. Vascular ultrasound devices available in catheterization laboratories can be used to precisely localize the deeper veins and successfully achieve access. Surrounding structures can be identified and avoided. The actual technique of using ultrasound-guided venous access is straightforward and is part of most residency training programs. Usually, veins can be identified with this approach without a tourniquet, but the use of a tourniquet can enhance the venous structures in difficult cases.

Vein access with ultrasound can be done either before or after sterile draping the patient. Deep veins in the antecubital fossa are so predictable that the region can be prepared and draped in the expectation of success. A sterile sleeve is placed on the ultrasound probe and used directly in the sterile field to obtain access. A variant of these approaches is to use the ultrasound before draping to map vein locations; this then facilitates the further use of ultrasound under sterile conditions to achieve access.

Contrast-Guided Access

The third approach to in-lab venous access involves the use of iodinated contrast. This approach does increase the contrast load of the procedure and should not be used unless it is clear whether the patient has an allergy to iodinated contrast. If a peripheral intravenous line exists in the distal forearm, a small amount of contrast injected into this line can produce a simple venogram that may localize other veins up the forearm. Placing a tourniquet on the arm after injection holds the contrast in place and allows a more leisurely inspection of the arm. Knowing the location of venous courses can then allow either a better visual inspection or better localization for ultrasound in order to achieve access. Likewise, access with x-ray guidance into the contrast-containing vein directly with a metal access needle is another possibility to consider.

There may be times when the need for venous access is apparent after arterial access is already in place. Because the patient has probably already been administered heparin, central neck access or femoral access is riskier, but arm access may also be problematic due to the patient already being secured in position in a cold environment. If peripheral veins are not easily localized and an alternative to ultrasound is needed, an arterial contrast injection can be used in the forearm. Waiting for several seconds will result in the passage of the contrast from the arterial to venous system through the forearm capillaries. Using a tourniquet or image-saving function on the imaging chain can provide a road map for underlying veins in the arm and localize a site for access.

RIGHT OR LEFT ARM USE FOR PERIPHERAL VENOUS ACCESS

Whether the right or left arm makes the best site for venous access has not engendered the same degree of attention as the debate over the best side for arterial access. For most cases, the side ipsilateral to the arterial access is convenient. On the other hand, the use of the arm contralateral to that of the arterial access is not prohibited and might make logistic sense in some situations. For instance, one might have an arterial procedure underway from the right arm when the need for venous access becomes apparent. Catheterization laboratory staff can prepare the left arm for venous access without the need to take down the right arm that is already set up for arterial access. Likewise, positioning of the left arm for arterial access may make venous access difficult, and under the circumstances, right arm venous access might make better sense.

In some cases, anatomic abnormalities might result in a side preference. Congenital central venous abnormalities, such as persistent left superior vena cava or anomalous venous return to the heart, might require some consideration for access. A multitude of acquired venous abnormalities may sway the decision for one side or another for venous entry. For instance, in-dwelling electrophysiologic devices may have resulted in central venous thrombosis, previous shoulder or forearm trauma may have resulted in venous damage that might impede passage of venous catheters, or a renal dialysis fistula may need to be avoided.

STEPS FOR EXCHANGING AN IV CATHETER PLACED OUTSIDE OF THE CATHETERIZATION LABORATORY FOR A VASCULAR SHEATH TO BE USED FOR RIGHT HEART CATHETERIZATION

1. Take down dressing used to protect site during transportation.
2. Flood entry site and indwelling catheter material with alcohol-based prep solution.
3. Only hold indwelling catheter with sterile gauze, never directly with gloves.
4. Use a puncture needle from an access kit to pass through the latex cap of the heparin well or to open a line for the vascular sheath wire.
5. Pass the wire up through the IV into the vein without resistance.
6. While still holding the IV with gauze, slide it off of the wire, and deposit it off of the sterile field.
7. Replace gloves or cover field if sterility has been violated.
8. Instill local anesthesia to skin entry site (optional); nick skin with blade (optional).
9. Advance the vascular sheath over the wire into the vein without pain or resistance.
10. Remove the vascular access wire and dilator.
11. Flush the vascular sheath. Aspiration may not be possible.

APPROACHES TO PREVENT AND TREAT VENOSPASM

- Routine antispasm cocktails are not needed, as venospasm is uncommon
- Spasm is seen if the catheter diameter is large compared to the vein
- Nitroglycerin is effective (IV, sublingual, or topical at site)
- Calcium channel blockers are not effective
- Cold flush fluid will induce spasm
- Warmth will reverse constriction

Breast cancer survivors may express an aversion to the use of the arm ipsilateral to their cancer. Although the risk of lymphedema under these circumstances has been overstated, compliance to patient wishes is best considered.

Regardless of the underlying pathology, asymmetric appearance of veins with one arm showing significantly larger venous structures may be a warning sign that relative central obstruction may exist on that side. Despite the better appearance of the distal veins, it may be better to use the smaller veins on the contralateral arm if there is a plausible reason for central venous obstruction. While initial venous access may appear invitingly easy, the frustration of trying to negotiate a central venous obstruction may quickly introduce delays into the procedure.

PLACEMENT OF THE VASCULAR SHEATH

Vascular sheaths used for right heart catheterization from the peripheral vasculature are analogous to those used in other venous systems for the same procedure. Sheath size depends on the catheter that is used. Diagnostic right heart catheters for pressure measurements can be as small as 4 F in diameter, and thermodilution catheters exist in 5-F and larger diameters. Although it is an unproven hypothesis, the use of the smaller-diameter catheters, such as the 5-F over larger 7-F catheters, should logically reduce potential mechanical trauma within the vein and reduce the potential for venospasm.

Using one of the standard, commercially available radial access kits provides the tools needed for finalizing access for right heart catheterization, assuming the kit has an entry needle, wire, and vascular sheath with its dilator. Similar to arterial access, the use of hydrophilic sheaths reduces the potential of spasm and eases entry into the vein over noncoated sheaths, based on experience. The approach based on a preexisting heparin well is outlined in the *Steps for Exchanging an IV Catheter* sidebar.

After the sheath is placed in the vein on the access wire, the dilator and wire can be removed and the sheath flushed with fluid. While it is routine to apply negative pressure prior to injection to watch for blood return in the arterial system, this maneuver often results in collapse of the vein, with prolapse into the sheath and resulting failure to see blood. This is normal and not a sign of failure if the sheath placement has been otherwise unremarkable. As long as flush fluid passes without resistance, the sheath is most likely in the vein in the correct position. Venospasm is unusual, and suggestions on therapy are noted in the *Approaches to Prevent and Treat Venospasm* sidebar.

If the wire or sheath fails to pass without resistance, or if the patient complains of pain, this should prompt the operator to stop and investigate the situation. Unless there is an obvious answer to the problem on inspection, a limited venogram is usually instrumental in understanding the situation. Several common situations and solutions may be found, as listed in Table 2, ranging from minor malposition of the catheter in an otherwise normal vein to inadvertent perforation. Although arterial perforation is best managed by passage through the region of perforation and continued use of the site,

TABLE 2. COMMON SITUATIONS AND SOLUTIONS FOR FAILURE TO SMOOTHLY PASS UP THE VEIN	
Situation	**Solution**
Side branch entered	• Reposition the wire into the main channel
Spasm	• See the *Approaches to Prevent and Treat Venospasm* sidebar
Thrombosis or obstruction	• Consider collateral routes and direct with a nontraumatic wire • Consider the etiology for thrombosis and the use of alternative veins, possibly in the other arm
Vein perforation	• If the wire is not in a proximal vein, reentry will not be easy (unlike in an artery), and new access is advisable
Venous valves	• Redirect the catheter with a soft wire that is appropriate for the catheter lumen • Use a bolus of fluid to open valves • If the use of a balloon-tipped catheter is problematic, a small amount of balloon air may deflect its course away from the valve.

venous perforation results in an injury that is difficult to traverse. In addition, the vein is thin and can easily be further traumatized. Venous perforation is often best handled by applying local hemostatic pressure and finding a new venous site.

With a properly placed vascular access sheath in place, passage of the right heart catheter up the arm should be smooth and unremarkable. Some operators like to advance catheters over an intraluminal wire to act as a track through junctions and valves. Initial passage of the catheter without the use of a wire is also feasible and successful in most cases. Medially passing catheters in the basilic vein can often pass without x-ray guidance, as the path up this vein usually leads straight into the axillary and then subclavian vein. Those catheters passing up the cephalic vessel should be supervised as they traverse a 90º junction with the axillary vein. Confirmation that the catheter took a path that coursed toward the central veins and not down the basilica is needed. Resistance can be investigated with contrast injection and treated accordingly (Table 2). When the subclavian vein is reached, techniques to pass further are identical to the techniques typically used for central venous access in invasive cardiology.

Once the right heart procedure is completed, site care should follow the same hemostatic care one might provide after the removal of any large intravenous peripheral line. The vascular sheath should be aspirated to remove thrombus, although venous collapse may prevent much aspirate. The sheath is then removed and occlusive pressure applied. Unlike arterial access, there is no need for a hemostatic band. Long-term vein thrombosis has not been studied systematically after right heart catheterization, although clinical thrombosis has not yet been reported, and in my experience with heart failure patients, repeated punctures have been possible in the same venous system.

SUMMARY

Right heart catheterization, including venous access from the periphery, has been done since the early days of cardiac catheterization. Modern tools have made the use of peripheral veins attractive once again. Combined with the radial arterial techniques developed over the last couple of decades, the ability to do both arterial and venous procedures from the arm brings further utility to the transradial field. Realistically, it is successful venous access in the forearm that sets the stage for a successful right heart catheterization. ■

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1. O'Grady NP, Alexander M, Burns LA, et al; Healthcare Infection Control Practices Advisory Committee (HICPAC). Guidelines for the prevention of intravascular catheter-related infections. Clin Infect Dis. 2011;52:e162-193.