The Use of Micropuncture Technique for Vascular or Body Cavity Access

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More than 1 million cardiac catheterizations are performed every year in the United States, and incur substantial risk of access site bleeding. Furthermore, insertion of central venous catheters and performance of pericardio- or pleurocentesis are common practice, also with substantial risk of vascular or organ injury. One of the major risks for access site bleeding is multiple or posterior arterial puncture with a large needle. Using a very small needle to obtain initial access to vessels or organ cavities has the potential to reduce the risk of bleeding or organ injury. Multiple unsuccessful attempts to achieve vascular access are more forgiving, and accidental organ injury during pericardio- or pleurocentesis is less traumatic when using a small micropuncture needle. This article reviews the use of micropuncture technique for vascular or organ cavity access, a technique that has the potential to decrease vascular access site complications and organ injury.

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KEY WORDS

Micropuncture • Vascular access • Pericardiocentesis • Jugular vein access • Femoral access • Coronary angiography • Left heart catheterization • Right heart catheterization • Central line insertion • Angioplasty • Percutaneous coronary intervention

More than 1 million cardiac catheterizations are performed every year in the United States.[1] This procedure has undergone an unparalleled development since its inception; however, procedure-related bleeding complications still exist and have been associated with adverse outcomes. Access site bleeding accounts for a majority of procedure-related hemorrhage.[2,3] Although radial access is becoming increasingly popular because of fewer complications as compared with femoral access, the latter is still the most common site used for coronary angiography.[4] Despite increasing use of radial artery access, the use of femoral access is indispensable for catheter insertion, percutaneous valve implantation, intra-aortic balloon pump insertion, and radial artery access failure. Increasing

awareness of access site complications, smaller sheath size, use of fluoroscopy and ultrasound, as well as access closure devices have been introduced to decrease access site complications.[5] However, various potent periprocedural antiplatelet and anticoagulation therapies have put patients at increased risk for bleeding.[6,7] One of the major risks for access site bleeding is multiple or posterior arterial puncture with a large needle. Using a very small needle to obtain initial access should reduce the risk of bleeding despite multiple or posterior arterial punctures. Furthermore, accidental organ injury such as myocardial or lung puncture during pericardiocentesis or pleurocentesis can be greatly contained by using a small micropuncture needle.

Complications With Femoral Artery Access

Vascular complications associated with femoral artery access for cardiac catheterization include local hematoma, retroperitoneal hematoma, pseudoaneurysm, arteriovenous fistula, and occlusive thrombus.[1] Hematoma usually occurs 12 to 24 hours postprocedure, leading to patient discomfort, or a drop in blood pressure or hematocrit, whereas pseudoaneurysms and arteriovenous fistulas may take days or weeks to become apparent. Male sex, young age, diagnostic procedure, and elective procedure have a low risk for complications, whereas advanced age, female sex, liver disease, coagulopathy, immunosuppression, renal dysfunction, emergent procedures, and prolonged multivessel intervention are expected to have higher rates of complication.[8] In a large multicenter registry of 18,137 consecutive patients undergoing percutaneous coronary intervention (PCI), the variables associated with increased incidence of vascular complication included age ≥ 70, female sex, body surface area < 1.6 m^2, history of congestive heart failure, chronic obstructive pulmonary disease, renal failure, lower extremity vascular disease, bleeding disorder, emergent priority, myocardial infarction, shock, type B2 or type C lesions, three-vessel PCI, use of thienopyridines, or use of glycoprotein IIb/IIIa receptor inhibitors.[9] Arteriotomy puncture site is also an important predictor of vascular complications. Complications can happen because of posterior arterial wall puncture, multiple punctures, puncture above the inguinal ligament (high sticks), or puncture of the profunda femoris and superficial femoral artery (low sticks). High sticks are associated with retroperitoneal hemorrhage,[10] and low sticks with pseudoaneuryms, hematomas, and arteriovenous fistulae.

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The incidence of major femoral bleeding complications has been reported to be approximately 3.5%.[11] The incidence of arteriovenous fistula and pseudoaneurysm has been reported to be approximately 0.6% and 1.2%, respectively.[12] Procedure-related bleeding is associated with a much higher risk of death during clinical follow-up, as reported in many trials and registries.[7,13-18] Data from the National Heart, Lung, and Blood Institute Dynamic Registry revealed that access site hematomas requiring blood transfusion are associated with much greater increase in hospital death and increased mortality at 1-year follow-up.[18] Patients who develop retroperitoneal hemorrhage can have a mortality rate ranging from 4% to 10%.[10,19] Peripheral vascular complications prolong hospitalization and increase hospital costs considerably. It is, therefore, critical that we reduce the access site complications. Using a small needle such as a micropuncture needle may reduce this complication rate.

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Advantage of the Micropuncture Technique for Vascular Access

Although much effort has been devoted to closing the arteriotomy puncture, it is of paramount importance to have proper identification and reduce the trauma to the access site initially. For cardiac catheter use, intra-aortic balloon insertion, and percutaneous valve implantation, the use of the femoral access site is indispensable. The femoral artery puncture site is usually located by anatomic landmarks, using the anterior superior iliac spine and pubic symphysis to identify the inguinal ligament, and puncturing approximately 2 cm below the inguinal ligament at the level of the common femoral artery. Fluoroscopy and ultrasound are helpful for correct identification of the vessel. However, it is not unusual for initial femoral artery puncture to fail, due to the failure to advance a guidewire; this leads to multiple

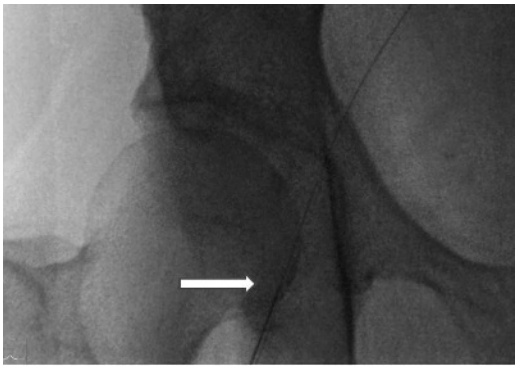


Figure 1. Entrance of the micropuncture needle into the femoral artery (*arrow*). In the case of a high femoral stick, the needle and wire can be removed safely in this stage, avoiding a large puncture hole and risk of potentially deadly retroperitoneal bleeding.

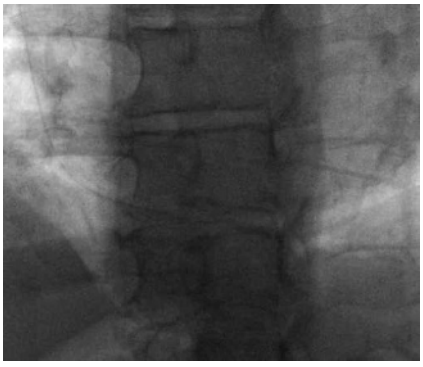


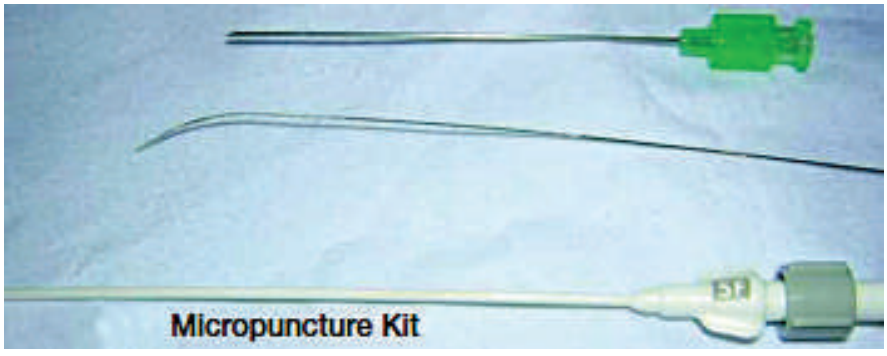
Figure 2. Micropuncture wire tip seen in the aorta due to accidental carotid artery puncture during attempted right jugular vein access for right heart cathterization.

arterial punctures until successful wire advancement can occur, thereby dramatically increasing risk of access site bleeding, particularly in patients on anticoagulation medication. Furthermore, accidental posterior puncture of the femoral artery is not uncommon. Using a very small needle such as a micropuncture needle can reduce this bleeding risk, as trauma to the femoral artery is minimal. The most important application of the micropuncture technique is the ability to abort high puncture of the femoral artery to reduce the potentially deadly complications of retroperitoneal bleeding. After the needle and wire insertion, fluoroscopy can visualize the exact entrance of the micropuncture needle in the femoral artery. Figure 1 shows fluoroscopic confirmation of the perfect needle entry in the femoral artery at the lower third of the femoral head. If the puncture site appears to be too high, with the risk of retroperitoneal bleeding, the needle and wire can be removed before the larger 4-Fr sheath is inserted in the femoral artery. Unfortunately, this important technique has not been used by many operators or reported in published trials. After insertion of a 4-Fr sheath, femoral angiogram can be used to show the entrance site in more detail, and the procedure can be aborted at this stage for high or low stick. The micropuncture technique can be useful to minimize arterial trauma, especially when the patient is coagulopathic, or when there are chances of unsuccessful entry into the artery because the vessel is diseased, small, calcified, or tortuous, and a smaller access needle is desirable. Figure 2 shows accidental carotid artery puncture. The tip of the micropuncture wire can be seen in the aorta. The wire and needle can be removed safely without any risk for bleeding or hematoma formation.

Micropuncture Technique

A standard vascular access kit includes an 18-G straight entry needle. A micropuncture kit includes a 21-G needle for initial access (Figure 3).[20] This is inserted at a 45° angle. Once pulsatile blood is seen, a guidewire is advanced through the lumen of the needle. Because of the difference in the diameter of the lumen, with the 18-G needle, the blood flows out of the needle on access spurts more than it does with the 21-G needle.[21] An 0.018-inch guidewire is threaded, as compared with a .035-inch guidewire in the standard kit. At this point, fluoroscopy of the needle tip will show the operator the approximate level of entry. For a high or undesirable puncture site, the micropuncture needle and wire can be removed with minimal risk of bleeding. Once the correct entrance site is confirmed, the needle is then removed and a 4-Fr short catheter with a 3-Fr inner dilator is placed over the guidewire. Following this, an appropriately sized wire (0.035 in) is placed through the 4-Fr catheter with subsequent upsizing to the desired sized sheath. The use of micropuncture offers the advantage of having a very small puncture site. The finer profile of the micropuncture needle causes less injury to the artery and adjacent structures than does the large-bore needle, thereby

Figure 3. Micropuncture set. From Ginapp T.[21] Reprinted with permission from *Cath Lab Digest* 2007;15(6). Copyright HMP Communications.



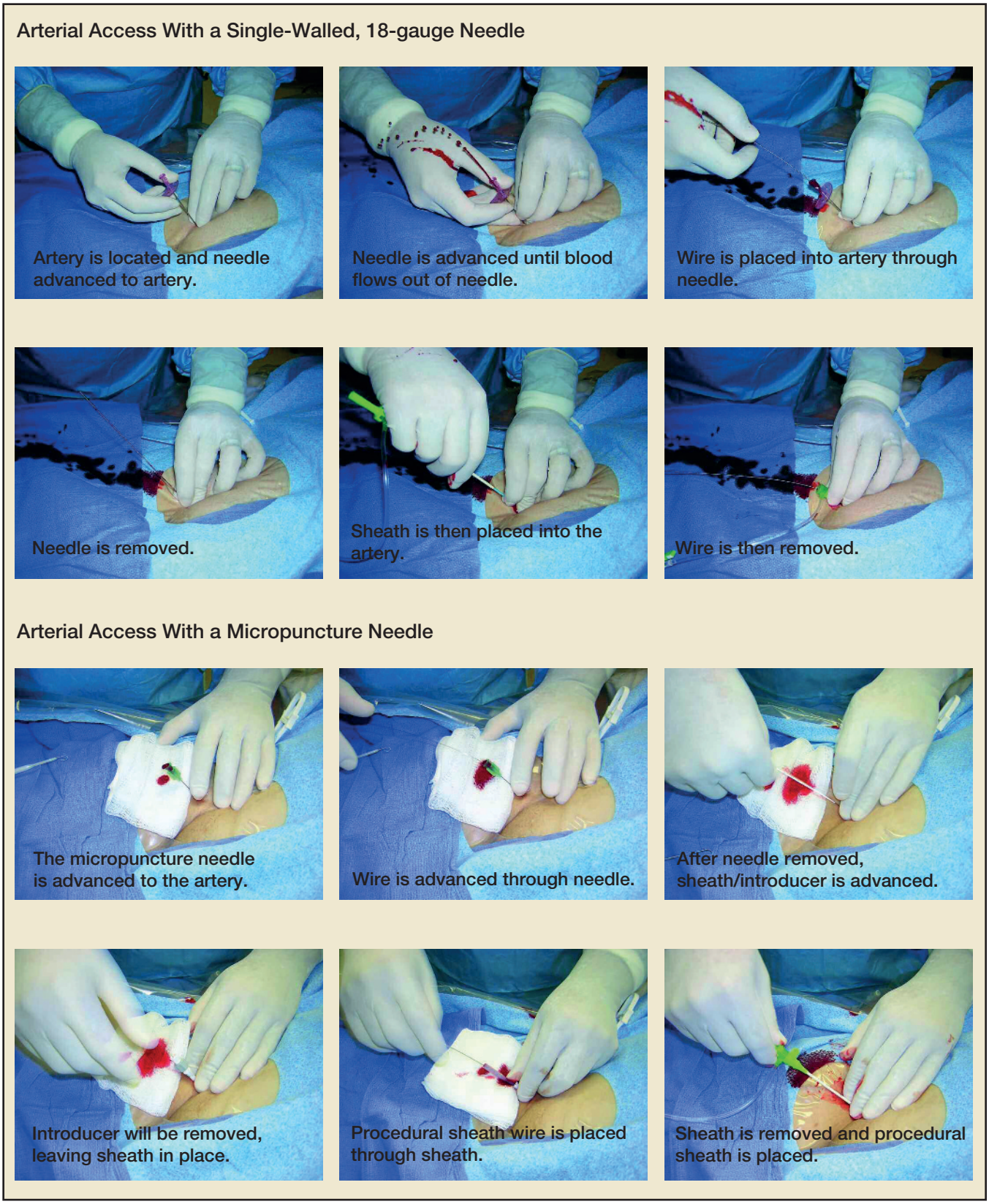


Figure 4. Demonstration of femoral artery cannulation using a standard needle and a micropuncture needle. From Ginapp T.[21] Reprinted with permission from *Cath Lab Digest* 2007;15(6). Copyright HMP Communications.

reducing complications, particularly in difficult cases in which the needle needs to be withdrawn and a second puncture made.[2] Figure 4 shows a comparison of standard versus micropuncture technique.

Published Data

There are no randomized trials comparing standard needle use for femoral access with micropuncture technique. Only one retrospective study was published in 2012 comparing access site complications with a micropuncture 21-G needle and a standard 18-G needle in 3243 consecutive patients who underwent PCI over 4 years.[22] The data were analyzed and concluded that the micropuncture approach did not reduce vascular complication (1.3% vs 1%; $P = .54$), and actually marginally raised the incidence of retroperitoneal bleeding (0.7% vs 0.18%; $P = .04$). This study excluded patients receiving thrombolytic drugs, glycoprotein IIb/IIIa inhibitors, warfarin, and those who received an intra-aortic balloon pump. Furthermore, the study had major limitations; it was nonrandomized, a retrospective analysis and had bias toward micropuncture use in sicker high-risk patients. In this study, patients in the micropuncture group were older, had a smaller body surface area, and had a higher prevalence of peripheral vascular disease and renal failure. Furthermore, routine fluoroscopy to visualize the tip of the needle (in order to abort high sticks) was not performed, eliminating one of the most useful elements of the micropuncture technique. Moreover, this study evaluated the use of micropuncture for arterial access, not for central venous catheter (CVC) insertion or body cavity access. Despite the presence of sicker patients in the micropuncture group, the use of micropuncture did not increase event rates, suggesting that the micropuncture technique was very safe. A randomized controlled trial with routine fluoroscopy of the needle tip to abort high sticks needs to be performed for further clarification. A double-blinded randomized trial, the Femoral Micropuncture or Routine Introducer Study (FEMORIS), was designed to compare the rates of complications found when using either the micropuncture needle introducer or a standard 18-G needle to access the femoral artery. This trial intended to include patients aged > 18 years undergoing left heart catheterization for likely PCI. Exclusion criteria included patients undergoing diagnostic left heart cardiac catheterization without PCI, use of a primary vascular access site other than the femoral access, stand-alone right heart or combined left and right heart procedures, or planned access using the same groin within 14 days. The primary outcome was the incidence of access site complications within 7 to 14 days of the procedure. Unfortunately, according to a recent update, this study was terminated because the original design is no longer consistent with current clinical practice.[23] Details are not available on the ClinicalTrials.gov Web site.

Micropuncture Technique for Central Venous Access

Access to central venous circulation is an important component of inpatient care, and is vital to the management of critically ill patients. CVCs allow delivery of intravenous fluids and medications that cannot be safely given through peripheral lines or when peripheral access cannot be obtained. It is also used for measurement of hemodynamic variables, hemodialysis access, and placement of transvenous pacemakers, as well as for cardiac electrophysiology procedures in which multiple catheters are often used. The most common sites for placement of these CVCs include the internal jugular vein (IJV), subclavian vein (SCV), and femoral vein (FV). Arterial puncture, hematoma, and pneumothorax are some of the common mechanical complications associated with their placement.[24] Carotid artery puncture during IJV cannulation can lead to life-threatening hemorrhage, stroke, and airway compromise. With a large-bore catheter, the carotid artery is punctured in 1 to 7 cases per 1000 attempts at line placement in IJV.[25] The anatomical position of the IJV and carotid artery varies; they often do not sit side by side, the right IJV being anterior to the right common carotid anterior artery in 20% of cases and anterolateral in 71% of cases.[26] FV access may result in femoral arterial puncture, pseudoaneurysm formation, hematoma extending to retroperitoneal space, bowel and bladder penetration, and femoral nerve injury, especially in obese patients in whom the anatomic landmarks are difficult to palpate. SCV cannulation is associated with subclavian artery puncture, mediastinal hematoma, and an increased risk for hemothorax and pneumothorax as compared with IJV access.[24] The use of ultrasonography to obtain central venous access has been shown to decrease the incidence of complications[27]; however, adverse events have been reported.[25] There is a definite need to further improve outcomes, especially in patients

Carotid artery puncture during IJV cannulation can lead to life-threatening hemorrhage, stroke, and airway compromise.

who are coagulopathic or hypotensive, in whom the risk of bleeding is more or the risk of arterial puncture and other complications is higher. Micropuncture can be useful in cannulation of these veins to decrease procedural complications. Accidental puncture with the micropuncture needle in the carotid artery should not lead to any significant bleeding during jugular vein cannulation. It also helps limit injury to other vascular and nonvascular adjacent structures if they are accidentally punctured.

Micropuncture Technique for Drainage of Body Cavities

Micropuncture can be used to access body cavities, especially when a drainage catheter is indicated. Some complications involved with pericardiocentesis include ventricular puncture, cardiac laceration, arrhythmias, and damage to nearby organs, including the lung, liver, and spleen.[28] A potentially deadly complication of pericardiocentesis is myocardial wall puncture, which can lead to tamponade. This risk can be reduced using micropuncture, because an accidental puncture with such a small needle is less hazardous. The use of this technique can be helpful in limiting iatrogenic pneumothorax associated with thoracentesis,[29] and can be effective in the placement of peritoneal catheters for dialysis,[30] percutaneous placement of nephrostomy tubes, or drainage of abdominal fluid collections. It is hoped that a randomized trial will be conducted to evaluate the usefulness of the micropuncture technique in obtaining organ cavity access. Although the benefit of using micropuncture has not been proven, it can be said that using micropuncture has no drawbacks, and has the potential to prevent life-threatening complications.

Conclusions

In an era in which a large volume of percutaneous procedures are performed daily, it is critical to reduce the complications associated with these procedures. A meticulous approach at the time of vascular entry is essential to reduce complications. Proper identification of anatomic landmarks and use of imaging modalities should be used routinely. Routine use of the micropuncture technique has the potential to reduce adverse events with no disadvantages.[31] The micropuncture technique is simple and, although not evidence based, it is intuitive that less trauma correlates with fewer complications. Although using this technique may take a few extra minutes as compared with the standard technique, it is time and money

MAIN POINTS

- More than 1 million cardiac catheterizations are performed every year in the United States, and incur substantial risk of access site bleeding. Insertion of central venous catheters and performance of pericardiocentesis and pleurocentesis is common practice, and also carries a substantial risk of vascular or organ injury.
- Vascular complications associated with femoral artery access for cardiac catheterization include local hematoma, retroperitoneal hematoma, pseudoaneurysm, arteriovenous fistula, and occlusive thrombus. Using a small needle such as a micropuncture needle may reduce these adverse events.
- The most important application of the micropuncture technique is the ability to abort high puncture of the femoral artery to reduce the potentially deadly complications of retroperitoneal bleeding.
- Carotid artery puncture during internal jugular vein (IJV) cannulation can lead to life-threatening hemorrhage, stroke, and airway compromise. With a large-bore catheter, the carotid artery is punctured in 1 to 7 cases per 1000 attempts at line placement in IJV. Accidental puncture with the micropuncture needle in the carotid artery should not lead to any significant bleeding during jugular vein cannulation.
- A potentially deadly complication of pericardiocentesis is myocardial wall puncture, which can lead to tamponade. This risk can be reduced using micropuncture, because an accidental puncture with such a small needle is less hazardous. The use of this technique can be helpful in limiting iatrogenic pneumothorax associated with thoracentesis, and can be effective in the placement of peritoneal catheters for dialysis, percutaneous placement of nephrostomy tubes, or drainage of abdominal fluid collections.

well spent if even one major complication can be avoided. ■

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