Editorial

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10 best practice tips with radial arterial catheterization

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Abstract

Radial arterial catheters (RAC) are used extensively across critical care settings (Anesthesia, Intensive Care, Emergency Medicine) for continuous hemodynamic monitoring, allowing for immediate adjustments in vasopressor therapies and blood collection. Radial catheter failures are an ongoing significant issue for critical care clinicians with reported incidences at almost 25%. Common complications include loss of function, lack of blood return, poor quality waveforms and dislodgement, posing potential patient risks, and sudden loss of intra-arterial monitoring frequently requires prompt replacement. Contemporary research and technological improvements have highlighted several concepts to enhance the approach of RAC insertion and management while reducing immediate and late complications. The authors have prioritized the following 10 "best practice" aspects that may improve overall device function and reliability.

Keywords

intensive care unit, radial artery, peripheral arterial catheterization, ultrasonography, best practice, outcomes

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Radial arterial catheters (RAC) are used extensively in critical care settings for continuous hemodynamic monitoring, allowing for immediate adjustments in vasopressor therapies and blood collection. This stalwart device has been relied upon habitually during the current COVID-19 pandemic, emphasizing its dependency with critically ill patients on life-supportive therapies. There is a growing interest to utilize RAC's within prehospital settings[1,2] and outside critical care which increases clinicians' reliance for a dependable and functional device.[3]

However, radial arterial catheter failure poses a significant issue for critical care clinicians[4] with reported incidences at almost 25%.[5] Common complications include loss of function, lack of blood return, poor quality waveforms and dislodgement, constituting potential patient risks, and sudden loss of intra-arterial monitoring frequently requires prompt replacement.[6]

Contemporary research and technological improvements have highlighted several concepts to enhance the approach of RAC insertion and management while reducing immediate and late complications. The authors have prioritized the following 10 evidence-based strategies that may improve overall device function and reliability (Table 1).

Ultrasound

Ultrasound (US) guidance is known to improve first-pass success, reduce multiple puncture attempts, and decrease failure rates when compared to traditional palpation methods as demonstrated through several

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Table 1. 10 tips for preventing radial arterial catheter failure in critical care. Implementing these "best practices" may assist in providing standardized strategies to improve radial arterial catheter insertion, management, and outcomes, impacting both clinician and patient alike.

Ultrasound guidance	Strong clinical evidence demonstrates exceptional improvements in assessment and procedural aspects of vascular device insertion.
Allen's test (modified)	Assessment of the region and performing appropriate collateral circulation evaluation.
Skin assessment	Inspect wrist area for bleeding, hematoma, redness, swelling, or signs of localized infection.
Local anesthesia	Controlling localized pain for both alert and sedated patients during arterial cannulation.
Catheter-to-vessel ratio (CVR)	Measurement of vessel diameter with US and use of appropriate catheter size, maintaining a CVR of $<45\%$.
Angle of insertion	Measure the vessel depth with US, inserting catheter at 30°–45° or less. Avoid angles of insertion $>45°$.
Catheter length	Consider radial artery depth and angle of insertion, to ensure at least 65% of the catheter dwell length within the vessel.
Catheter material	Polyurethane (PU) and polyether block amide (PEBA) offer differing material characteristics, influencing device functionality.
Distance from wrist crease	Consider insertion at least 4–10 cm proximal from the wrist crease to reduce failure caused by flexion/range of movement (ROM) and provide improved stabilization and securement.
Securement and stabilization	Effective stabilization, securement, and dressing with a combination of sutureless securement device $\pm$ cyanoacrylate glue.

systematic reviews.[7,8] These benefits may also improve dwell times and functionality, infection risk reductions, and additional procedure-related complications.[7,8] Recommendations for USG arterial catheter placement from professional bodies clearly acknowledges the advantages offered in procedural workflow, a standardized approach for vessel assessment (vessel health, size/appropriateness), and an optimized location of best-avoided anatomical structures (e.g. radial nerve), including vessel abnormalities.[9–12]

Allen's test

In ICU, RACs may dwell for many days, potentially increasing the risk of vessel occlusion and hand ischemia. With its widespread use and clinical advantages to assess the collateral circulation, the predictive value of an Allen's Test is now increasingly being questioned, even with its fast and non-invasive attributes.[13] Despite the comparison with other available diagnostic tests (Barbeau test, palmar arch, and princeps pollicis artery ultrasound) reporting overall accuracy of 97.2%,[14] the Allen's Test suffers from a series of limitations: it is operator dependent, requires visual assessment and is frequently subjected to interobserver variation.[13,15]

With a negative predictive value ranging from 18% to 99%, a positive result for abnormal collateral circulation is not considered a good predictor of hand ischemia and could lead to excluding the radial artery in favor of other insertion sites associated with greater procedural risks (e.g. bleeding or infection after femoral artery cannulation).[13,15]

On the contrary, if a negative Allen's Test is returned, further clinical assessment with Doppler Ultrasound or plethysmography and pulse oximetry (Barbeau) tests should be performed.[15]

Skin assessment

The insertion of vascular devices creates a wound, vulnerable to irritation and infection.[16] Device-related skin complications are frequently described in the literature and skin-related infections have been reported to influence bloodstream infection rates.[17–22]

Radial artery catheters have increased risk of complications, with some published Hazard Ratios high as 18, as reported by Buetti et al.[22] and Ullman et al.[23] The authors hypothesize that augmented rates of infectious complications may relate to limb mobility (particularly the range of motion at the wrist joint/crease) and traction on the arterial catheter and tubing together, suggesting the need for increased attention by healthcare providers to appropriate stabilization and dressing, along with daily inspection of the insertion site.[22,23]

Local anesthesia

Needle insertion triggers type A nerve fibers which cause the initial sharp intense pain. Pain during needle insertion is influenced by the needle design, gauge, depth of insertion, use of topical anesthesia, and the nature of the tissue into which the drug is deposited.[24] Patients who experienced arterial punctures, and particularly arterial vessel cannulation, report higher pain scores when compared to venous procedures. Local anesthesia is recommended as a best practice intervention and may improve success rate at first attempt, increasing satisfaction for both patients and

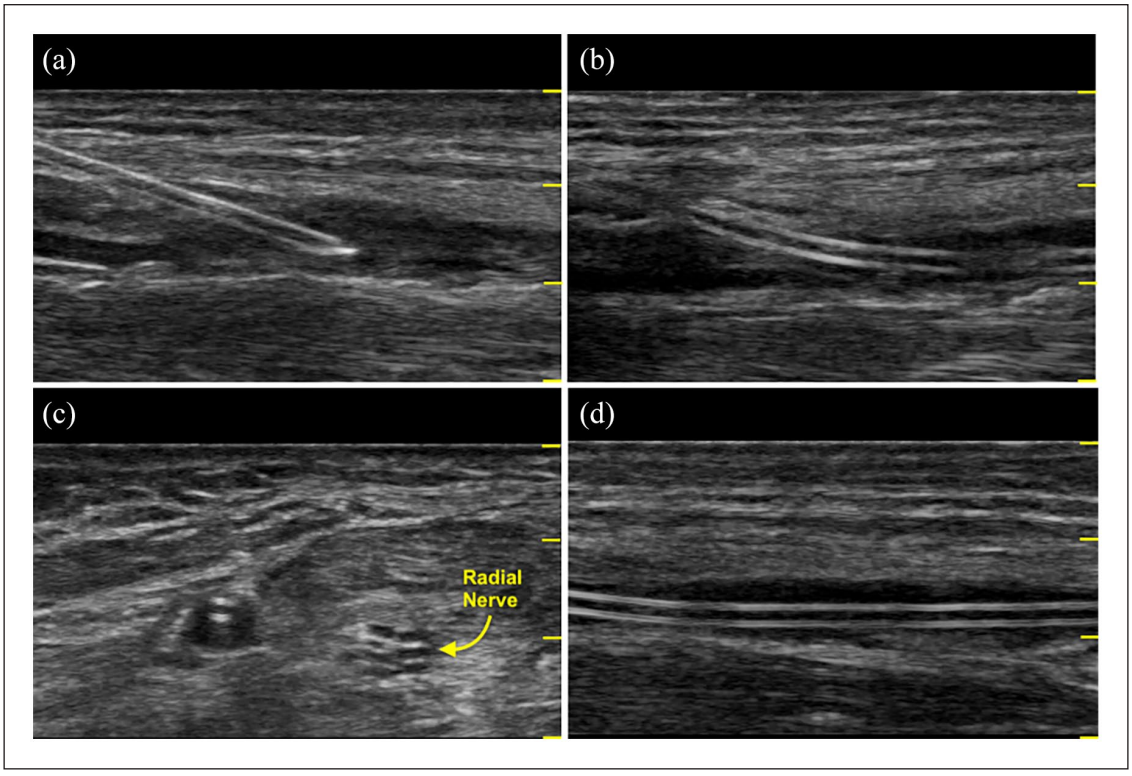

Figure 1. Ultrasound views demonstrating (a) 30°–45° needle angle for insertion, (b) RAC dwell angle, (c) CVR with transverse view, and (d) CVR with longitudinal view and RAC dwell length.
CVR: catheter to vessel ratio; RAC: radial arterial catheter.

healthcare providers. Local anesthetic infiltration (lidocaine or mepivacaine), refrigerant sprays and vapo-coolants, and topically applied agents (gels, creams, or patches) are safe and effective choices.[25–28]

Catheter-to-vessel ratio (CVR)

The disruption to blood flow dynamics and associated risks of thrombotic-related complications and occlusion are becoming more relevant in critical care settings. Radial arterial occlusion may occur in <10% of all procedures,[29] and with some patients having incomplete palmar arches, this risk diminishes collateral perfusion and potentially leads to ischemia in the presence of vessel occlusion. However there has been insufficient recent evidence looking at the incidence or clinical relevance of occlusion due to the large sample population required to demonstrate significance.[13] Ultrasound measurement of vessel diameter provides accuracy in determining the appropriate CVR, which may improve blood flow around intravascular devices, including arterial catheters. Although earlier research discusses venous implications, acknowledging relevant parallel characteristics for arterial devices should be considered. Maintaining an appropriate CVR (<45%) reduces the catheters' impact on blood flow, therefore potentially lowering the risk for thrombo-embolic-related complications.[30,31] However still there requires further investigation into use and benefits in arterial practices.

Angle of insertion

Lower angles of insertion (<30°–45°) reduces the risk of catheter body kinking and the associated device failure. The choice of in- or out-of-plane US techniques will change the angle of insertion (and catheter dwell length) (See Figures 1 and 2). Recent publications have demonstrated that trigonometry offers benefits during USG vascular access procedures, in the context of appropriate insertion angle and optimizing overall catheter dwell length.[32,33]

Catheter length

An appropriate catheter length, allowing for longer subcutaneous tracts, provides increased device stability and improved waveforms, may enhance catheter dwell times, and reduce failure, thrombosis, and arterial inflammation risks.[32,34] In order to reduce failure after RAC placement, it is recommended that more than 65% of the catheter should dwell within the vessel.[32]

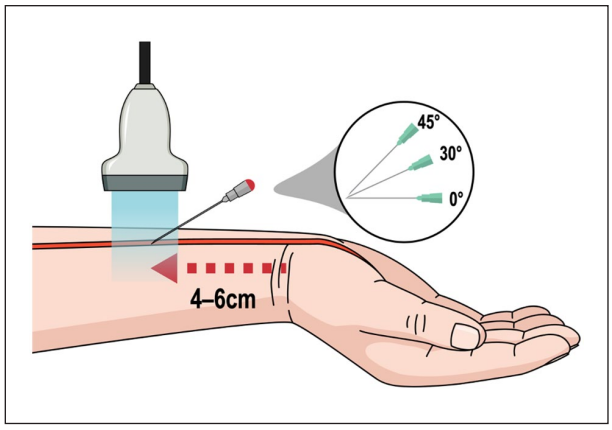

Figure 2. Ultrasound guidance, angle of needle insertion and distance from wrist crease to optimize radial catheter insertion.

Catheter material

The choice of material can impact arterial catheter's function and potential for failure. Polyurethane (PUR) catheters may kink and become dysfunctional due to the softer nature of the material, as opposed to the improved kink-resistance offered by Polyether Block Amide (PEBA)-made devices.[35,36] Device failure from kinking is frequently seen when standard peripheral venous catheters are used for arterial cannulation. Although these devices share common insertion procedural characteristics, they lack design characteristics that provide safe identification and performance with the different roles and should be considered independently.

Distance from wrist crease

Range of movement (ROM) areas and difficulties of effective fixation/stabilization is associated with device failure; increasingly relevant with agitated patients and using wrist restraints. Moving the insertion site proximally, 4–10 cm from the wrist crease, provides more stability for overall securement and may reduce mechanical failures related to ROM, improving RAC outcomes in ICU patients (See Figure 2).[37]

The Arterial Insertion Method (AIM) provides a systematic approach in RAC insertion with US guidance, strengthening various procedural aspects, impacting catheter performance, reducing mechanical failures, and enhances dressing adherence and securement which may improve dwell time, device functionality and reduce variations in practice.[6,38]

Stabilization and securement

Securing RACs with sutures is frequently associated with bleeding and ongoing need for repeated dressing changes, increased risk of infection, loss of access and needlestick injuries, and should be avoided whenever possible.[39,40] Cyanoacrylate tissue adhesives, widely used for skin wounds closure, provides effective securement for RAC and, in addition, an antimicrobial and hemostatic effect at the insertion site.[5,41] The combination of an engineered adhesive securement device (EASD), or sutureless, and transparent polyurethane dressing significantly prevents accidental catheter removal and dislodgement.

Author's note

The authors are members of the WoCoVA, AVA, AVAS.

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