

Ultrasound-guided central venous access

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Abstract

Central venous catheterization is a critical component of management for the critically ill patient in the operating room and intensive care unit. When using ultrasound techniques for central venous access, access is achieved with fewer attempts, a reduced incidence of carotid artery punctures or 'hits', an increased success rate, and a decreased duration of procedure compared to the traditional landmark approach.

Introduction and context

Central venous catheterization is a critical component of management for the critically ill patient in the operating room and intensive care unit [1]. Traditionally, the right internal jugular vein (RIJV) has been chosen as the first-choice site of access. By use of certain landmarks (carotid artery, sterno-cleidomastoid muscle, and so on) vascular access is achieved. However, significant complications are associated with the technique [2]. This review will use catheterization of the RIJV as the model for ultrasound (US) guidance. With widespread use of US techniques, it is reported that successful RIJV catheterization is achieved with fewer attempts, a reduced incidence of carotid artery (CA) punctures or 'hits', an increased success rate and a decreased duration of procedure [3-6]. Before continuing it is important to emphasize that knowledge of both methods is required in clinical practice.

Percutaneous central venous catheterization achieved popularity due to three major historic events. First, the publication by Seldinger of a catheterization technique that progressively increased vascular catheter size by utilizing wire guides [7]. Second, with increased number of cardiac surgical procedures (coronary artery bypass graft), a need came about for rapid access to the central venous circulation for both monitoring hemodynamic function as well as delivering fluids and medications to the central circulation. Finally, the invention and

development of the pulmonary artery catheter by Swan, Ganz, and colleagues gave clinicians extensive hemodynamic information at the 'bedside' [8]. Prior to the introduction of this catheter, the quantity and quality of hemodynamic information could only be achieved in a cardiac catheterization laboratory. The choice of RIJV access is based upon relative anatomic constancy, ease of access, large caliber, absence of venous valves, and direct route to the right atrium. In addition, the site is 'removed' from the surgical field. A key consideration for successful venous catheterization via the RIJV route is the anatomic relationship between the RIJV and the CA. As the patient's head is rotated from neutral (0°) to 90°, most authorities report a greater degree of overlap of the CA by the RIJV. This potentially can increase the number of CA hits [9-11]. Most experts therefore recommend the patient's head (facing left) to be in a lateral position of 30-45° to puncture the RIJV. However, using different imaging modalities, others could not duplicate this anatomic relationship [12].

Recent advances

With the advent of clinical US techniques in the 1980s, it became evident that safer, more accurate, and more rapid access could be achieved [13]. Regulatory authorities have strongly recommended its use for central vascular access procedures. These guidelines in the United States and Great Britain fall just short of recommending mandatory use of US [14,15]. Roysse [16] considers the

clinical use of US as a spectrum from US-guided vascular catheterization and neural blockade to echocardiography. He suggests educational opportunities in this area should emphasize similar clinical challenges rather than differences in these approaches.

The critical research study in this area was published by Karakitsos *et al.* [3], who conducted a randomized prospective study comparing landmark-based techniques to US techniques for RIJV access. In an investigation with 450 patients in each group, they reported significant differences (US versus landmark) for access time (17 versus 44 seconds), success rate (100% versus 94%), CA puncture (1% versus 10%) and number of attempts (1 versus 3). The latter is important, since it is hypothesized that the number of attempts is related to complication rates and infection. Wigmore *et al.* [17] compared landmark-based and US techniques after the introduction of the National Health Service Vascular Access Guidelines. They also report (US versus landmark) a higher failure rate (0.6% versus 6%), more attempts (1.2 versus 1.3) and a higher complication rate (2% versus 9%). One often-ignored benefit of US examination of the neck vessels is that it confirms the patency of the RIJV; it is indeed not uncommon to uncover an asymptomatic thrombosis in patients in whom a RIJV catheter has been used previously.

Education and training are key to the successful application of US-guided techniques; these involve knowing the basic principles of US, knowing classic and ultrasonographic anatomy, and training on phantoms to acquire the technical skills and eye-hand coordination. In clinical practice, US-guided RIJV access means visualizing the US anatomy, confirming RIJV presence and patency by compressing the vessel, and finally, confirming appropriate placement of needle and/or wire guide [18]. However, one of the limits and causes of failure or complications with using US is that, at present, it is difficult to visualize the tip of the venipuncture needle. This is due, in part, to the needle design and the physics of the US system. [19,20].

Implications for clinical practice

The most feared complication of RIJV access is placing an introducer or catheter into the CA. In the American Society of Anesthesiologists' Closed Claims Study, CA puncture was associated with the second largest 'payout'; cardiac tamponade was first [21]. There are two schools of thought in managing this problem. The first is 'watchful waiting' to determine if signs of vascular injury are observed, for example, increasing size of a hematoma, compromise of the airway by a hematoma, and neurological and/or vascular compromise. The second is

immediate surgical or interventional radiological treatment of the vascular injury. The current literature suggests earlier surgical or interventional radiological treatment is preferable, depending on the nature of the injury and other co-morbidities [22-24].

Although this review focuses on RIJV catheterization, US is used for arterial cannulation as well as catheterization of other venous sites. This includes peripheral venous access in patients with diminished anatomic signs of peripheral venous structures, percutaneous insertion of peripherally-inserted central catheters, and catheterization of the femoral vein. Even subclavian vein catheterization can now be achieved under US guidance by experts (supra- or subclavicular approach).

In closing, it is important to re-emphasize that one technique (landmark versus US) is not superior for all patients; knowledge of both methods is required in clinical practice. As more studies are published in this area, the advantage of US will be more easily discerned, and US-guided vascular access will be employed with greater frequency.

Abbreviations

CA, carotid artery; RIJV, right internal jugular vein; US, ultrasound.

Competing interests

The author declares that he has no competing interests.

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