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A modified technique of percutaneous subclavian venous catheterization in the oedematous burned patient

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Abstract

Infraclavicular subclavian venepuncture in the oedematous burned patient is often difficult because of increased depth of the vein. In addition, proper patient positioning is not easily achieved because of extensive burns, generalised oedema and bulky dressings. To overcome these difficulties, a modified technique of infraclavicular subclavian venepuncture has been developed. The introducer needle is bent to create a mild curvature. It is inserted at a point 1–2 cm inferior to the palpable lower border of the clavicle along the junction of the middle and medial thirds of the bone, advanced along the deep surface of the clavicle and directed at the superior border of the suprasternal notch. This medial point of insertion shortens the distance of access to the subclavian vein. The curve allows the tip to be kept close to the undersurface of the clavicle as the needle is advanced, thereby reducing the risk of injury to deep structures. The advantages of the modified technique are demonstrated in anatomical dissections. This technique is a viable alternative when conventional techniques fail.

Keywords: Infraclavicular subclavian vein; Venepuncture; Catheterization; Oedema; Anatomical dissections

1. Introduction

Central venous catheterization is a common procedure for venous access, central venous pressure monitoring, intravenous therapy and parenteral hyperalimentation in burns critical care. The infraclavicular route is widely used because of the ease with which the subclavian vein is located. The vein remains patent even in profound shock [1] and catheter fixation is more comfortable over the upper chest than at other sites in the neck. However, since the procedure is blind, serious complications have been reported and these include accidental injury of the subclavian artery, pleura or brachial plexus [2–6].

The clavicle is a well-established landmark for the subclavian vein. Thus, understanding the relationship between the clavicle and the subclavian vein is critical to successful execution of technique. We have demonstrated that with the shoulders in neutral position, i.e. neither abducted nor shrugged, the subclavian vein lies under the medial one-third or more of the clavicle and this segment of bone is the landmark for the vein [7]. When the shoulder is elevated, the acromial end of the clavicle moves cephalad, reducing overlap. The vein in this situation assumes a more inferior and medial relationship (Fig. 1). Shoulder retraction increases the area of contact between the vein and the undersurface of the clavicle whereas protraction lifts the clavicle off the vein. Thus, infraclavicular subclavian venepuncture should be performed with shoulders in the neutral position and in slight retraction [7].

However, correct shoulder positioning may be unattainable in the presence of oedema and bulky dressings around the chest, axilla and upper limbs. In such situations, the shoulders naturally assume a shrugged and protracted posture. This becomes unfavourable because the clavicle has moved out of position and ceases to be a reliable landmark for subclavian venous access (Fig. 1) [7]. In addition, tissue oedema increases the depth of the subclavian vein, further contributing to the difficulty of access.

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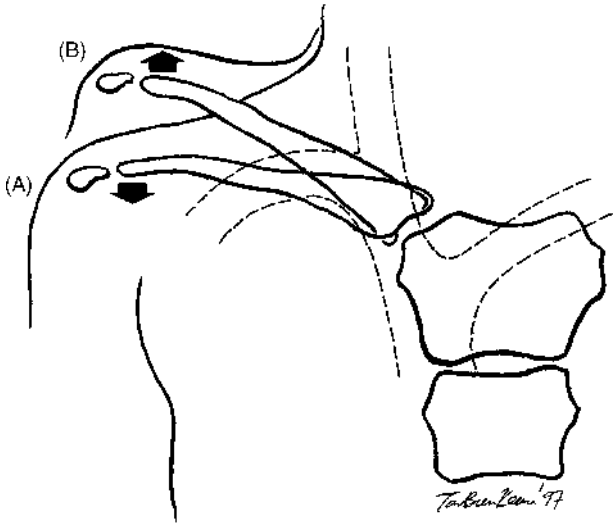

Fig. 1. (A) When the shoulders are in neutral position (i.e. not abducted or shrugged), the subclavian vein is overlapped by the medial one-third or more of the clavicle. This segment of bone serves as a landmark for the vein. (B) Shoulder elevation displaces the clavicle cephalad and reduces the segment of overlap (reproduced with permission from Lippincott Williams and Wilkins [7]).

The following description illustrates how the technique of percutaneous subclavian venous catheterization can be adapted to the altered anatomy in the oedematous burn patient. It is a simple modification of the conventional technique, and its anatomical basis is demonstrated by cadaveric dissections.

2. Materials and methods

A standard 6.35 cm introducer needle for central venous catheterization was used to simulate the technique of percutaneous subclavian venepuncture in a large-build, obese, 90 kg male cadaver. There was generalised oedema due to congestive heart failure, which was the cause of death. Following percutaneous venepuncture, dissection of the infraclavicular region was performed to demonstrate the path of the introducer needle. This was achieved in the following manner: a skin incision was made along the length of the clavicle from the sternoclavicular to the acromioclavicular joint. The subclavian vein was exposed by detaching the clavicular origins of the pectoralis major and subclavius muscles. Superiorly, a skin-platysmal flap was raised cephalad to expose the root of the neck. The internal jugular vein was uncovered by dividing the sternal and clavicular heads of the sternocleidomastoid muscle. This vessel was then traced to its junction with the subclavian vein from which the brachiocephalic vein arose, behind the sternoclavicular joint.

The technique of subclavian venepuncture was modified in the following manner: The cadaver was placed supine and in a 15–20° Trendelenburg position. The shoulders were

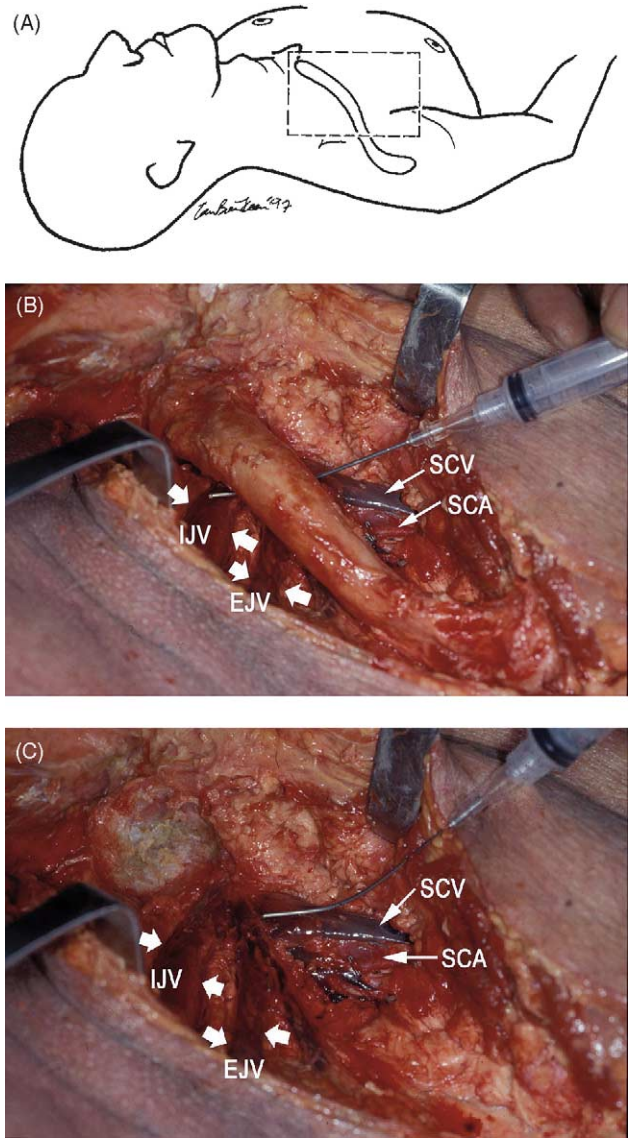

Fig. 2. The infraclavicular area in an obese, oedematous cadaver (right side, superior view). (A) Illustration of the area dissected. (B) Using a medial approach, a curved 18 gauge introducer needle is easily inserted under the clavicle. (C) Same specimen, clavicle removed. The curvature of the introducer needle has brought the terminal portion of the needle in line with the plane of the vein for safe cannulation. SCV: subclavian vein; SCA: subclavian artery; IJV: internal jugular vein; EJV: external jugular vein.

maintained in as neutral a position as possible with the arms by the side of the trunk. In addition, a small sandbag or pillow was placed beneath the vertebral column between the scapulae. The introducer needle was bent using digital pressure to create a gentle curve 3 cm from the tip (Fig. 2A–C). The degree of curvature was judged according to the thickness of the chest wall and severity of the oedema, i.e. the deeper vein, the greater the curve. Care was taken to ensure that the needle was not inadvertently kinked in the process, as this would obstruct the subsequent passage of the guide wire.

The purpose of creating a curve in the needle was to ensure that the tip remained close to the bone throughout its passage under the clavicle (Fig. 2B). The surface marking of

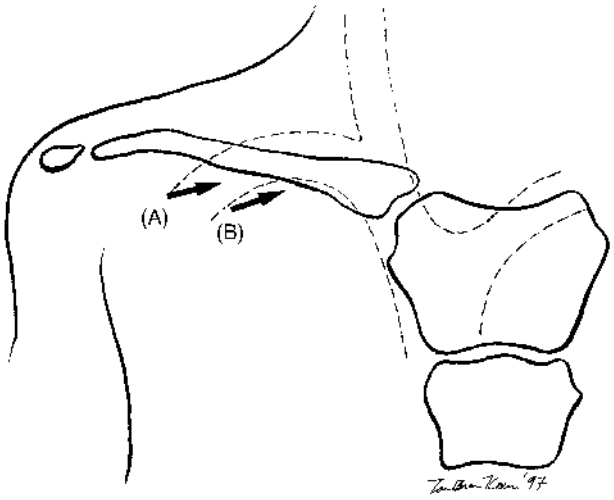

Fig. 3. Surface marking of infraclavicular approaches to the subclavian vein. (A) Conventional—the point of needle insertion is 2 cm inferior to the lower border of the clavicle at the mid-clavicular line. (B) Modified approach—the point of needle insertion is 1–2 cm inferior to the lower border of the clavicle along the junction between the medial and middle thirds of the bone.

the entry point of the needle was 1–2 cm inferior to the lower border of the clavicle at the junction between its middle and medial thirds, where the bone–vein relationship is more constant (Fig. 3). During insertion, the needle tip was directed at the upper border of the suprasternal notch. Beneath the skin, the needle was advanced till contact was made with the anterior surface of the clavicle. We then ''walked'' the tip down the bone's surface until contact was made with the deep aspect before further advancement. Along the undersurface of the clavicle, constant tactile contact with the bone was maintained while the needle was being advanced. Failure to do so may result in accidental puncture of deeper structures. Constant negative pressure was applied on the syringe until a flashback of blood was seen, indicating successful cannulation of the vein.

This modified technique was successfully applied in 30 subclavian venepunctures for patients with gross oedema as a result of extensive burns. In all cases, the modified technique was employed only when conventional techniques were unsuccessful, or when other means of access (such as the internal jugular vein) were unavailable. There were no complications.

3. Discussion

The modified technique was developed to overcome the limitations of the usual conventional technique.

3.1. Conventional technique

3.1.1. Patient positioning

The shoulders should be in the neutral position [7–10] and in slight retraction [11]. This ensures maximal overlap between the medial third of the clavicle and the subclavian vein (Fig. 1). Shoulder retraction also prevents interference with the path of the needle insertion by the humeral head and brings the vein into close contact with the undersurface of the clavicle [7]. In addition, the patient should be in a 15–20° Trendelenburg position as this distends the central veins and minimises the risk of air embolism.

3.1.2. Technique of needle insertion

A commonly employed approach [3,12–15] is to enter the skin 1–2 cm inferior to the lower border of the clavicle along the midclavicular line (Fig. 3). The bevel of the needle should be directed caudally as this ensures that the subsequent passage of the guide wire is caudal-ward and not cranial-ward. As the needle tip is directed at the upper border of the suprasternal notch and advanced along the undersurface of the clavicle, cannulation of the vein should occur at the junction between the middle and medial thirds of the clavicle.

3.2. Modified technique

The oedematous burn patient presents specific problems that cannot be overcome with the conventional technique. First, the chest, shoulders, axilla and upper limbs being tightly encased by oedematous tissue, with or without burns, create a situation in which neutral positioning of the shoulders is impossible. Bulky dressings and soft bedding (e.g. low air-loss bed) further contribute to malpositioning and the body tends to be in a flexed habitus. The natural posture is one in which the shoulders are ''shrugged'' and protracted, which makes it unfavourable for the infra-clavicular approach because the clavicle has moved out of position and ceases to be a reliable landmark (Fig. 1) [7]. Second, since it is possible that chest wall oedema increases the thickness of subcutaneous tissue by as much as 2–3 cm, the introducer needle becomes too short for a safe, level approach to the vein (Fig. 4). If the point of needle insertion is shifted medially, the angle is too steep (Fig. 5) and risks

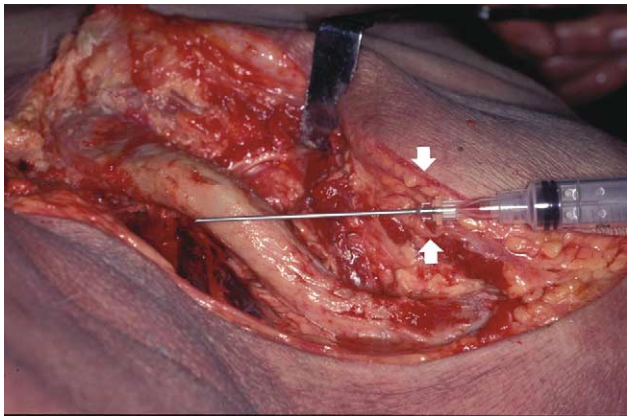

Fig. 4. Infraclavicular area of same cadaver (right side, superior view). Because of tissue oedema and thickness of subcutaneous tissue (indicated by broad arrows), a standard introducer needle is too short for a safe, level approach to the subclavian vein.

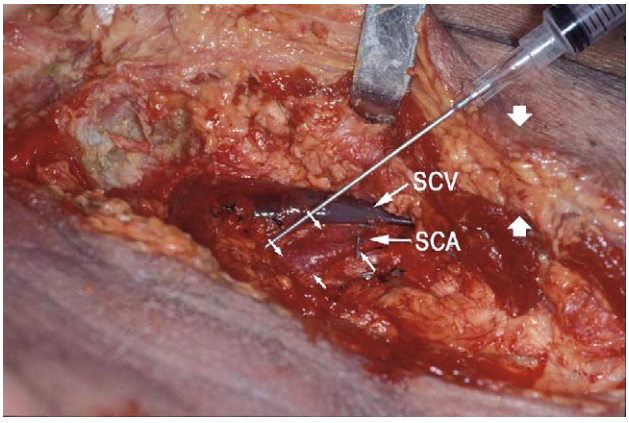

Fig. 5. Infraclavicular area of same cadaver with clavicle removed (right side, superior view). When the point of needle insertion is shifted medially, the approach of a straight introducer needle is too steep. There is a risk of piercing the subclavian vein through-and-through, as well as injuring the subclavian artery or pleura, which lie deep to the vein. SCV: subclavian vein; SCA: subclavian artery; broad arrows indicate the thickness of subcutaneous tissue due to oedema and obesity.

penetrating the subclavian artery or the pleura deep to the vein.

The modified technique is designed to overcome these problems and two key differences from the conventional stand out, (1) adopting a medial approach which shortens the distance of access to the vein and (2) pre-bending the introducer needle, which allows it to be advanced more accurately toward its target.

The entry point on the skin is 1–2 cm inferior to the lower border of the clavicle along the junction between the middle and medial thirds of the bone [16]. The main advantage of the medial approach is the constant relationship between the vein and the medial segment of the clavicle. Because the site of the costoclavicular ligaments is the fulcrum of clavicular movements [17], bone–vein relationships remain fairly constant at this point, independent of shoulder position. Furthermore, the broad target formed by portions of the three great veins—subclavian, internal jugular, and innominate, increases the likelihood of success.

Due to the thickness of the clavicular head, the medial approach mandates a steeper angle of insertion. In this situation, a curved introducer needle is better able to negotiate the infraclavicular path to locate the vein. At the same time, the upward angulation of the needle brings the tip level with the subclavian vein (Fig. 2). This increases the likelihood of successful cannulation.

Some practical aspects of cannula modification deserve mention. To avoid inadvertent needle stick injury to the operator, the introducer needle should be ensheathed in flexible transparent tubing during bending. Fresh needles are used to avoid biological contamination in the event of accidental injury. Also, the introducer needle should be bent mid-shaft, creating as uniform a curve as possible. Bending it back-and-forth should be avoided to prevent metal fatigue and fracture. Kinking is avoided.

Finally, a word of caution: one should not lose bearing of the direction of curvature after needle entry into skin. Its direction should always be maintained and marked by an indicator on the needle sleeve to prevent rotation, since any minor deviation is exaggerated by the curve and this makes it hazardous. If the vein cannot be located, a new attempt should be made only after fully withdrawing the needle.

This technique is also suitable for the obese or large-build patient, in whom the thickness of subcutaneous tissue precludes a level needle approach to the vein.

In the burned patient, the choice among various methods of central venous access is determined by the physician's familiarity with a given technique, the presence of intact skin at potential sites of line insertion and the need for frequent re-siting of catheters to reduce the risk of catheter-related sepsis. In an oedematous patient, the internal jugular vein is in fact a better choice, as it is more superficial. Nevertheless, it behoves the burns physician to be familiar with all approaches so that options are maximised in what are often difficult situations.

Acknowledgements

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