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Efficacy and safety of ultrasound-guided cannulation via the right brachiocephalic vein in adult patients

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Abstract

Central venous catheter (CVC) insertion is difficult to perform and is a high-risk operation; ultrasound (US)-guided cannulation helps increase the odds of success while reducing the associated complications. The internal jugular vein (IJV) and subclavian vein (SCV) are the most commonly sites in US-guided CVC insertion. In the present study, we evaluated the safety and efficacy of US-guided supraclavicular right brachiocephalic vein (BCV) cannulations in adult patients.

Between January 2016 and December 2017, 428 adult patients requiring 536 CVC insertions underwent ultrasound-guided right BCV cannulation. The success rate and complications related to indwelling catheters were analyzed.

The technical success rate was 98.32% (527/536). The procedure was successful at the first try in 511 cases (95.34%). The mean operation time was 13.26 ± 3.34 minutes. The mean length of catheter introduction was 13.57 ± 3.53 cm. Incidence of intraoperative complications was 2.61%. For 3 patients, the procedure was terminated due to pneumothorax (PNX), and in 11 arterial punctures there were self-limiting hematomas. The incidence of postprocedure complications was 5.97% (32/536). These complications included catheter-related infections (n = 18) and thromboses (n = 14). Insertion lasted an average of 10.68 ± 8.77 days.

Supraclavicular, in-plane, US-guided cannulation of the right BCV is an effective and safe method for inserting central venous catheters in adult patients. It provides another option for catheter access to boost clinical performance in central venous catheterization.

Abbreviations: BCV = brachiocephalic vein, CVC = central venous catheter, IJV = internal jugular vein, IP = in-plane, PNX = pneumothorax, SCV = subclavian vein, US = ultrasound.

Keywords: brachiocephalic vein, central venous cannulation, internal jugular vein, subclavian vein, ultrasound-guidance

1. Introduction

Central venous catheters (CVCs) serve critical functions in the hospital. They are primarily used when there is no peripheral access, to administer medications requiring large vessels, to provide parenteral nutrition, and to provide access for hemodialysis.[1–3] CVC placement is a challenging and high-risk procedure in patients, even for experienced practitioners. To date, ultrasound (US) is the method of choice for locating vessels and guiding venous punctures in adult and pediatric patients because it increases the odds of success while reducing the number of surgical attempts as well as the associated complications.[4,5] The internal jugular vein (IJV) and subclavian vein (SCV) are the most commonly used sites for US-guided CVC insertion in adult patients. Recently, brachiocephalic vein (BCV) cannulation from the supraclavicular area was proposed, with potential advantages in neonates and infants.[6–9] Nevertheless, the latter technique has been reported only rarely in adult patients.[10] The primary objective of this retrospective analysis was to evaluate the clinical effectiveness and safety of US-guided supraclavicular BCV cannulation in adult patients.

2. Materials and methods

This was a retrospective study approved by the ethics committee of our hospital. Clinical data were acquired from medical records (primarily operative reports and nursing records). A total of 428 adult inpatients (surgical and medical) requiring 536 US-guided right BCV CVC placements performed between January 2016 and December 2017 were retrospectively analyzed (Table 1). Ventilated patients and patients undergoing emergent or urgent procedures were excluded from the study. We recorded success at the first attempt, puncture times, operation time, and complications on the medical records. Operation time was defined as the time between sterilization and x-ray.

The BCV CVC placement was performed as follows: probes were inserted into sterile covers, with a sterile gel between the

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Table 1

Patient baseline characteristics (N = 428).

	Mean ± SD
Age, years	56.27 ± 18.34
Male/Female	225/203
Height, cm	165.8 ± 10.58
Weight, kg	56.27 ± 18.34
Infectious disease N (%)	28 (6.54)
Heart disease N (%)	24 (5.61)
Lung disease N (%)	38 (8.88)
Kidney disease N (%)	22 (5.14)
Neurological disease N (%)	30 (7.01)
Cancer N (%)	286 (66.82)

cover and probe. Ultrasound probes were moved downward along the IJV to the superior sternoclavicular joint. Then, the probes were rotated to achieve a good longitudinal view of the BCV starting at the IJV and SCV intersection. With the probe held in one hand, a needle was placed with the other hand and used to pierce the skin in the vicinity of the US probe. By the in-plane (IP) approach, the needle was advanced following the long axis of the US probe until appearance on the monitor. Negative pressure was employed for guiding the needle tip into the BCV (Fig. 1). In case of good spontaneous return of blood flow through the needle, withdrawal of the US probe was performed; next, a J-shaped guide wire (Arrow) was introduced into the vein. Upon successful guidewire advancement, correct positioning was verified ultrasonically. A 6 Fr double-lumen catheter was passed through the guidewire into the vein. Catheter insertion lengths were calculated using anatomical marks, ranging between 9 and 15 cm. Catheter position was confirmed by x-ray.

One attempt was defined as a new skin puncture. If 3 attempts to cannulate the BCV failed, the ipsilateral IJV or SCV were punctured.

Statistical analysis was performed using Microsoft Excel, including average, mean, and standard deviation.

Table 2

Details of BCV cannulation (N = 536).

Success rate (%)	98.32
Success rate of first attempt (%)	95.34
Operation time (Mean ± SD)	13.26 ± 3.34 minutes
Length of catheter introduction (mean ± SD)	13.57 ± 3.53 cm
Average insertion duration (Mean ± SD)	10.68 ± 8.77 (3–28) days

3. Results

A total of 428 adult inpatients required 536 US-guided right BCV CVC placements between January 2016 and December 2017. The primary reasons for undergoing the procedure included lack of peripheral access, administration of chemotherapeutics, hemodynamic monitoring, and sepsis. The male-to-female ratio was 1.11 (225 vs 203), and patient weights ranged from 46 to 87 kg. The average height was 165.8 ± 10.58 cm (range, 148–183 cm), and mean age was 56.27 ± 18.34 years (range, 28–82 years). Cannulation was successful in 527 (98.32%) cases (Table 2). In 511 cases (95.34%), right BCV puncture was successful on the first try; in 16 cases (2.99%) success was obtained after 2 attempts. The mean operation time was 13.26 ± 3.34 minutes (range, 9–16 minutes). The mean length of catheter insertion was 13.57 ± 3.53 cm (range 9–15 cm). Eleven arterial punctures (2.05%) caused self-limiting hematomas. Five complete cannulation procedures were then repeated successfully. X-ray revealed PNX in 3 cases (0.56%), with no requirement for chest drainage. After implantation, mean insertion time was 10.68 ± 8.77 (3–28) days. The incidence of postprocedure complications was 5.97% (32/536), and complications included catheter-related infections (n = 18) and thromboses (n = 14), all of which led to removal (Table 3).

4. Discussion

The BCV is found at the IJV and SCV intersection, and both BCVs merge into the superior vena cava. BCV cannulations

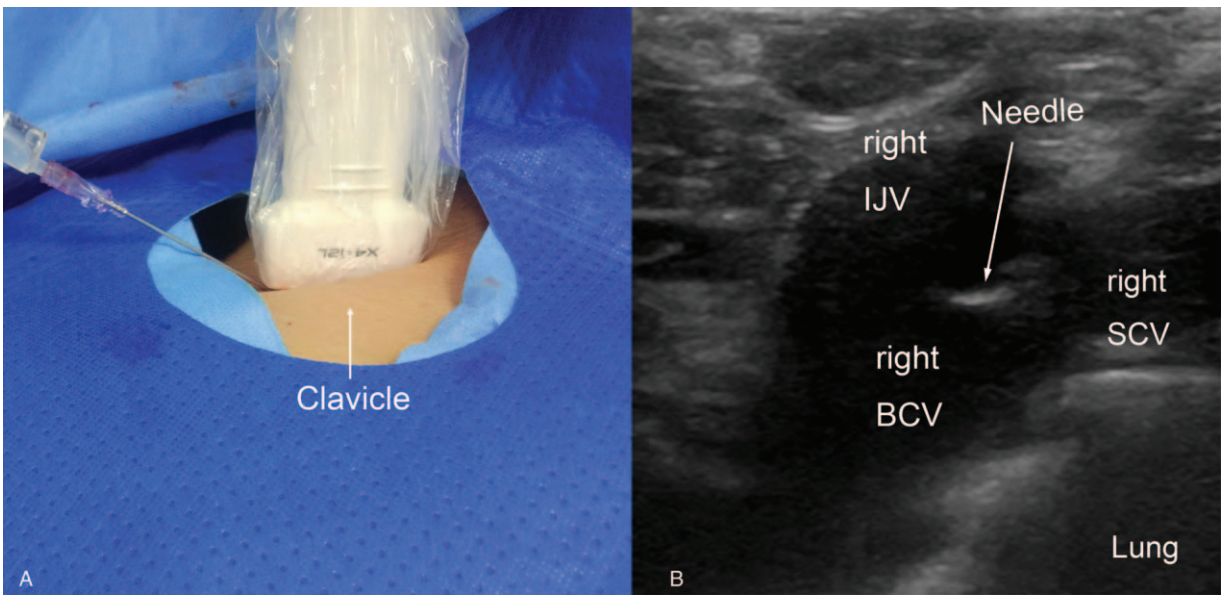

Figure 1. (A) US probe and needle direction. (B) US view of the needle (arrow) within the right BCV.

Table 3

Complications observed (N = 536).

Complications	N (%)	Intervention
Artery puncture	11 (2.05)	None, self-limiting
Pneumothorax	3 (0.56)	None, self-limiting
Catheter-related infection	18 (3.36)	Catheter accidental remove
Thrombosis	14 (2.61)	Catheter accidental remove

might have been unpopular due to initial findings of pneumothorax in 1969.[11] Thus, BCV cannulation has been referred to as "an overlooked approach" or "the forgotten central line".[12,13] With US routinely employed clinically, the brachiocephalic approach has attracted increasing attention because the BCV position does not involve interfering bone; therefore, the entire needle trajectory can be visualized during cannulation. In recent years, studies have described US-guided cannulation of the BCV in children and infants. Nevertheless, this method has been rarely reported in adult patients.

Cannulation is substantially more successful in left versus right BCV in pediatric patients.[14] However, in adults, the left BCV is deeper and has a larger variation than that of the right-sided vessel. It is therefore poorly revealed by ultrasound. Furthermore, ultrasound is unable to identify thoracic catheters when merged via the left BCV junction. The right BCV approach was developed to avoid lymphorrhagia associated with thoracic catheter damage. Patients with surgical contraindications, including right jugular venous thrombosis are given priority for the left lower jugular vein approach in CVC implantation. This study of supraclavicular, ultrasound-guided, in-plane BCV cannulation in adult patients demonstrated high clinical effectiveness. In the present study, the success rate was 98.32%, requiring only one attempt in 95.34% of cases. Furthermore, no severe complications were observed. By comparison to Jordan et al,[15] our overall success rate was slightly lower; however, their study had a small cohort of 25 patients.

The major CVC complications include puncture of the artery, hematomas and PNX. The puncture approach contributes to complications, and PNX rates are elevated with subclavian approaches, while puncture of the artery occurs more commonly when femoral and jugular veins are involved.[1] In the present study, the rate of brachiocephalic artery puncture was 0.93% (5/536) with the US-guided technique. PNX incidence was 0.56% (3/536), similar to the PNX rate published for IJV cannulation.[16] The subclavian approach results in elevated PNX incidence, because the pleural space and the puncture site are anatomically close.[17] The US-guided right BCV approach has the major advantage of real-time detection of needle advancement within the vein; furthermore, the direction of the puncture needle is parallel to the pleura, thereby minimizing the risk of pleural or arterial puncture.

Other advantages of the present technique include needle visualization in the whole path (skin to vein), patient comfort with the catheter secured over the shoulders and easy dressing maintenance. IJV cannulation is often rather uncomfortable despite the large size of this vessel. Moving the neck could disrupt the dressing integrity, resulting in an insertion site that is vulnerable to infection. BCV cannulation affords lower odds of infection than those of internal jugular, subclavian, and femoral central lines.[15] Reported data show a catheter-related infection rate of 11% in IJV and SCV cannulation procedures.[4] Our results show that the catheter-related infection rate was 3.36%, lower than their reports.

There is no doubt that good training is required to adopt this method. The surgical operator factor may influence the result. In this study, surgeons were systematically trained, completing more than 1000 cases of CVC. A thorough understanding of the anatomy is absolutely essential as well as familiarity with the in-plane technique that also requires good hand-to-eye coordination. Previous findings suggest the US-guided method markedly reduces the operation time.[18] Our average operation time was 13.26 minutes.

This work had some limitations. First, its retrospective nature may prevent the assessment of some important outcomes and parameters. Furthermore, due to the low event incidence observed, larger sample studies should be performed to validate the current findings. More studies using US-guided, in-plane cannulation of the right BCV are required to confirm its clinical effectiveness. Long-term complications of BCV lines also deserve further attention.

In conclusion, this supraclavicular, in-plane, US-guided right BCV cannulation appears to be a convenient, effective, and safe method for CVC insertion in adult patients. This approach provides another option for catheter access to boost the clinical performance of central venous catheterization.

Author contributions

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Writing – review & editing: Qian Chen.

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