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Original Contribution

A comparison of the supraclavicular and infraclavicular views for imaging the subclavian vein with ultrasound☆,☆☆,★

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ABSTRACT

Introduction: Ultrasound guidance for central line placement in the subclavian vein (SCV) is more efficient and safer than landmark-based technique. The supraclavicular (SC) approach is an alternative to the infraclavicular (IC) approach, but the research is sparse. The objective was to determine which approach provides the best view.
Methods: This was a prospective anatomical survey of voluntary normovolemic patients. Four experienced emergency physicians and 1 resident scanned the right and left SCVs from SC and IC approaches. They assigned a score for the views obtained on a 5-point Likert scale.
Results: Ninety-eight patients were enrolled. Mean Likert scores for the 4 views were: right SC, 4.06 (95% confidence interval [CI], 0.22); right IC, 3.07 (95% CI, 0.25); left SC, 3.82 (95% CI, 0.23); left IC, 3.12 (95% CI, 0.25). When combining data from right and left, the mean score for the SC view was significantly higher than the mean score for the IC view: 3.94 (95% CI, 0.16) vs 3.10 (95% CI, 0.18). The following ratings were obtained: right SC view was good or excellent in 71.5%; left SC view was good or excellent in 66.3%; right IC view was good or excellent in 37.8%; and left IC view was good or excellent in 38.8%.
Conclusion: The SC approach allows for a better view of the SCV on ultrasound than the IC approach. Future research should determine if this translates to a greater success rate when placing central lines in the SCV.

1. Introduction

Ultrasound (US) guidance is the standard of care for central venous line (CVL) placement. The benefits of US guidance include an increased success rate, greater efficiency, and a decreased rate of complications [1-4]. In a review of strategies to improve patient safety, the Agency for Healthcare Research and Quality in the United States identified US guidance during CVL insertion as 1 of 11 risk reduction strategies unequivocally supported by evidence [2]. Although operator experience reduces complications via the landmark-based approach, variation in individual patient anatomy and thrombosed veins leads to failed attempts regardless of experience [1,2].

Ultrasound guidance for CVL placement in the internal jugular and femoral veins has been the focus of numerous studies [1,5]. Less research has assessed the use of US guidance for the placement of CVLs in the subclavian vein (SCV) [6]. Subclavian lines are often still performed using the blind technique [7]. This may be related to the overlying clavicle, which partly restricts the sonographic view of the SCV. However, blind insertion of subclavian CVLs can result in serious complications such as pneumothorax and hemothorax, which occur more often when compared with blindly inserted internal jugular and femoral lines [8].

The SCV does have some advantages over CVLs placed elsewhere. Because of surrounding support structures, this large diameter vein often remains patent in the setting of hypovolemic shock [9]. It is often used in blunt trauma patients with cervical spine collars or a contraindication to a femoral line. It also leads to fewer cases of catheter-related infections and thrombosis [8,10].

There are 2 possible approaches for cannulating the SCV: infraclavicular (IC) and supraclavicular (SC). Both are described in the literature, with a historical focus on the landmark technique [9]. Ultrasound-guided IC cannulation is done using a lateral approach, which locates the axillary vein after it emerges from under the clavicle [7,11]. To our knowledge, there are only a limited number of articles, which have reported on US guidance for the SC approach [12-14].

The primary objective of this study was to determine which US-guided approach, IC or SC, provides the best view of the SCV. A secondary objective was to determine whether the right or left side provides a better view.

2. Methods

This study was a prospective anatomical survey of the SCV using US. Study physicians were asked to locate the SCV on a cohort of

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volunteer emergency department (ED) patients who provided informed consent. Approval for the study was obtained from the Health Sciences North Research Ethics Committee.

2.1. Study setting and population

This study took place in the Health Sciences North ED, the sole ED for Sudbury, which has a metropolitan population of 160 000. The annual ED volume is approximately 60 000. Health Sciences North serves as the trauma and tertiary care center for Northern Ontario.

2.2. Study protocol

One emergency medicine resident enrolled all patients. Four staff emergency physicians and the emergency medicine resident performed the USs. All were certified in emergency US by the Canadian Emergency Ultrasound Society. All had experience placing CVLs under US guidance. For the 2 staff physicians and resident with no experience placing subclavian CVLs under US guidance, training was provided. The training module included a text and lecture, which was adapted from The EDE 2 Course (www.ede2course.com, used with permission). This training included instruction in the identification of the SCV by both the IC and SC approaches. Hands-on training sessions were supervised by 1 of the 2 more experienced authors (SJS). Physicians were considered trained when they felt comfortable locating the SCV by both approaches.

2.3. Patient selection

Patients in the Health Sciences North ED were approached for possible study inclusion by one of the study authors (MRS). The study was explained to each patient, and written and voluntary informed consent was obtained. Inclusion and exclusion criteria are listed in Table 1. Inclusion criteria included well-appearing adults 18 years and older who were normovolemic. All patients were screened for exclusion criteria including signs and symptoms of hypovolemia.

2.4. Procedure and technique of SCV localization under US

Patients who provided consent had their SCVs scanned by one of the study physicians. Both the right and left SCVs were scanned using IC and SC approaches. A Sonosite M-Turbo US machine (Sonosite, Inc, Bothell, WA), equipped with a small footprint, high frequency (13-6 MHz), linear array probe, was used.

Table 1
Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
Adults (>18 y old)	Presenting complaints
GCS 15	Dyspnea
Well appearing	Gastrointestinal or other symptoms suggesting hypovolemia/hypervolemia
Ability to provide informed consent	Acute head, neck, or thoracoabdominal trauma
	Medical history
	Neck surgery
	Radiation or burns to neck/chest
	Hypervolemia (eg, dialysis patient)
	Dementia
	Physical examination
	Abnormal vital signs
	Respiratory distress
	O_2 saturation <95%
	Signs of hypovolemia or hypervolemia (eg, congestive heart failure)
	Cervical collar
	Inability to remain supine
	Altered mental status

For both approaches, the patient was placed in the supine position, with the head and neck in neutral position. For the SC approach, the protocol allowed the physician to have the patient turn their head slightly away from the probe to facilitate probe placement. The physician could start with either the left or right SCV via either the SC or IC approach. For the SC approach, the physician could either identify the SCV at its confluence with the internal jugular vein or more laterally along its course. The best point along the path of the SCV as seen in its long axis was used to rate the view obtained.

For the IC approach, the SCV was first identified in its short axis. The probe was then rotated to a long-axis view. The physician then rated the view obtained. The long-axis SCV view was used to perform ratings because this plane was felt to be safer for CVL placement because it allows one to more reliably follow the needle tip.

2.5. Data collection

Patient data (age, sex, height, weight, and calculated body mass index [BMI]) were entered into a standardized Microsoft Excel spreadsheet (Microsoft Corporation, Redmond, WA). Height and weight were obtained from the patient. If there was uncertainty, height and weight were measured. A study physician then rated the views obtained of the SCV vein on a 5-point Likert scale. A score of 1 meant that the physician could not locate the SCV and that cannulation would be impossible. A score of 2 meant that the vein could be located but that cannulation would be difficult. A score of 3 meant that an adequate view was obtained but that the physician would look for another, possibly better, site for cannulation. A score of 4 meant that a good view was obtained and that they would feel comfortable inserting the central line and would not consider another site. A score of 5 indicated an excellent view of the SCV and that cannulation would be anticipated to be easy. Physicians were asked to consider the size of the vein, depth of the vein, and the relationship to important adjacent structures (arteries and pleura) before making their decision. Physicians were also asked to indicate which one of the 4 views provided the best view for CVL placement in each patient.

2.6. Statistical analysis

A sample size calculation was performed to determine that a sample of 55 patients was needed to provide the study with 90% power to detect a 20% difference between the IC and SC approaches. The 20% difference was estimated by the authors as the difference required for an emergency physician to switch from one approach to another for CVL placement. Descriptive statistics were used as appropriate. Statistical analyses were performed with SPSS version 20.0. Multivariate logistic regression was used to determine if there was a relationship between the assigned score and age, sex, height, weight, and BMI. To determine interrater reliability, scans were repeated in 20% of subjects by one of the study authors (MRS) who was blinded to the original result. Agreement was defined a priori as no more than a difference of 1 point on the Likert scale. The weighted κ statistic was used to express interrater reliability.

3. Results

Between April 1 and May 31, 2011, 98 patients were enrolled in the study, with equal representation of males and females (49 each). The mean age was 49.5 years old (range, 18-88 years). The mean BMI was 28.1 kg/m^2 (range, 19.4-46.9 kg/m^2), with 70.4% of the patients being overweight (BMI >25 kg/m^2) and 4% in the morbidly obese category (BMI >40 kg/m^2).

The mean Likert scores for the 4 views were: right SC, 4.06 (95% confidence interval [CI], 0.22); right IC, 3.07 (95% CI, 0.25); left SC, 3.82 (95% CI, 0.23); left IC, 3.12 (95% CI, 0.25). When combining data from right and left, the mean score for the SC view was significantly

higher than the mean score for the IC view: 3.94 (95% CI, 0.16) vs 3.10 (95% CI, 0.18). There was no statistical difference between the right and left sides. When combined, the mean scores were as follows: right SCV, 3.57 (95% CI, 0.18); left SCV, 3.47 (95% CI, 0.18).

Table 2 summarizes the proportion of patients who received each score for each of the 4 views obtained. The right SC view was rated as good (4/5) or excellent (5/5) in 71.5% of patients and adequate (3/5), good, or excellent in 88.8%. The left SC view was rated as good or excellent in 66.3% of patients and adequate, good, or excellent in 84.7%. The right IC view was rated as good or excellent in 37.8% and adequate, good, or excellent in 64.3%. The left IC view was rated as good or excellent in 38.8% and adequate, good, or excellent in 67.3% of patients.

Physicians were also asked to decide which view, of the 4 scans, provided the best view for cannulation. Their selections were as follows: right SC, 51 (52%); left SC, 24 (25%); right IC, 14 (14%); left IC, 10 (10%). Overall, the SC view was preferred over the IC view in 77% of patients.

Twenty percent of patients were scanned a second time by a physician who was blinded to the results of the first scan. The 2 physicians agreed 85% of the time. The weighted κ statistic was 0.354.

There was no relationship between the assigned score and patient age, sex, height, or weight. The BMI had a significant influence on the scores for both the SC and IC views with a higher BMI being associated with a lower score ($P < .05$).

4. Discussion

The benefits of US-guided CVL access are well established [1,2,4]. However, research on the sonographic approach to the SCV, an ideal vein in many critically ill patients, is limited. A recent study in the critical care literature compared the US-guided approach to the SCV with landmark technique in mechanically ventilated patients [3]. They reported significantly fewer complications and a higher success rate in the US group, but physicians rated this technique as technically difficult [3]. The IC approach was the only one used in this study.

Our study showed that the SC approach provided superior views when compared to the IC approach. These findings suggest that using an SC approach may be a technically easier option. Interrater reliability was fair, perhaps due to the different experience levels of the study physicians.

Although the view obtained was not significantly different when comparing the right and left SCVs, the right SCV was chosen 66% of the time as the best view. The right side may have been preferred when using the SC approach because the pleural dome is lower on this side, making pneumothorax less likely [3,9]. The right SCV may have also been favored by study physicians because the thoracic duct enters the left SCV, making it prone to injury if the left side is used for cannulation [9,15].

High BMI is associated with failures of blind subclavian line placement. One study found a 20.1% failure rate in patients with a BMI greater than 30 kg/m^2 [16]. Despite the fact that 70% of the patients in our study were overweight, the SCV was still well visualized with US in many patients. Although scores were lower in patients with a higher BMI, US guidance may be beneficial in this patient population.

Table 2
Number of patients receiving each score at each site examined

Score	Right SC (%)	Right IC (%)	Left SC (%)	Left IC (%)
5 (excellent)	47	17	35	17
4 (good)	23	20	30	21
3 (adequate)	17	26	18	28
2 (inadequate)	9	23	10	21
1 (impossible)	2	12	5	11

4.1. Limitations and future questions

We compared the views of the SCV obtained with US from 4 locations rather than the ability to cannulate the vein using US guidance from these positions. Studies on US-guided IC cannulation demonstrate its safety and efficacy [3]. Studies on blindly inserted supraclavicular subclavian lines demonstrate favorable success and complication rates [15,17]. However, research regarding US guidance of the SC approach is lacking. An interventional study should be performed before widely recommending this technique to physicians. However, our results do suggest that the SC approach to the SCV may be a useful alternative to the IC approach when placing US-guided CVLs in the SCV.

The study population was a convenience sample. This may introduce selection bias. However, every effort was made to choose patients with a wide range of ages, heights, and weights and to have an even male-to-female distribution. Patients were relatively healthy and euvolemic. The results may differ in a dehydrated or critically ill population.

Finally, US is a highly operator-dependent technique. All study physicians were experienced with bedside US and US-guided procedures. The proportion of adequate views for cannulation may be lower when obtained by physicians with less experience.

5. Conclusion

This study demonstrates that good or excellent views of the SCV can be obtained with US in most ED patients of various ages and sizes. This study also demonstrates that the SC view is superior to the IC view for visualizing the SCV. Further research is needed to determine if the US-guided SC approach would yield greater success and decreased complications compared to the IC approach when placing CVLs in the SCV.

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