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Original Contribution

Influence of caudal traction of ipsilateral arm on ultrasound image for supraclavicular central venous catheterization☆,☆☆

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ABSTRACT

Background: The first step for successful ultrasound (US)–guided subclavian vein (SCV) catheterization using a supraclavicular approach is to obtain a good longitudinal image of SCV for in-plane needle placement. We evaluated the efficacy of caudal traction of ipsilateral arm on the exposure of the SCV.
Methods: We enrolled 20 infants, 20 children, and 20 adults undergoing general anesthesia. After tracheal intubation, US probe was applied as the supraclavicular approach, and the longitudinal US image of SCV was obtained in 3 different ipsilateral arm positions: neutral, caudal traction, and abduction. The length of puncturable SCV, the diameter of SCV, and the available angle for needle insertion in 3 different arm positions were analyzed.
Results: In all patients, the length of puncturable SCV and the available angle for needle insertion were significantly increased after caudal traction (35.6% ± 27.1% and 25.0% ± 19.3%, respectively) and decreased after the abduction (36.6% ± 22.9% and 29.5% ± 23.8%, respectively) compared to neutral position. The diameter of SCV was not changed after applying the caudal traction in infants and children. However, in adults, the caudal traction slightly increased the diameter of SCV ($P = .012$).
Conclusion: The caudal traction of ipsilateral arm toward to the knee improves the longitudinal US view of SCV for the supraclavicular approach, without reducing its size. Proper caudal traction of the arm might ensure the high success rate with safe needle insertion technique. Abduction should be avoided during US-guided supraclavicular SCV catheterization.

1. Introduction

Central venous catheterization is frequently necessary for hemodynamic monitoring, administration of medications, rapid volume resuscitation, or nutritional support and is recommended in cases of difficult peripheral catheterization [1]. Since the UK National Institute for Clinical Excellence recommended the ultrasound (US)–guided technique for internal jugular vein (IJV) catheterization, the method has rapidly gained acceptance, and numerous specialty groups have recommended its use for central catheter placement [2–5].

Several studies have recommended the supraclavicular (SC) versus infraclavicular (IC) approach for US-guided subclavian vein (SCV) catheterization [5–11], as it has several advantages including a shorter puncture time, lower incidence of multiple attempts, and a lower rate of guide wire misplacement into the IJV [10]. The first step of this technique is to obtain a clear longitudinal view of the SCV and needle for in-plane long axis needle placement. In addition, having sufficient space to manipulate the needle and US probe over the SC area is required for successful catheterization [3,10,12]. Caudal traction of the ipsilateral arm to the knee may widen the space for the needle and US probe by moving the clavicle downward.

To date, no studies have assessed the effect of arm position on the longitudinal US view of the SCV for the SC approach. We hypothesized that caudal traction of the ipsilateral arm would widen the space between the clavicle and the Pirogoff confluence, which is the length of the puncturable SCV. To this end, we evaluated the influence of caudal traction on the relative position of the clavicle to the SCV for real time US guidance using the SC approach in pediatric and adult patients.

2. Methods

This prospective study was approved by the Institutional Review Board of Seoul National University Hospital (reference no. H-1504-069-664) and registered with Clinical Trials (reference no. NCT02478749; principal investigator's name was Jin-Tae Kim, and the

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date of registration was June 1, 2015). After obtaining written informed consent from the parents of children or adult patients, 20 infants, 20 pediatric patients aged 1 to 5 years, and 20 adult patients undergoing general anesthesia for elective surgery from June 2015 to July 2015 were enrolled in the study. Patients with infection in the supraclavicular area, vascular malformation, history of thoracic surgery or clavicular fracture, or history of central venous catheter insertion through the SCV were excluded. Anesthesia was induced with 5 mg/kg thiopental sodium and 8% sevoflurane under 100% O_2 mask ventilation, followed by 0.6 mg/kg rocuronium to facilitate tracheal intubation.

After tracheal intubation, all of the measurements were performed on the right SCV by 1 anesthesiologist (EHK). Patients were placed in a supine position with a rolled towel placed under the shoulders. The head was turned 30° away from the side of the measurements to facilitate probe placement. The longitudinal view of the SCV with the SC approach was obtained using US at 3 different arm positions: (1) neutral, (2) under caudal traction (ipsilateral arm was gently pulled towards the knee by an investigator IKS), and (3) under abduction (the ipsilateral arm was abducted) (Fig. 1). The order of the arm positions was randomly determined.

The US probe was placed on the neck to visualize the transversal image of the carotid artery and the IJV and then was slowly moved downward and tilted to the caudal side, first showing the subclavian artery on the longitudinal view and then showing the SCV, more anteriorly, lying on the pleura. The SCV was visualized in its proximal longitudinal part where it meets the IJV to form the brachiocephalic vein (Pirogoff confluence) (Fig. 2A). After obtaining the longitudinal US images of the SCV, they were analyzed by the other investigator. The point on the skin surface (point S) connecting a vertical line tangentially drawn from the medial border of the clavicle was determined. The other point was marked at the folding point formed by the upper border of the SCV and the lateral border of the IJV at the Pirogoff confluence (point P), and a vertical line crossing this point was also drawn. The puncturable longitudinal length of the SCV was defined as the distance between 2 parallel vertical lines that crossed points S and P. The available angle for needle insertion was defined as the angle between the vertical line and the connecting line of points S and P. The puncturable longitudinal length of the SCV, the available angle for needle insertion, and the diameter of the SCV at point P were measured at 3 different arm positions from the image taken at the end of expiration (Fig. 2B).

We used a LOGIQe US unit (GE Healthcare System, Milwaukee, WI) with appropriate probes for the patients according to their age: the linear "Hockey stick" probe (i12L-RS probe, 8-10 MHz) was used for infants, the linear probe (8L-RS probe, 8-13 MHz) for the children aged from 1 to 5 years, and the convex probe (4C-RS probe, 2.0-5.5 MHz) for the adult patients.

2.1. Statistical analysis

We considered that the 20% increase in the longitudinal length of the SCV in the US image was clinically significant. Normality of the data distribution was tested using the Kolmogorov-Smirnov test. The significance of the difference between the neutral position and arm traction was evaluated using a paired *t* test. The differences among the 3 different age groups were evaluated using an analysis of variance test. Data are presented as means ± SDs (95% confidence interval [CI]) or medians (interquartile ranges) or numbers and percentages for absolute values as appropriate. Significance was defined as a *P* value less than .05 or a Bonferroni-corrected *P* value less than .025. All of the statistical analyzes were performed with SPSS software (SPSS 21.0; IBM, Inc, Chicago, IL).

3. Results

A total of 60 patients were enrolled in this study, and their characteristics are shown in Table 1. Table 2 shows the puncturable longitudinal length of the SCV in the US image, the available angle for needle insertion, and the diameter of the SCV in 3 different ipsilateral arm positions. In infants, children, and adults, the longitudinal length of the SCV in the US view was significantly increased by 39.6% ± 22.4%, 33.7% ± 19.2%, and 33.7% ± 37.3%, respectively, after applying caudal traction of the ipsilateral arm ($P = .000$; 95% CI was 29.1%-50.1%, 24.7%-42.6%, and 16.2%-51.1% for infants, children, and adults, respectively) and was significantly decreased by 39.3% ± 18.0%, 38.7% ± 28.2%, and 31.9% ± 21.8%, respectively, after abduction of the ipsilateral arm ($P = .000$; 95% CI was 30.8%-47.7%, 25.5%-51.9%, and 21.7%-42.1% for infants, children, and adults, respectively) (Fig. 3).

We assumed that an increment of more than 20% in the length of the SVC compared to the neutral position was clinically significant. In total, 80% of enrolled infants and children showed a clinically significant increment; meanwhile, only half the adult patients showed a clinically significant increment after applying caudal traction of the ipsilateral arm (Fig. 4).

The available angle for needle insertion became wider after caudal traction of the ipsilateral arm by 24.4% ± 11.4% (95% CI, 19.1%-29.7%),

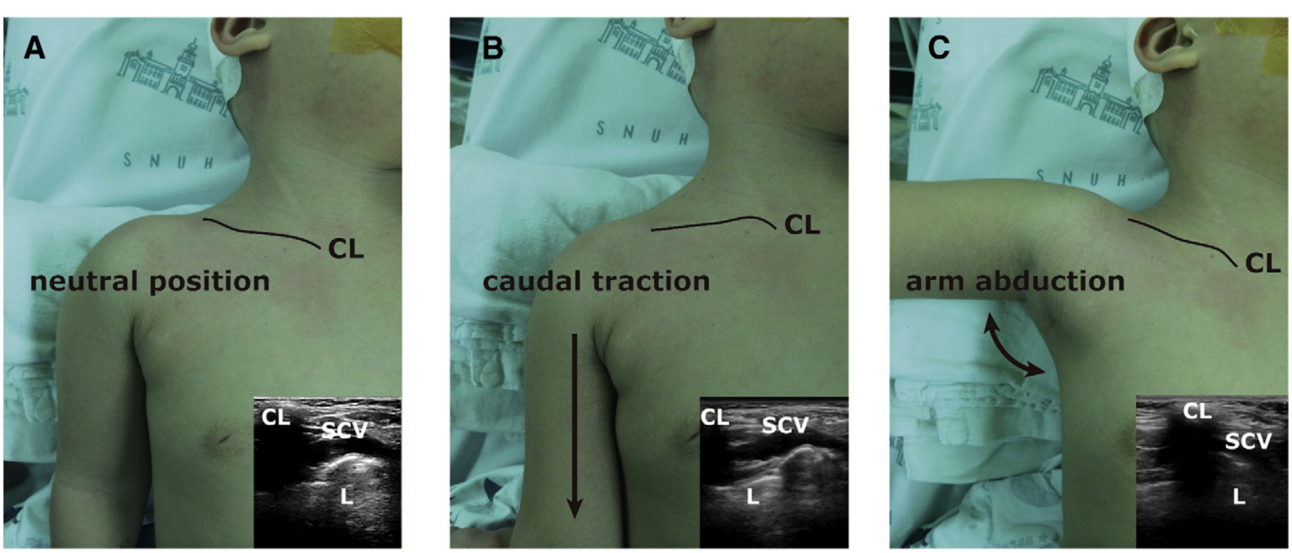

Fig. 1. The influence of different arm positions on the relative position of the clavicle the neutral position (A), caudal traction (B), and abduction (C). Abbreviations: CL, clavicle; L, lung.