Comparative Evaluation of Ultrasound Guided Supraclavicular and Infraclavicular Subclavian Venous Catheterization in Pediatrics: Prospective, Randomized, Single-Blinded Clinical Trial

Original Article

Radi Abdelgawad, Saad-Elden Al-Khatib, Ismail Ahmed

Department of Anesthesia, Intensive Care and Pain Management, Faculty of Medicine, Al Azhar University, Cairo, Egypt

ABSTRACT

Background: Placing a central venous catheter (cvc) is a crucial invasive surgery that children of all ages undergo in the operating theater and the intensive care unit. the purpose of this study was to compare two methods for subclavian venous catheterization in pediatric patients: ultrasound-guided supraclavicular (sc) and infraclavicular (ic). the goal of this comparison is to help clinicians practice cvc insertion with more speed, accuracy, and less problems.

Methods: This prospective, randomized, single-blinded clinical trial administered to forty children, comprising both sexes, between the ages of four and twelve, American society of anesthesiologists I, II, III physical status, needing central venous line insertion, intra-operative hemodynamic monitoring, volume, inotrope resuscitation, difficult peripheral Intravenous access and intravenous nutrition and medications. There were two groups of patients: SC and IC.

Results: The groups were significantly different according to puncture time, total access time, guidewire misplacement and catheter insertion length. Catheter insertion duration, quality of needle visualization, number of attempts, and first attempt success rate were not significantly different across the groups that were evaluated. There was no significant difference between studied groups according to pneumothorax and hematoma.

Conclusions: SCV catheterization in pediatric patients in comparison to the IC approach, resulted in a reduced puncture time and a reduction in the occurrence of guidewire misplacement.

Key Words: Central venous catheter, infraclavicular approaches, subclavian vein, ultrasound-guided supraclavicular.

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Corresponding Author: Radi Mohammed Radi Moustafa Abdelgawad, MSc Student, Department of Anesthesia, Intensive Care and Pain Management, Faculty of Medicine, Al Azhar University, Cairo, Egypt, **Tel.:** 01155275790, **E-mail:** radim.radi.6.206@azhar.edu.eg

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INTRODUCTION

Vascular access in children can be challenging. There is considerable evidence that supports the use of Ultrasound (US) to facilitate central venous access in adults, but the evidence is less in children. While there is evidence of a benefit for those who are acquiring skills and for less frequent operators, the benefits may be minimal for experienced operators[1, 2].

Placing the central venous catheter (CVC) is an essential invasive procedure for use in the intensive care unit with children of any age. And the success of its implementation significantly influences health care units. There have been numerous historical and clinically significant methods of CVC, and the advantages and disadvantages of each have been the subject of extensive discussion for many years[3].

CVC is frequently implemented in intensive care units and operating rooms for a variety of purposes[4].

CVC is a catheter that is inserted into a major vein; another name for it is a central venous access catheter, central line, or central venous insertion line. A peripherally inserted central catheter (PICC) line in the arms, the internal jugular vein (IJV) in the neck, the subclavian vein (SCV) or axillary vein in the chest, and the groin (femoral vein) are the most typical locations for catheter insertion. CVC is utilized for reasons such as obtaining blood tests (particularly the "Central venous oxygen saturation"), measuring central venous pressure, and administering fluids or medications that cannot be taken orally or would be harmful to a smaller peripheral vein[5]. Ultrasonography is proving to be a valuable tool for assisting in the insertion of percutaneous central lines[5].

US is a diagnostic imaging technology that can be used to observe the subcutaneous body structures for abnormalities or lesions in internal organs, tendons, muscles, joints, and blood vessels. Diagnostic sonography

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uses a hand-held probe and a water-based gel to couple the US between the transducer and patient, providing detailed sonograms with smaller wavelengths[6].

Due to the small and superficial structures that need to be visualized and the restricted space available for the US probe, a small, high-frequency probe is therefore required. In contrast to curved probes, linear probes are the favored option due to their reduced image distortion. The 6-13 MHz 1-6cm linear "Hockey Stick" Probe (HSP) was utilized by a sonosite titanw US unit located in Bonnell, WA, USA[6].

In this study, we aimed to compare US-guided SC and IC approaches for SCV catheterization in pediatric population to get clinical practice of rapid, accurate CVC insertion and less complications.

METHODS

This prospective, randomized single blinded investigation was conducted on 40 children between the ages of four and twelve, both sexes, American society of anesthesiologists (ASA) I, II, III physical status, needing central venous line insertion, intra-operative hemodynamic monitoring, volume, inotrope resuscitation, difficult peripheral Intravenous access and intravenous nutrition and medications. Ethical Committee permission from Cairo, Egypt's Al-Azhar University Hospitals was required for the study to go forward. Guardians of the patients were asked to sign a document indicating their informed consent.

Exclusion criteria were patients with coagulopathy, cutaneous infection near the proposed point of insertion, skeletal deformity, history of previous neck surgery, head and neck mass.

Success rate of cannulation by either approach, number of attempts to cannulate a vein, smoothness or unsuccessfulness of guidewire and catheter insertion, length of catheter inserted, and any related complications.

Randomization and blindness

The patients were randomly allocated in equal numbers to US guided for SCV catheterization through SC approach or IC approach utilizing computer-generated random numbers that were placed in distinct opaque envelopes that were opened by the study investigator just prior to the insertion of the CVC. The same anesthesiologist performed both approaches. The functional data collectors had no idea the study was randomized until it was over.

The entire patient population was subjected to complete history taking, physical examinations, laboratory investigations [complete blood picture (CBC) and coagulation profile (Bleeding time, clotting time, prothrombin time (PT), partial thromboplastin time, and international normalized ratio (INR)] and radiological investigations [US and Chest *X*-Ray].

Procedure Techniques

Under complete aseptic conditions, all CVC was carried out. All patients underwent standard monitoring during the surgery, which included an electrocardiogram and a pulse oximeter. In group SC, the SC strategy was directed by US to insert a CVC into the SCV. A CVC was inserted into a SCV using an IC technique that was guided by US in group IC.

A rolled towel was placed beneath each patient's shoulders as they were all positioned in a 10 head-down posture. While angling the head 30 degrees away from the site of venipuncture, the ipsilateral arm was carefully pulled towards the knee. US scanning, we used a US unit with its linear probe (5-10MHZ). The right SCV catheterization was performed by the operator standing on the child's right side, while the US unit's display was placed on the left side so that the operator could see the patient's landmarks and the US image. To get longitudinal photos of the SCV and the brachiocephalic vein for the SC approach, the US probe was rotated laterally and caudally after reaching the IJV - SCV junction by tracing the IJV. Tilting the probe revealed the skin entrance site for needles in small children. Positioning the US probe over the clavicle allowed the IC approach to view the distal part of the SCV. Optimal longitudinal images of the distal SCV, clavicle, and proximal SCV were obtained by adjusting the US probe at the IC level. A well-defined SCV not only confirmed the largest SCV, but also the best longitudinal perspective of the SCV diameter (Figure 1,2).

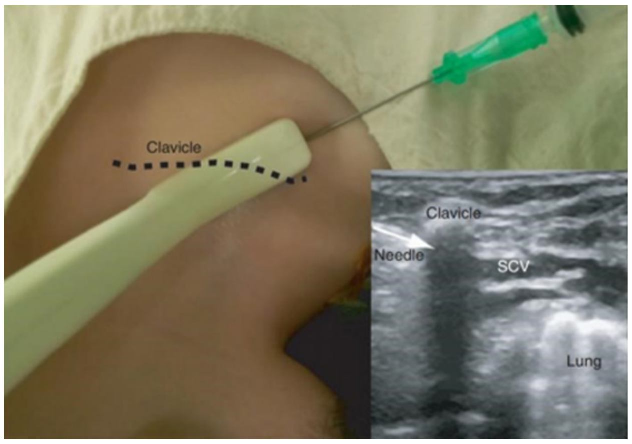

Fig.1: Ultrasonographic longitudinal view of the right SCV and illustration of the probe application for the IC approach. Needle tip directed at the SCV before the acoustic shadow of the clavicle in the US image. US probe placed over the clavicle to obtain a US image for the IC approach and the needle adjusted for the in-plane approach. SCV, subclavian vein.

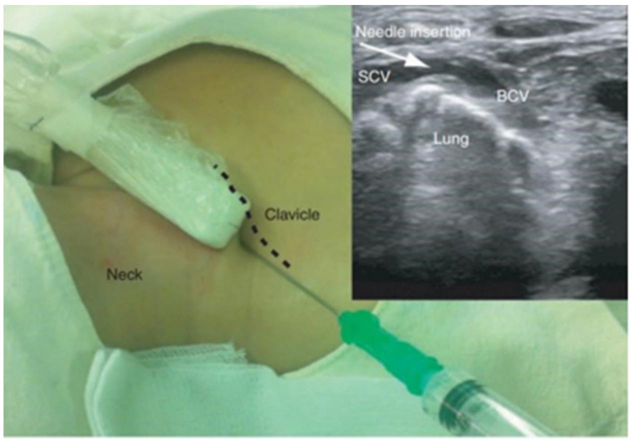

Fig.2: Ultrasonographic longitudinal view of the right SCV and the illustration of the probe application for the SC approach. Arrow indicates the SCV puncture site and the direction of the needle's advancement in the US image. US probe placed in the SC region in order to obtain a US image for the SC approach and the needle adjusted for the in-plane approach. SCV, subclavian vein; BCV, brachiocephalic vein.

Central venous catheterization

Pediatric CVC sets (4Fr or 5Fr) were used. The SCV was punctured using a syringe-attached, 21-gauge 4-centimeter needle. Under US's supervision, the needle was advanced using an in-plane approach, with great care to preserve the best longitudinal image of the SCV only after successful blood aspiration was confirmed and the tip of the needle was visible in the SCV was the guidewire placed into the vessel using the needle, with the J-tip pointing in the caudal direction. To ensure the guidewire was properly inserted into the SCV, ultrasound was utilized. After a satisfactory chest *X*-Ray and aspiration of blood through the catheter, it was determined that the catheter had been successfully inserted.

Respiratory rate and heart rate were measured after CVC insertion and at 30, 60, 90min, 2, 4, 6, 8, 12, and 24 hours post procedure. Primary outcome was distribution of puncture timed, and secondary outcomes were total access time which refers to the duration required to retrieve data or complete an operation, combining both the request time and the processing time, catheter insertion time which refers to the time of insertion of catheter in the patient, guidewire misplacement and catheter insertion length. Immediately US then chest *X*-Ray (CXR) 2hr then 24hr.

Sample Size Calculation

The sample size calculation was done by G*Power 3.1.9.2 (Universitat Kiel, Germany). According to a previous study[7]. the mean±SD access time was 4.30±1.02min with supraclavicular approach and 6.07±2.14min with infraclavicular approach. The sample size was based on the following considerations: 1.056 effect size, 95% confidence limit, 80% power of the study, group ratio 1:1 and four cases were added to each group to overcome dropout. Therefore, we recruited 20 patients in each group.

Statistical analysis

SPSS v26 (IBM Inc., Chicago, IL, USA) was used for statistical analysis. The two groups were compared using an unpaired Student's *t*-test for quantitative data, which were provided as means and standard deviations (SD). When applicable, the Chi-square or Fisher's exact test was used to examine the qualitative variables, which were indicated as percentages and frequencies. It became statistically significant if the two-tailed *P* value was less than 0.05.

RESULTS

The groups that were studied did not differ significantly according to age, sex, weight, height, body mean index (BMI), Blood pressure (BP), temperature, Heart rate (HR), Respiratory rate (RR), cyanosis (Table 1).

Table 1: Distribution of demographic data and physical examination

		Group SC (*n*=20)	Group IC (*n*=20)	*P*
Age (years)		8±4	8.5±3.5	0.676
Sex	Male	11(55.0%)	10(50.0%)	0.751
	Fmale	9(45.0%)	10(50.0%)	
Weight (kg)		27.5±6.25	27.3±6.2	0.919
Height (cm)		66.85±10.69	67.65±18. 97	0.870
BMI (kg/m²)		22.66±8.3	24.7±16.3	0.620
		Physical examination		
BP (mm Hg)		95.05±17.6	88.35±15.6	0.2
Temperature(°C)		37.8±0.31	37.7±0.39	0.37
HR (beats/min)		100±10	101±11	0.76
RR (count/minute)		27.75±6.14	26.3±4.9	0.41
Cyanosis		4(20.0%)	7 (35.0%)	0.28

Data are presented as mean±SD or frequency (%); BMI: Body mass index; SC: supraclavicular; IC: infraclavicular; BP: Blood pressure; HR: Heart rate; RR: Respiratory rate.

There was no significant difference between studied groups according to hemoglobin (HB), Red blood cells count (RBCs), and white blood cells count (WBCs) (Table 2).

Table 2: Distribution of laboratory investigations

	Group SC (*n*=20)	Group IC (*n*=20)	*P*
HB (g/dl)	13.7±2.2	12.6±2.3	0.130
RBCs (million/mcl)	4.6±0.29	4.8±0.59	0.181
WBCs (million/mcl)	7.7±1.5	7.9±1.06	0.629

Data are presented as mean±SD; SC: supraclavicular; IC: infraclavicular; HB: hemoglobin; RBCs: red blood cells; WBCs: white blood cells.

The groups that were studied did not differ significantly according to occurrence of complications namely pneumothorax and hematoma (Table 3).

Table 3: Distribution of complications within the groups that were examined

	Group SC (*n*=20)	Group IC (*n*=20)	*P*
Pneumothorax	0(0.0%)	2(10.0%)	0.146
Hematoma	0(0.0%)	0(0.0%)	1

Data are presented as frequency (%); SC: supraclavicular; IC: infraclavicular.

The groups that were studied did not differ significantly according to first attempt success rate, multiple attempts and needle visualization quality and catheter insertion time, while there was significant difference between studied groups according to puncture time, total access time, guidewire misplacement and catheter insertion length (Table 4).

Table 4: Distribution of primary outcome and secondary outcomes between studied groups

		Group SC (*n*=20)	Group IC (*n*=20)	*P*
primary outcome	Puncture time (s)	40.6±10.13	75.4±25.1	≤0.001*
Secondary outcomes	Total access time (s)	89.9±12.4	153.2±40.9	≤0.001*
First attempt success rate		14(70.0%)	11(55.0%)	0.32
Multiple attempts		6(30%)	9(45%)	0.11
Catheter insertion time (s)		133.5±11.35	129.8±10.5	0.291
Guidewire misplacement		0(0.0%)	6(30.0%)	0.007*
Catheter insertion length (cm)		5.8±1.4	7.3±2.4	0.02*

Respiratory rate and heart rate were measured after CVC insertion and at 30, 60, 90min, 2, 4, 6, 8, 12, and 24 hours post procedure. No adverse effects were recorded.

DISCUSSION

Patients in serious illness or undergoing major surgery frequently require CVCs, making CVC insertion a crucial procedure[8, 9].

In the current investigation, the groups that were studied did not differ significantly according to blood pressure, temperature, heart rate, respiratory rate, cyanosis, jaundice and lymph node enlargement. In contrary, Guilbert *et al.,*[10]. reported that among 40 patients, there were 6 with respiratory distress syndrome, 9 with hemodynamic failure, 8 with infectious disease and 6 with neurologic failure.

Regarding distribution of laboratory investigations, our findings revealed that the groups that were studied did not differ significantly according to HB, RBCs, and WBCs.

Regarding complications between the studied groups, we found that among the groups that were examined, no significant difference was found. according to pneumothorax and hematoma. Our results supported by Lu *et al.,*[11]. reported that The groups that were studied did not differ significantly regarding complications. Also, Mahmoud *et al.,*[12]. reported that both the SC and IC approaches were used to catheterize the right subclavian vein in 210 patients; 105 patients in each group participated in the study. Regarding pneumothorax and hematoma, there was no significant difference among the groups.

Regarding distribution of primary outcome and secondary outcomes between studied groups, our current investigation showed that the studied groups did not differ significantly according to first attempt success rate, multiple attempts and needle visualization quality and catheter insertion time, while there was significant difference between studied groups according to puncture time which significantly decreased in the SC group as compared to the IC group, total access time which significantly shorter in SC compared to IC group, guidewire misplacement and catheter insertion length which significantly shorter in SC compared to IC group. Our results matched with Byon *et al*.,[13]. reported that there was no significant difference between the examined categories regarding puncture time which significantly shorter in SC compared to IC group, the studied groups did not differ significantly regarding guidewire misplacement. There was no significant difference between the studied groups regarding catheter insertion time and first attempt success rate in the same line Kim *et al.,*[14]. reported that SC and IC were not significantly different from one another. regarding success at first attempt for catheterization and time required for catheterization.

One of the study's limitations was the small sample size. There was just one location where the research took place. The patients were followed up on for a relatively short period. So, we recommended that, a representative sample of patients with similar age, sex, and disease severity. Data collection using standardized tools and protocols, at regular intervals postoperatively.

CONCLUSIONS

The studied groups did not differ significantly according to puncture time which significantly decreased in the SC group as compared to the IC group, Total access time which significantly decreased in the SC group as compared to IC group, Guidewire misplacement and

Catheter insertion length which significantly shorter in SC compared to IC group. While the studied groups did not differ significantly according to rate of success on the first attempt, Multiple attempts and visualization quality of the needle and catheter insertion time. Furthermore, in Group (SC) no patient reported pneumothorax and no patient reported hematoma. In Group (IC), there were 2(10%) with pneumothorax and no patient reported hematoma. The studied groups did not differ significantly according to pneumothorax and hematoma.

ABBREVIATIONS

(ASA): American Society of Anesthesiologists, **(BMI):** body mean index, **(BP):** Blood pressure, **(CBC):** complete blood count, **(CVC):** central venous catheter, **(HB):** hemoglobin, **(HR):** Heart rate, **(IC):** infraclavicular, **(IJV):** internal jugular vein, **(INR):** international normalized ratio, **(LN):** lymph node, **(PICC):** peripherally inserted central catheter, **(PT):** prothrombin time, **(RBCs):** Red blood cells count, **(RR):** Respiratory rate, **(SC):** supraclavicular, **(SCV):** subclavian vein, **(SD):** standard deviations, **(WBCs):** white blood cells count.

CONFLICT OF INTERESTS

There are no conflicts of interest.

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