ORIGINAL ARTICLE

Evaluation of Ultrasound Guided Supraclavicular and Infraclavicular Subclavian Venous Catheterization in Pediatrics: A Comparative Approach

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Abstract

Background: ***For kids of all ages, the insertion of a central venous catheter (CVC) ranks high among the most crucial invasive operations performed in the OR and ICU. In addition, the results of health care are highly dependent on how well it is put into practice. The pros and cons of each of the several central venous catheterization techniques that have been developed throughout the years have been extensively debated.***

Aim and objectives: ***In order to achieve clinical practice of quick, precise CVC insertion with fewer problems, we compared ultrasound-guided supraclavicular (SC) and infraclavicular (IC) methods for subclavian venous catheterization in pediatric patients.***

Subjects and methods: ***Fifty patients participated in this prospective, randomized, single-blind clinical trial that took place in the operating room and pediatric intensive care unit (PICU) of Al-Azhar University Hospitals.***

Results: ***Regarding pneumothorax and hematoma, there was no statistically significant distinction among the groups that were evaluated. First attempt success rate, number of attempts, quality of needle visualization, and time(s) spent inserting the catheter were not significantly different between the groups. However, puncture time(s), total access time(s), guidewire misplacement, and length(cm) of catheter insertion were significantly different.***

Conclusion: ***When compared to the IC method, SCV catheterization in paediatric patients reduced guidewire misplacement and puncture time.***

Keywords: Pediatrics; Ultrasound; Central venous catheter(CVC); subclavian vein(SCV)

1. Introduction

Pediatric vascular access is not without its challenges. Ultrasound has a lot of data to help with central venous access in adults, but not as much in kids. Although there may not be much of an advantage for seasoned operators, there is some proof that it helps novices and operators who don't use it very often.[1]

For children of any age, the insertion of a central venous catheter (CVC) is among the most crucial invasive operations performed in the critical care unit. In addition, the results of health care are highly dependent on how well it is put into practice. The pros and cons of each of the several central venous catheterization techniques that have been developed throughout the years have been extensively debated.[2]

Operating rooms and intensive care units often undertake central venous catheterization for a variety of reasons.[3]

Introductory catheters inserted into major veins are called central venous catheters (CVCs), central lines, central venous lines, or central venous access catheters. The most common sites for catheter insertion are the groin (femoral vein), the subclavian vein (or axillary vein), the internal jugular vein (in the neck), or the veins of the arms (a peripherally inserted central catheter, or PICC line). Use it to get blood tests (especially the "central venous oxygen saturation"), assess central venous pressure, and inject fluids or medications that wouldn't be safe to take orally or through a smaller peripheral vein.[4]

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Ultrasound is a diagnostic imaging tool that can see behind the skin to look for abnormalities or diseases in internal organs, tendons, muscles, joints, and blood vessels. Diagnostic sonography employs a handheld probe and a gel made of water to connect the ultrasonic waves from the transducer to the patient. This allows for the creation of detailed sonograms at lower wavelengths.[5]

This study set out to compare two methods of subclavian venous catheterization—ultrasound-guided supraclavicular (SC) and infraclavicular (IC)—in order to help clinicians implant CVCs more quickly and accurately with fewer difficulties in pediatric patients.

2. Patients and methods

Following approval by the local ethical committee, a prospective, randomized, single-blind clinical trial investigation was carried out on 40 patients ranging in age from 4 to 12 years at Al-Azhar University Hospitals, within the operating room and pediatric intensive care unit (PICU). Two groups of patients were formed: Twenty patients participated in the SC group and underwent an ultrasound-guided subclavian venous catheterization.

Group-(IC): Twenty patients underwent subclavian vein catheterization guided by ultrasound using the IC technique.

Inclusion Criteria

All children who need central venous line insertion, intra-operative hemodynamic monitoring, volume and inotrope resuscitation, difficult peripheral IV access, and intravenous nutrition and medications.

Exclusion Criteria:

Infection of the skin or underlying muscles at the site of insertion, arachnoid cysts, a history of neck surgeries, a lump in the neck or head, or parental disapproval.

Sampling:

Based on the following criteria, the sample size was estimated using the G*power 3.1.9.7 sample size calculation test:

There is a 90% two-sided confidence level, an 80% test power, and a 5% margin of error. Twenty patients were assigned to each Group in order to measure variables such as access time, success rate of cannulation by either strategy, number of attempts to cannulate the vein, smoothness or failure of guidewire and catheter insertion, length of catheter inserted, and complications.

Randomization:

An equal number of patients were assigned to have subclavian venous catheterization guided by ultrasonography. Before inserting the CVC, the researcher would open one of two opaque envelopes containing computer-generated random numbers; these were used in the SC strategy or the IC approach, respectively. This anesthesiologist performed both procedures. Throughout the trial, the functional data collectors were oblivious to the randomization process.

Methods:

Complete history taking, including the patient's current medical condition, past medical history of any chronic diseases, reasons for CVC insertion, total number of CVCs implanted, and standard physical examinations were performed on all patients. Additionally, standard laboratory tests, including an instantaneous ultrasound and chest x-ray 2 hours and 24 hours after injection, were performed, (figure 1).

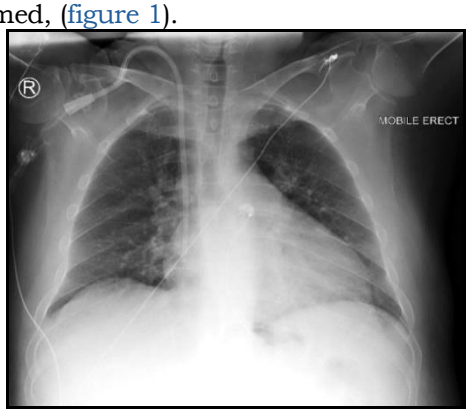

Figure 1. Chest x-ray post insertion of tunnelled vascath of Rt subclavian vein.

Technique of central venous catheterization

Under strict aseptic conditions, all central venous catheter insertions were carried out. All patients will undergo the surgery with standard monitoring, which includes an electrocardiogram and a pulse oximeter.

In the SC group, a central venous catheter (CVC) was placed into the subclavian vein using an ultrasound-guided supraclavicular approach. For the IC group, an infraclavicular approach guided by ultrasound was used to introduce a central venous catheter into the subclavian vein.

We made use of a linear probe (5-10 MHZ) on an ultrasound machine. To position the operator for the right SCV catheterization, they sat on the child's right side. On the left side of the child, they could see the patient's landmarks and the US image from the US unit.

For the SC approach, the longitudinal pictures of the SCV and the brachiocephalic vein were obtained by turning the US probe laterally and caudally after reaching the IJV-SCV junction along the IJV,(Figure 2).

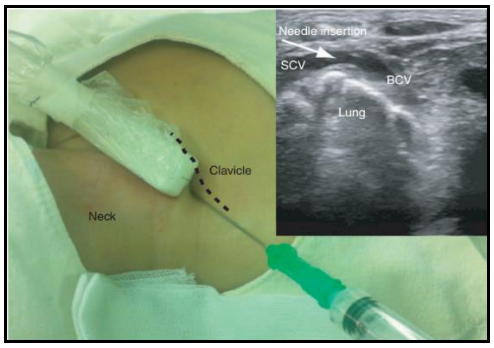

Figure 2. Ultrasound imaging shows the right SCV along its longitudinal axis, including a demonstration of the SC approach's probe application. In the ultrasound picture, the SCV puncture site and the needle's movement are indicated by an arrow. Obtaining a US image for the SC approach requires placing a US probe in the SC region, and the needle needs to be adjusted for the in-plane approach. The brachiocephalic vein (BCV) and the subclavian vein (SCV).

The needle entry site on the skin might be seen by tilting the probe for small infants. The IC method involved placing the US probe over the clavicle in order to see the SCV's distal end in the IC region. Figure 3 shows the results of correctly adjusting the US probe to get the best longitudinal image of the distal SCV at the IC level, the clavicle, and the proximal SCV. A well-defined SCV not only validated the biggest SCV diameter, but it also confirmed the best longitudinal perspective of the SCV.

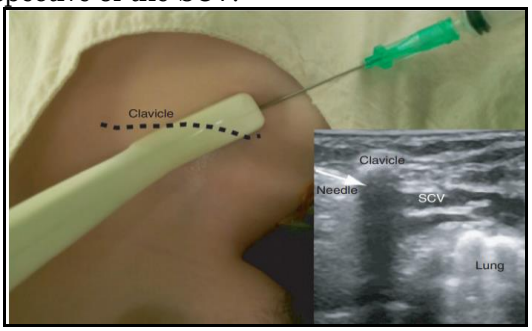

Figure 3. Visualization of the right SCV's ultrasonographic longitudinal section and the IC approach's probe application. Using the US picture, point the needle at the SCV just before the clavicle's acoustic shadow.IC approach US imaging acquired using a probe placed over the clavicle, with the needle fine-tuned for an in-plane approach. Subclavian vein, or SCV.

Central venous catheterization:

The CVC sets used were those for pediatric patients, with either 4 or 5 flush ports. To puncture the SCV, a syringe was used in conjunction with a 21-gauge 4-cm needle. With the US as a guide, the needle was progressed in an in-plane approach while meticulously preserving the best SCV longitudinal view (Figure. 2 and 3).

After successfully aspirating blood and seeing the needle tip in the SCV, the guidewire was inserted into the SCV through the needle while maintaining the J-tip pointed caudally. To ensure the guidewire was properly inserted into the SCV, ultrasound was utilized. Aspiration of blood through the catheter and subsequent evaluation of a chest x-ray confirmed successful catheter insertion.

Measured Parameters

Forty-one pediatric patients, both male and female, with ASA physical status grades of I, II, or III, who were scheduled for elective or emergency general anesthesia procedures requiring central venous catheterization, were included in the research.

Exclusion criteria for the study were the presence of infection at the puncture site, abnormal coagulation profile, contralateral pneumothorax, clavicle and upper rib trauma, abnormal anatomy of the neck or clavicle, and cervical spine damage.

Following CVC insertion (time 0), at 30, 60, 90, 2, 4, 6, 8, 12, and 24 hours after the procedure, the patient's respiratory rate, heart rate, and oxygen saturation levels will be monitored. A record was made of any issues or negative effects. Outcomes: total access time, number of catheter insertions, number of guidewire misplacements, catheter insertion length in centimeters, and immediate ultrasound followed by chest x-ray two hours and twenty-four hours later.

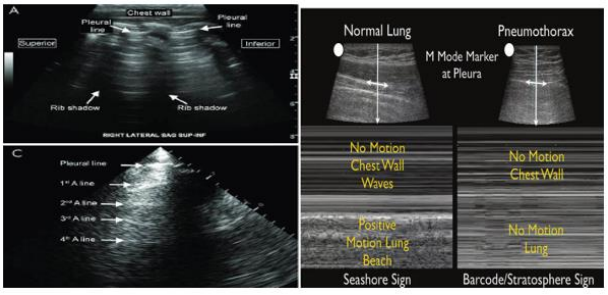

Figure 4. M-mode of normal lung versus pneumothorax.

Ethical Consideration

The Al-Azhar University Faculty of Medicine officially gave its consent. The parents were informed of the study's goals, methodology, and risk-benefit analysis prior to their enrollment. Following an explanation of the study's purpose to each patient's guardian, written informed permission was obtained.

Statistical Analysis

Using SPSS, a statistical computer package developed by IBM Corp. in Armonk, NY, USA, the gathered data were organized, tabulated, and subjected to statistical analysis. The mean±standard deviation was used to summarize numerical variables like age and body weight, which followed a normal distribution. An

independent t-test was employed to compare the means of the two groups. We will display the non-normally distributed variables as the median and interquartile range (IQR). To test for significance, we utilized the Mann-Whitney U-test. The chi-squared test was utilized to ascertain significance, and numerical and percentage data were used to represent the qualitative data. Statistical significance was determined by a two-sided p-value less than 0.05.

3. Results

Table 1. Distribution of demographic data.

	GROUP-(SC)	GROUP-(IC)	P-VALUE
Age(years) Mean±SD	8±4	8.5±3.5	0.676
SEX			
Male	11(55%)	10(50%)	0.751
Female	9(45%)	10(50%)	
Weight (kg) Mean±SD	27.5±6.25	27.3±6.2	0.919
Height(cm) Mean±SD	66.85±10.69	67.65±18.97	0.870
BMI(kg/m²) Mean±SD	22.66±8.3	24.7±16.3	0.620

P-value<0.05 statistically significant

Age, sex, weight, height, and body mass index did not show any statistically significant differences between the groups that were evaluated,(table 1;figure 5).

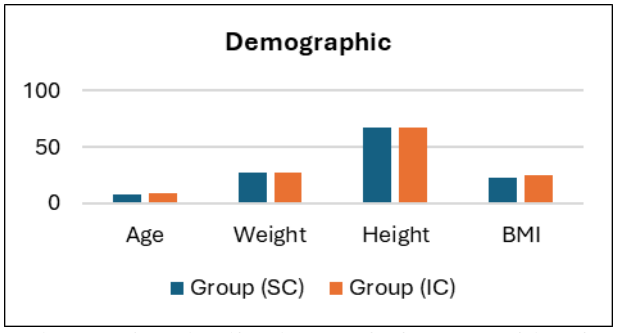

Figure 5. Distributions of demographic data between studied groups.

Table 2. Distribution of physical examination between studied groups.

	GROUP-(SC)	GROUP-(IC)	P-VALUE
BLOOD PRESSURE MM HG MEAN±SD	95.05±17.6	88.35±15.6	0.2
TEMPERATURE °C	37.8±0.31	37.7±0.39	0.37
HEART RATE (BEATS/MIN)	100±10	101±11	0.76
RESPIRATORY RATE (BREATHS/MIN)	27.75±6.14	26.3±4.9	0.41
CYANOSIS			0.28
YES	4(20%)	7(35%)	
NO	16(80%)	13(65%)	

P-value<0.05 statistically significant.

Blood pressure (mm Hg), temperature (°C), heart rate (beats/min), respiration rate (breaths/min), cyanosis (bluish green coloration of the skin), jaundice (yellowing of the eyes), and enlarged lymph nodes (redness of the skin) were not significantly different among the groups that were tested,(table 2;figure 6).

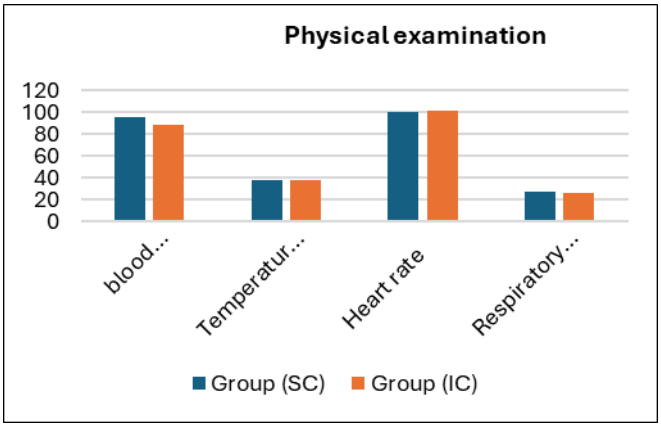

Figure 6. A study on the dispersion of vital signs (temperature, pulse, and respiration rate).

Table 3. Distribution of laboratory investigations.

	GROUP-(SC)	GROUP-(IC)	P-VALUE
HB(g/dl) Mean±SD	13.7±2.2	12.6±2.3	0.130
RBCs(million/mcl) Mean±SD	4.6±0.29	4.8±0.59	0.181
WBCs(million/mcl) Mean±SD	7.7±1.5	7.9±1.06	0.629

P-value<0.05 statistically significant

When looking at HB, RBCs, and WBCs, the groups that were tested did not show any statistically significant differences,(table 3; figure 7).

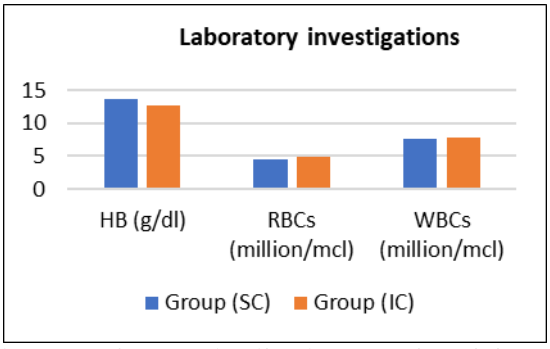

Figure 7. Distribution of laboratory investigations between studied groups.

Table 4. Distribution of complications between studied groups.

	GROUP-(SC)	GROUP-(IC)	P-VALUE
PNEUMOTHORAX			
Yes	0(0%)	2(10%)	0.146
No	20(100%)	18(90%)	
HAEMATOMA			
Yes	0(0%)	0(0%)	1
No	20(100%)	20(100%)	

P-value<0.05 statistically significant.

When it came to pneumothorax and hemorrhage, the groups that were evaluated did not vary significantly,(table 4;figure 8).

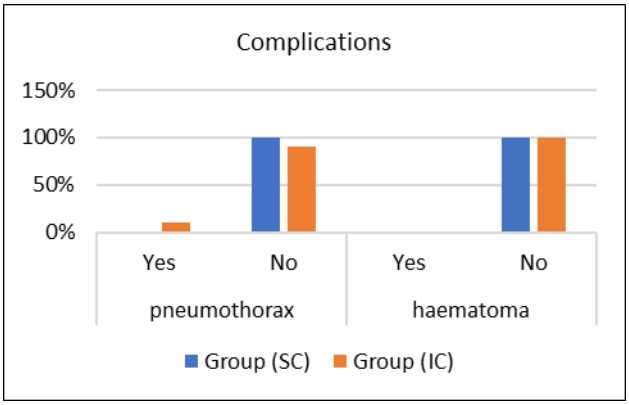

Figure 8. Distribution of complications between studied groups.

Table 5. Distribution of 1ry outcome and 2ry outcomes between studied groups.

	GROUP-(SC)	GROUP-(IC)	P-VALUE
1RY OUTCOME			
PUNCTURE TIME(S) MEAN±SD	40.6±10.13	75.4±25.1	≤0.001
2RY OUTCOMES			
TOTAL ACCESS TIME(S). MEAN±SD	89.9±12.4	153.2±40.9	≤0.001
FIRST ATTEMPT SUCCESS RATE			0.32
YES	14(70%)	1(55%)	
NO	6(30%)	9(45%)	
MULTIPLE ATTEMPTS			0.11
YES	7(35%)	12(60%)	
NO	13(65%)	8(40%)	
QUALITY OF NEEDLE VISUALIZATION			0.11
GOOD	13(65%)	8(40%)	
POOR	7(35%)	12(60%)	
CATHETER INSERTION TIME(S) MEAN±SD	133.5±11.35	129.8±10.5	0.291
GUIDEWIRE MISPLACEMENT			0.007
YES	0	6(30%)	
NO	20(100%)	14(70%)	
CATHETER INSERTION LENGTH(CM) MEAN±SD	5.8±1.4	7.3±2.4	0.02

P-value<0.05 statistically significant.

This table shows that groups were not significantly different in terms of first attempt success rate, number of attempts, quality of needle visualization, or time to insert catheter; however, groups were significantly different in terms of total access time, number of punctures, guidewire misplacement, and length of catheter insertion (in centimeters),(table 5;figure 9).

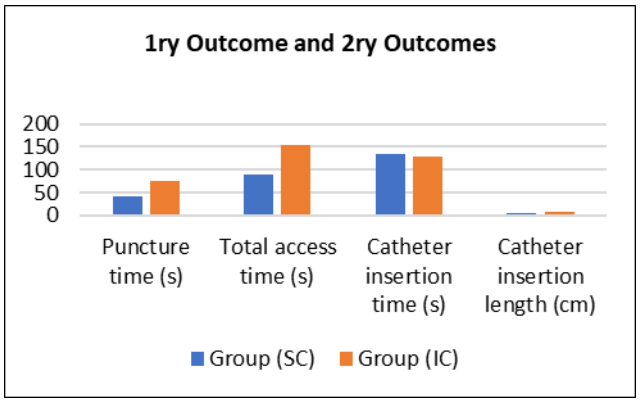

Figure 9. Distribution of puncture time(s), total access time(s), catheter insertion time(s), and catheter insertion length(cm).

4. Discussion

Regarding distribution of demographic data, our results showed that in Group-(SC), the mean age was 8±4years, there were 11(55%) males, the mean weight was 27.5±6.25Kg kg, the mean height was 66.85±10.69cm, the mean BMI was 22.66±8.3(kg/m²). In Group-(IC), the mean age was 8.5±3.5 years, there were 10(50%) males, the mean weight was 27.3±6.2Kg kg, the mean height was 67.65±18.97cm, and the mean BMI was 24.7±16.3(kg/m²). Regarding age, sex, weight, height, and body mass index (BMI), no statistically significant distinction was found between the groups that were analyzed.

This came in accordance with Byon et al.,[6] The study's authors sought to compare two methods for subclavian venous catheterization in children—ultrasound-guided supraclavicular (SC) and infraclavicular (IC)—and found no statistically significant differences between the two groups in terms of age, sex, weight, or height. The participants in the study were 98 children younger than three years old.

Also, Lu et al.,[7] who sought to evaluate the relative merits of supraclavicular and infraclavicular subclavian vein catheterization in newborns, found that 45 patients were assigned to the former Group, with an average age of 6.7±(3.5) months and 6.6±(2.0) kg of weight, while 46 patients were assigned to the latter Group, with an average age of 6.5±(3.7) kg of weight.

We found that in Group-(SC), the average blood pressure was 95.05±17.6 mm Hg, the average temperature was 37.8±0.31 °C, the average heart rate was 89.7±6.2 beats/min, and the average respiratory rate was 27.75±6.14 breaths/min. Out of this Group, 4 participants (20%) had cyanosis, 5 participants (25%) had jaundice, and 2 participants (10%) had enlarged lymph nodes. Seven patients (or 35% of the total) in Group (IC) exhibited cyanosis, seven (or 35% of the total) had jaundice, and four (or 20% of the total) had enlarged lymph nodes. The average temperature

was 37.7±0.39°C, the average heart rate was 89.55±6.04 beats/min, and the average respiration rate was 26.3±4.9 breaths/min. Blood pressure (mm Hg), temperature (°C), heart rate (beats/min), respiration rate (breaths/min), cyanosis (bluish skin color), jaundice (yellowing of the skin), and enlarged lymph nodes (redness of the skin) were not significantly different across the groups that were tested.

On the contrary, Guilbert et al.,[8] who 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 in Group-(SC), the mean HB was 13.7±2.2(g/dl), the mean RBCs was 4.6±0.29(million/mcl), and the mean WBCs was 7.7±1.5(million/mcl). In Group-(IC), the mean HB was 12.6±2.3(g/dl), the mean RBCs was 4.8±0.59(million/mcl), and the mean WBCs was 7.9±1.06(million/mcl). When looking at HB, RBCs, and WBCs, the groups that were tested did not show any statistically significant differences.

Regarding complications between the studied groups, we found that in Group-(SC) no patient reported pneumothorax and no patient reported haematoma. In Group-(IC), there were 2(10%) with pneumothorax and no patient reported haematoma. There was no statistically significant difference between studied groups according to pneumothorax and haematoma.

Our results are supported by Lu et al. [7] who found no statistically significant variation in complications across the groups studied.

Also, Mahmoud et al.,9 who sought to compare the two methods of ultrasonography-guided right subclavian vein catheterization in intensive care unit (ICU) and major elective surgery patients, found that 210 patients (105 in each Group) underwent right subclavian vein catheterization using either the supraclavicular or infraclavicular approach; no statistically significant difference was found in terms of pneumothorax or hemorrhage.

Similarly, Kim YJ et al.,[10] found no statistically significant distinction between infraclavicular and supraclavicular procedures regarding pneumothorax and hematoma.

On the other hand, Tarbiat et al.[11] They found that the study groups differed significantly with respect to the prevalence of hematoma at the puncture site, with the supraclavicular Group reporting a substantially greater rate than the infraclavicular Group.

Regarding distribution of 1ry outcome and 2ry outcomes between studied groups, our current study showed that in Group-(SC), the mean puncture time was 40.6±10.13(s), the mean total access time was 89.9±12.4(s), there were 14(70%) with first attempt success rate, 7(35%) with multiple attempts, 13(65%) Good quality of needle visualization, 7(35%) poor quality of needle visualization, the mean catheter insertion time was 133.5±11.35(s), 20(100%) no guidewire misplacement, the mean catheter insertion length was 5.8±1.4 (cm). In Group-(IC), the mean puncture time was 75.4±25.1(s). the mean total access time was 153.2±40.9(s), there were 11(55%) with first attempt success rate, 12(60%) multiple attempts, 8(40%) good quality of needle visualization, 12(60%) poor quality of needle visualization, the mean catheter insertion time was 129.8±10.5(s), 14(70%) no guidewire misplacement, the mean catheter insertion length was 7.3±2.4(cm)

There was no statistically significant difference between studied groups according to first attempt success rate, multiple attempts and quality of needle visualization and catheter insertion time(s), while there was statistically significant difference between studied groups according to puncture time(s) which significantly shorter in SC compared to IC group, total access time(s) which significantly shorter in SC compared to IC group, guidewire misplacement and catheter insertion length(cm) which significantly shorter in SC compared to IC group.

Our results matched with Byon et al.,[6] They found that the study groups differed significantly with respect to guidewire misplacement and insertion time, with the SC group reporting a significantly lower insertion time than the IC group. When it came to the success rate of first attempts and the amount of time it took to insert the catheter, there was not a statistically significant distinction between the groups that were evaluated.

In the same line Kim et al.,[10] in terms of first-attempt success rate and total catheterization time, no statistically significant variance was seen between supraclavicular and infraclavicular approaches.

Similarly, Momin et al,[12] according to those who conducted the study, Group SC had a substantially shorter access time than Group IC. This difference was found to be statistically significant.

Moreover, Mageshwaran et al.,[13] according to the paper, there was a statistically significant distinction between the groups in terms of guidewire misplacement and mean puncture time, with the SC group showing a much shorter duration compared to the IC group. When it came to the other variables, such as the number of tries and the total time it took to place the catheter, there was a statistically significant distinction between the groups.

As well, Saini et al.,[14] while the researchers

found no statistically significant variations in the two groups with respect to the success rate of first attempts or the quality of needle visualization, they did find a statistically significant difference in the length of the catheters inserted, with the IC group having considerably longer catheters.

4. Conclusion

When compared to the IC method, SCV catheterization in paediatric patients reduced guidewire misplacement and puncture time.

Disclosure

The authors have no financial interest to declare in relation to the content of this article.

Authorship

All authors have a substantial contribution to the article

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Conflicts of interest

There are no conflicts of interest.

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