Original Article

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Comparative Study of Central Venous Cannulation by Conventional Landmark versus USG Guided Technique in Paediatric Patients Undergoing Cardiac Surgery

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Abstract

Background: Central vein cannulation (CVC) in pediatric patients with congenital heart disease is a challenging task due to unpredictable altered anatomy. So the means to improve the success rate and minimize the complications of CVC must be sought after. **Material and Methods:** This prospective, randomized study involved 60 children divided into two groups (n=30 each). Children less than 12 years were included and those with any neck swelling and/or undergoing univentricular repair surgery were excluded. Patients were induced with oxygen:sevoflurane, midazolam (0.1mg/kg IV), fentanyl (5-10 mcg/kg IV) and Inj. pancuronium (0.1 mg/kg IV). Internal jugular vein was cannulated using conventional anatomical landmark technique in group I and using USG in the group II. Time of the procedure was calculated once painting and draping was done until cannulation of an IJV. Left IJV and femoral vein cannulation was performed in case of inability to cannulate right IJV. **Results:** The percentage of successful first attempt cannulation was 36.66% in landmark group whereas in USG group it was 73.33%. Mean number of attempts in both the groups were 2.03 ± 1.13 vs 1.37 ± 0.72 in the landmark and USG group respectively.(P=0.008) Time required for procedure was more in the USG group (45.17± 25.61 vs 68.7± 48.98 seconds).[P=0.023] Carotid artery puncture occurred in 43.3% cases in landmark group as compared to 10% in the USG group.[P=0.004]. **Conclusion:** Ultrasound guidance reduces the number of needle passes needed to puncture the vein, increase the overall success rate of venous puncture and minimizes complications such as arterial puncture or pneumothorax.

Keywords: Central vein; Ultrasonography; Landmark; Pediatric; Cardiac surgery.

Introduction

Central venous cannulation (CVC) is the cornerstone of monitoring during cardiac surgery because of the nature of the disease, cardiopulmonary bypass and post operative ICU stay.[1] Right internal jugular vein (IJV) is preferred for central venous cannulation because of its consistent, predictable anatomical location; short and straight course to the superior vena cava; position at the patient's head providing intra-operative accessibility and high success rate. But percutaneous cannulation of the internal jugular vein in pediatric patients may be technically difficult and is prone to complications. A good knowledge of anatomy does not always suffice when it comes to cannulation of IJV in pediatric patients especially in congenital heart diseases in which anatomy may be altered unpredictably. So cannulating an IJV of pediatric patient with congenital heart disease is a challenging task even in experienced hands.

Various methods and

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techniques have been described in literature so as to improve the success rate and minimize the complications of central venous cannulation.

This study represents our experience with two different techniques used for central venous cannulation viz. anatomical landmark guided technique versus ultrasonography (USG) guided technique with respect to safety, speed, feasibility and the complications.

Aims and Objectives

The purpose of this prospective randomized controlled study was to compare conventional landmark guided and USG guided central venous cannulation techniques with respect to number of attempts, time required, change of site and side along with the complications.

Materials and Methods

After institutional ethics committee approval and obtaining written informed consent from parent/guardian, 60 children undergoing cardiac surgery were randomly divided into two groups(n=30 each) by the sealed envelope technique. Internal jugular vein was cannulated using conventional anatomic landmark technique in group I and using USG in the group II. Children less than 12 years were included and those with any neck swelling and/or undergoing univentricular repair surgery were excluded.

After securing peripheral venous access, patients were induced with oxygen: sevoflurane, midazolam (0.1mg/kg IV), fentanyl (5-10 mcg/kg IV) and Inj. pancuronium (0.1 mg/kg IV) and airway was secured with proper sized portex endotracheal tube. A peripheral arterial (femoral or radial) cannulation was done for invasive blood pressure monitoring. For IJV catheterization, all patients were placed in 150 Trendelenberg position and shoulder pad was kept to achieve extension of the neck and strict aseptic precautions were followed.

In group I, an IJV was approached by conventional anatomical landmark technique i.e. using the triangle formed by the two heads of the sternocleidomastoid muscle and the clavicle beneath; puncture was made just lateral to carotid artery at the level of cricoid cartilage and the needle was directed downwards, forward and towards ipsilateral nipple while creating negative pressure in syringe till venous blood was aspirated and the IJV was accessed by Seldinger technique. Position of the catheter was confirmed by aspirating venous blood through all three lumens.

In group II, an IJV was approached under USG guidance where an assistant used to hold the linear USG probe on the neck of the patient in such a way that the thyroid gland, carotid artery and internal jugular vein were visualized on USG monitor and then the needle was advanced towards IJV under continuous USG guidance until venous blood was aspirated and then the same procedure as in group I was followed to insert the triple lumen catheter.

We defined ‘time’ of the procedure from the time of painting and draping till insertion of central venous catheter into the vein.

In both the groups, skin hematoma due to carotid artery puncture was considered as indication for changing over to either left IJV or femoral cannulation. The operator was experienced and constant throughout the study.

All data are presented as mean + SD and analyzed using SPSS 16 software by

computing percentages and descriptive statistics viz. mean, standard deviation and standard error of mean. The difference in mean between two groups was tested using independent Student's t-test and Chi-square test and P value <0.05 was considered significant.

Observations and Results

Patients in both groups were comparable with regard to demographic data, i.e., age, sex, height, weight and body mass index [Table 1].

The percentage of successful first attempt cannulation was 36.66% in landmark group whereas in USG group it was 73.33%. Also 40% and 13.3% patient required second and third attempt respectively for successful cannulation in landmark group as compared to 20% and 3.3% in USG group. A maximum of five attempts were required in landmark technique compared to four attempts in USG group. [Table 2] Significantly less number of

Table 1: Demographic parameters

Parameter	Mean± SD		P value
	Landmark technique	USG technique	
Age (months)	31.33 ± 24.15	38.56 ± 28.98	0.29
Sex (Male/Female)	16/14	16/14	0
Weight (kg)	9.6 ± 4.72	10.73 ± 4.99	0.37
Height (cms)	69 ± 20.09	79.4 ± 22.18	0.068
BMI (kg/m^2)	20.37 ± 5.57	17.19 ± 4.78	0.02

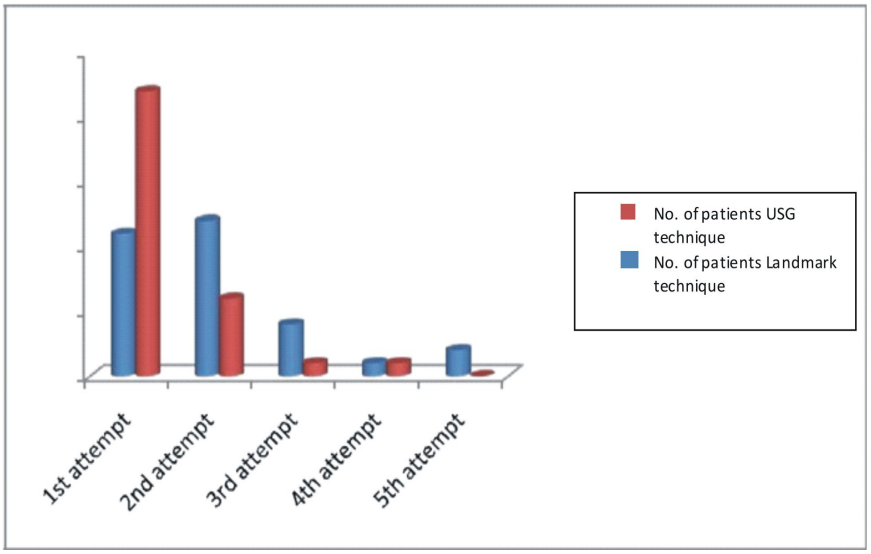
Table 2: Comparison of study parameters

Parameter	Mean± SD		P value
	Landmark technique	USG technique	
Number of attempts	2.03 ± 1.13	1.37 ± 0.72	0.008
Time required for procedure (seconds)	45.17± 25.61	68.7± 48.98	0.023
Change of skin puncture site	18/30 (60%)	4/30 (13.3%)	
Change to left side	6/30 (20%)	1/29 (3.3%)	0.04
Change over to femoral vein cannulation	5/25 (16.7%)	1/29 (3.3%)	0.08
Accidental carotid artery puncture	13/30(43.3%)	3/30 (10%)	0.004
Accidental pneumothorax/ hemothorax	0	0	0

Table 3: Number of attempts required for successful cannulation

Successful cannulation in	No. of patients		Total
	Landmark Technique	USG technique	
1st attempt	11	22	33
2nd attempt	12	6	18
3rd attempt	4	1	5
4th attempt	1	1	2
5th attempt	2	0	2

Bar diagram: Successful cannulation of IJV; comparison of number of attempts in 2 groups



attempts were required with USG for successful cannulation (P=0.008).

None of the patients had any complication like pneumothorax or hemothorax related to insertion of the catheter in either technique.

Discussion

Internal jugular vein is the most popular site for central venous cannulation because it is superficial, easily accessible, definite external anatomical landmarks and lower incidence of complications.[2] Although there are many effective methods to achieve IJV cannulation, there are very few quantitative data that identify the optimum conditions for successful placement of central venous access.[3]

The specific anatomical relationship between the internal jugular vein and carotid artery has previously been well elucidated[4] and it is reported that anatomical variation in the position of the internal jugular vein in adults may complicate venous access when a landmark-guided approach was used.[2,5]

Also, in morbidly obese patients, in whom the landmarks of the neck are obscured and in paediatric patients too; internal jugular catheterization is difficult as children may have anomalous venous anatomy that accounts for some of the difficulties.[6,7] The diameter of the internal jugular vein was predicted poorly by the patient's age or weight. In practice, surface markings are always not reliable means of locating the internal jugular vein as its position, particularly in a lateral plane tends to vary considerably.[3]

The insertion of central venous lines is not without hazard and carries the potential for serious complications. The occurrence of these complications has been the stimulus for the continuing search for safer routes of access which lead to the use of ultrasound to assist cannulation of the internal jugular vein.[5,8] Ultrasound has been used to assess the normal IJV anatomy to refine the technique of percutenous cannulation of IJV.[7] Ultrasound has been evaluated as an adjunct to central venous access under routine

circumstances of CVC.[8]

In this study, two different techniques were employed, viz. anatomical landmark guided technique vs ultrasound guided technique. This study took various anthropometric measurements and anatomical parameters into considerations to know whether any of these have significance in either of the techniques compared.

We found that 73.33% IJV's in the USG group were cannulated in the first attempt compared to 36.66% in landmark group. This finding is in concordance with the other studies[4,7,9-11] and is related to the fact that IJV was cannulated under vision with the USG.

Majority of the patients (40%) in the landmark group required second attempt for successful cannulation. Agarwal *et al*, 12 required more than one attempt in 12.5% patients with USG compared to 32.5% in landmark group. Curt D *et al* 10 reported fourth attempt (39.8%) and second attempt (15.1%) in landmark group vs fourth attempt (20.2%) and second attempt (17.7%) in USG group for cannulation.

Also the number of attempts taken for successful cannulation was significantly lower with USG technique (1.37 ± 0.72 vs 2.03 ±1.13).

Agarwal A *et al*[12] and Turker G *et al*[13] also reported similar results in their study.

Though the time required to cannulate an IJV was longer with USG guided technique; it was clinically insignificant and can be ascribed to the extra time needed to make a probe sterile before placing it on the concerned area of the neck and also we counted 'time' from the time when painting and draping was finished. Curt D *et al* 10 found 269 seconds in landmark group versus 150 seconds in USG group. Agarwal A *et al*[12] required 176.43 seconds ± 23.48 in landmark group versus 145 seconds ± 16.98 in USG group. Slama M *et al*[11] needed 235 seconds ± 408 in landmark group versus 95 seconds ± 174 in USG group. Such a big variation in time required could be ascribed to different definitions of 'time' in different studies. Also we think that the high volume of cases at our centre and familiarity with landmark technique resulting in greater level of expertise have contributed to this result.

We changed the puncture site in 60% patients in landmark group but only 13.3% in USG group required the same. Also incidence of cannulation of left IJV (because of inability to cannulate right IJV or because of complications) and femoral vein cannulation (because of inability to cannulate left IJV) was significantly high in landmark group (20% vs 3.3% and16.7% vs 3.3% respectively) in USG group. No other study in literature compares these parameters which denote the precision of the USG guided technique.

The carotid artery was punctured in 43.3% in landmark technique compared to 10% in ultrasound guided technique in our study which is similar to Troianos *et al*[4] who reported carotid puncture in 8.43% in landmark group and 1.39% in USG group. Curt D *et al*[10] had 19.4% carotid puncture in landmark group.[4,10-14] The higher rate of carotid artery puncture in landmark technique in our study can be ascribed to age group of patients, as anatomical landmarks are poorly defined in pediatric population.

None of the patients in either group had pneumothorax. Dimitrois K *et al*[14] report 2.4% cases of pneumothorax in landmark group versus 0% in USG group. Turker G *et al*[13] report 0% case of pneumothorax in either group. Agarwal A *et al*[12] report 2.5% cases of pneumothorax in landmark group versus no cases of pneumothorax in USG group.

No other complication was noted in our study in either group. Dimitrois *et al*[14] report 1.7% cases of hemothorax in landmark group. This shows the safety of USG guided IJV cannulation.

We also studied different complications in two groups according to patients BMI class. There was no significant difference in rate of complications according to BMI class.

Limitations

We did not consider coagulation profile of patients in our study as deranged coagulation parameters in patients with congenital cyanotic heart disease is expected[15] and central venous catheterisation could not be withheld in them.

Our study did not make any comparison of various degrees of rotation of the head and the size of IJV. Multiple other studies describe effects of different manoeuvres on IJV calibre like Valsalva manoeuvre, Tredelenburg position and hepatic compression etc. Sulek et al 16 has studied that more than 40 degree of head rotation to the left has changed the relationship of IJV with carotid artery from lateral to anterior. This could have resulted in more number of carotid artery puncture complications.

The Valsalva manoeuvre increases the diameter of IJV by about 126% as studied by M. Leon Skolnick[17] was not used in our study for the facilitation of IJV cannulation; since the patients included in our study had underlying cardiac disease and Valsalva manoeuvre would cause undesirable hemodynamic changes.

Conclusion

The study validates that ultrasound-guided technique is superior, safe and improves over the traditional landmark-guided technique for the cannulation of internal jugular vein.

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