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KEY WORDS:
Transoesophageal Echocardiography, Central venous catheter, Superior vena cava, Right atrium, Ultrasound guided, Right jugular vein

TRANSOESOPHAGEAL ECHOCARDIOGRAPHIC EVALUATION OF RIGHT INTERNAL JUGULAR CENTRAL VENOUS CATHETER POSITION: A PROSPECTIVE RANDOMISED STUDY OF COMPARISON OF PERES FORMULA, MODIFIED PERES FORMULA (KANCHI METHOD) AND RADIOLOGICAL LANDMARK BASED APPROACH IN INDIAN SUBCONTINENT POPULATION

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ABSTRACT

Introduction: Ideal position of catheter tip is considered to be at the junction of right atrium with lower superior vena cava (RA-SVC), for monitoring and administration of vasoactive drugs. The rationale of performing this study was to determine the method which was the most efficacious for positioning the CVC at the SVC-RA junction. We compared the Peres, Kanchi and Radiological landmark methods for accurate placement of tip using transoesophageal echocardiography and to determine which method out of the three was the most efficacious. **Methods:** Right internal jugular central venous catheter insertion was performed among patients who were randomly assigned to three groups; group-P (Pere's method; n=100), group-K (Kanchi method; n=100) and group-R (Radiological Landmark; n=100). The method of determination of ideal catheter tip position was considered to be within 2cm above and 1cm below the RA-SVC junction. Catheter tip position, abutment, angle to vascular wall, and flow stream were evaluated on bicaval view. **Results:** The mean distance from skin insertion point to RA-SVC junction assessed by TOE and mean determined length of catheter insertion were 16.74 ±0.78 cm and 15.53±0.40 cm in group-P; 14.71±0.76cm and 12.9±0.34 cm in group-K; and 15.92±1.1cm and 14.78±0.94cm. in group-R, respectively. The correlation coefficient was 0.60 in group-P, 0.4 in group-K and 0.81 in group-R. Abutment of the tip, angle to lateral wall, and disrupted flow stream were comparable in all groups. **Conclusion:** The radiological technique was more accurate than Peres and Kanchi method for catheter tip positioning.

INTRODUCTION

During perioperative period central venous catheters (CVC) are placed in patients for infusion of fluids, blood products and vasoactive drugs and to monitor venous pressure. Incorrect tip position can lead to serious complications such as cardiac tamponade, perforation or dysrhythmia caused by interaction with the vessel wall or endocardium.[1,2] It is advocated that the catheter tip should be at the junction of the right atrium (RA) and SVC (SVC-RA) junction to prevent risks like haemothorax, cardiac tamponade, puncture of cardiovascular organs.[3] The rationale of performing this study was to determine among commonly used methods which one would be the most efficacious method for right IJV cannulation at the SVC-RA junction.

Pere's formula is simple to use and easy to remember in traditional landmark based central venous catheterization.[5] Muralidhar et al., have advocated insertion of the CVC in the right internal jugular vein at a distance derived by dividing patient height (cm) by 12cm.[9] The aforementioned methods only determine the length up to which the CVC can be inserted in the right IJV for positioning it near the SVC-RA junction. But, by these methods, one cannot determine a safe point of skin puncture from where the CVC can be positioned safely at or near SVC-RA junction. To solve this problem a new formula called Radiological landmark technique was used by JH Ahn and colleagues to position the catheter tip close to SVC-RA junction after taking anatomical landmarks into consideration.[8]

The primary aim of this study was to compare the Peres's technique, Radiological landmark technique, modified Peres's technique (described by Kanchi et al) and to determine which method out of the three was the most efficacious in positioning the CVC at SVC-RA junction.

The secondary objective of the study was to provide a point of skin puncture from where, once the CVC was inserted, it would reach at or near the SVC-RA junction, hence avoiding any complications and hemodynamic monitoring problems. We took the help of Transoesophageal echocardiography (TOE) which is commonly used during cardiac surgeries, to verify position. TOE also helps to assess position and angle of catheter tip to vascular wall.

MATERIALS AND METHODS

This is a prospective randomized study conducted between March 2018 and October 2018 at our institution. Institutional ethics committee approval was obtained and written informed consent was taken from all the patients.

Inclusion Criteria

All patients of the age between 20 and 80 years, and height ≤160cm, who were posted for elective cardiac surgery.

Exclusion Criteria

Changes in mediastinal structure or neoplasm or any potential risk from TOE examination like oesophageal varices, fistula or stenosis, refusal to participate were excluded from study.

A central venous catheterization was done by real time ultrasound guidance. It is institutional protocol to do CVC catheterization under ultrasound guidance. The site for catheterization was at right internal jugular vein (IJV) as the study was conducted in cardiac centre where right IJV is commonly cannulated for central venous pressure measurement. Baseline subject characteristics like age, gender, height and weight were recorded. Since the maximum length of the CVC is 16 cm, for the purpose of using Pere's formula, we didn't include patients whose height was greater than 160 cm.

Patients grouping

Patients were randomized to three groups; group-P (Pere's method), group-K (Kanchi method) and group-R (Radiological landmark method) preoperatively. For each group we had included 100 patients. After induction of general anaesthesia, patient was intubated and ventilated to maintain normocapnia. For catheterization of IJV, each subject was placed in 10-degree Trendelenburg position with their head turned to left. The point of skin puncture was at the level of cricoid cartilage just lateral to the right common carotid artery in all three groups. After sterile preparation and draping, a 7 Fr, 16cm long triple lumen CVC was inserted with the modified Seldinger method in the right IJV.

In the group-P, after skin puncture, a commercially available guide wire (total length of 45 cm that comes with triple lumen) was inserted and advanced with the J-tip pointing downwards. The length was determined in the group-P using formula height /10. The ideal length was calculated as the length from the curve of the J-tip to the point of guide wire exposed at the skin insertion. An exposed guide wire length between the skin insertion site and rest of the length outside

the skin was determined using a sterile ruler. Ideal depth was determined by subtraction of this exposed length from total of 45 cm length.

In the group-K patients' same method as group-P was followed. In this group length was determined using the formula height /12cm.[5] In the aforementioned techniques, the point of skin puncture is at the level of cricoid cartilage just lateral to the right common carotid artery.

In group-R, right sternoclavicular joint was chosen as landmark. The vertical length from the right sternoclavicular joint to carina was measured from routine preoperative chest-X-ray using internal measuring tool available on picture archiving and communication system (PACS) (Fig1).

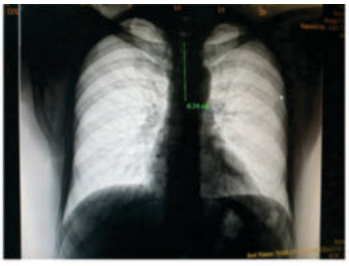


Fig1

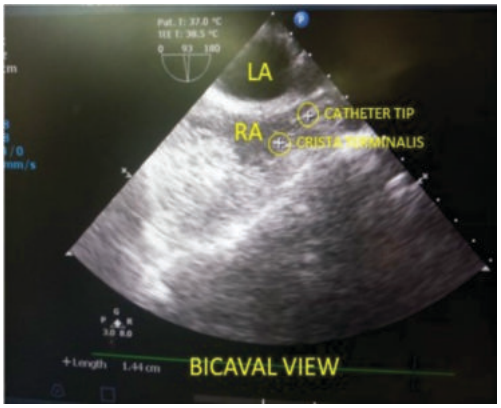
Radiological Landmark group: In R group, right sternoclavicular joint was chosen as landmark. The vertical length from midpoint of the sternoclavicular joint to carina was measured from routine preoperative chest Xray using internal measuring tool available on picture archiving and communication system (PACS) Fig1.

A point was chosen lateral to the right common carotid artery at the level of the cricoid cartilage, and the length from that point till the right sternoclavicular joint is measured. These two lengths were summated and 1.5 cm was added to it. The final length was the length up to which the CVC could be inserted, so that it would be positioned at or near the SVC-RA junction. (Fig2).

The insertion depth was measured by sum of measurements for the surface distance, vertical length from the midpoint of sternoclavicular joint and an additional 1.5cmFig2.

The ideal length was calculated by same method by deducting the measured distance in between j-tip and skin insertion point from total length.

The TOE examination was performed by one anaesthesiologist who was blinded to catheter insertion depth or method had been followed. In all groups, bicaval view of TOE identified the location of J tip in relation to SVC-RA junction Fig3.



In all three groups, once guide wire was advanced and secured at the calculated depth, the bicaval view of TOE was taken to identify the location of J-tip in comparison to SVC-RA junction. The area within 2cm above and 1cm below the SVC-RA was considered as the target zone. The optimum position was inserting the j-tip to the calculated depth within target zone. The ideal length was calculated as keeping the J-tip under TOE guidance at SVC-RA junction and then the length which remains outside was measured using sterile ruler. This outside measured length was subtracted from total length of 45 cm to get the length. The difference between ideal and calculated length was measured to find out the p value. Catheter was examined to find out whether it was located centrally in the lumen or abutted to the wall. With the normal saline flush, it was observed whether microbubbles were hitting the wall or not. If the catheter abutted the vascular wall, angle was more than 40-degree, position was regarded as risky.

Statistical analysis: Statistical analysis was assessed by SPSS version 22 from IBM. Continuous variables are expressed in terms of mean ± SD and categorical variables by frequencies or percentages. To compare the continuous variable in between three groups ANOVA test was used. Chi square test was used to compare the designated variables. Pearson's correlation coefficient was calculated to represent the relationship between ideal distance from the skin insertion point to the SVC-RA junction and calculated depth of catheter insertion in each group. A p value <0.05 was considered statistically significant.

For selecting patients in each group, we had followed simple randomization which was done by picking up chits. Every time chits were picked up by a person who did not have any interest or participated in the study

Sample Size

We were expecting the 13% better result in radiological Landmark Group in echocardiographic assessment of catheter tip location as compared to the other two methods, assumed precision as 5% and with 99% confidence interval the minimum required sample size is 292.

Formula

Sample size, $n = [Z^2_{1-\alpha/2} * p * (1-p)]/d^2$ where

p : Expected proportion

$Z^2_{1-\alpha/2}$: Confidence interval

d : Precision

Calculation

Sample size, $n = [2.57^2 * 0.13 * (1-0.13)]/(0.0.05)^2$

$= 292$

RESULTS

A total of 300 patients were studied (100 in each group) who had undergone triple lumen CVC insertion as a routine procedure for cardiac surgeries. Patients who were randomised for the study were included since no one denied to participate. The patient demographics and clinical characteristics are mentioned in table 1. The mean distance from skin insertion point to the RA-SVC junction assessed by TOE in all groups. The length of CVC insertion was the further than SVC-RA junction in groups P, followed by near to SVC-RA junction in group R, and proximal to SVC-RA junction to group K. (table 1). The relationship between the actual distance from RA- SVC junction and the calculated length of catheter insertion was compared in three groups and the difference between them was statistically significant p <0.001. The correlation coefficient in group-P, group-K and group-R were 0.60, 0.41 and 0.81 respectively. The catheter insertion length was strongly correlated with calculated length in group-R in comparison to other two groups. The optimal positioning was achieved in 77% patients in group-P, 72% patients in group-K, and 87% patients in group-R.

The number of CVC tips positioned proximal to the target

zone was 24 in group-P, 28 in group-K and 10 in group-R, which was statistically significant. Abutment of the CVC tip to the lateral wall of SVC was comparable between all the groups. It was evident on TOE examination, that, the patients where flow stream had hit the SVC wall were more in group-P and group-R, but none in group-K. `

DISCUSSION

In our study we have compared the formula of determining the length of CVC insertion by radiological landmark guidance (summating the carina-sternoclavicular joint distance and sternoclavicular joint-the point at the level of cricoid cartilage just lateral to common carotid artery distance; then adding 1.5 cm to this value), with Peres's method and Kanchi method. Our study as primary objective demonstrates that the length of insertion of CVC for ideal positioning, derived from the radiological and TOE guidance, is more precise for accurate positioning. The relationship between the actual distance from SVC-RA junction and the calculated length of catheter insertion was compared in three groups which was statistically significant p <0.001. The correlation between the actual length of CVC insertion and the calculated length of CVC insertion was maximum in the group R, and lowest in the group K. The number of patients in whom the desired position was achieved were greater in group R, followed by group P, and the least in group K. The patients in whom the CVC tip reached distal to SVC-RA junction were more in group P, very few in group R, and there were no such cases in group K. The number of patients where the CVC tip lied proximal to the SVC-RA junction were highest in group K, followed by group P, and the least in group R. It can be inferred from the aforementioned findings that the length of CVC insertion calculated by the Kanchi method provided such values which didn't lead to positioning the CVC tip beyond the SVC-RA junction. The only inaccuracy caused by the Kanchi method led to positioning the CVC tip proximal to the SVC-RA junction. This is a merit of the technique from the perspective of safety. Whereas, Peres's technique led to positioning of the CVC tip proximally as well as distally, which is a demerit in terms of accuracy. Though the incidence of flow stream hitting vascular wall was more in Peres and Radiological landmark technique, there were no complications like perforation. In group R, the number of patients having CVC tip positioning distal as well as proximal to the SVC-RA junction were very few and it was the highest in number to be positioned near to the desired SVC-RA junction amongst the three groups. Thus, our study findings demonstrate that the CVC insertion by means of radiological landmark is the most efficacious technique compared to Peres's and Kanchi method in Indian subcontinent.

In all patients the point of needle insertion was at the level cricoid cartilage just lateral to common carotid artery distance and thus our study followed a uniform insertion point as secondary objective. Our findings were similar to original study by J.H. Ahn et al [8] which also reported radiological landmark-based technique was more accurate than Pere's formula to locate catheter technique.

The original study, was conducted in non-Asian population, but our study shows that it's equally applicable in Indian subcontinent population. Length of CVC insertion strongly correlated with the calculated length in group-R in comparison to other two groups. In clinical practice, verification of catheter tip happens post-operatively once the chest radiograph which is identified by characteristic widening of right mediastinal border or high up in the RA away from tricuspid valve.[4] On the other hand, one more recommendation is that catheter tip should be no more than 2cm below a line joining lower borders of medial ends of clavicle on a posterior-anterior (PA) chest radiograph.[5] .Optimal positioning of CVC in the right sided internal jugular vein was done comparing with P wave normalisation on electrocardiography (ECG)[6]. Among all described methods have own limitation though assessing by echocardiography is more accurate where SVC-RA junction is at the base of superior edge of crista terminalis[6]

Previous studies analysed the techniques to calculate the distance between the carina and SVC-RA junction. The right trachea-bronchial angle used as landmark for RA-SVC junction was located at least 2.9 cm above SVC-RA junction.[7] Another study showed the mean distance from right tracheobronchial angle till carina was 0.87 cm on computerised tomography (CT) imaging.[10] In another CT imaging study, the mean SVC length was 6.5 cm, the carina was located at a mean distance of 1.3 cm below the midpoint of SVC.[11] Taking these measurements into consideration, JH Ahn and colleagues,[8] devised a formula to calculate the distance from the point of skin insertion till carina on preoperative chest radiographs and the distance from the point of skin insertion till SVC-RA junction on TOE in a pilot study of 30 patients. The mean difference amongst the two values (the distance between the carina and SVC-RA junction) was 2.6 (1.1) cm. Depending on pilot study finding and from other researches, JH Ahn et al,[8] concluded that a minimum length to locate catheter tip near RA-SVC junction was 1.5 cm from carina and devised a formula adding this length from carina.

Our study has several strengths. Radiological landmark technique is a new concept and we have compared this technique with Kanchi and Pere's method whereas original study was done with Pere's method only. It's cost effective since no added cost or funding was required.

There are few limitations in this study. We couldn't include patients taller than 160 cm, because of unavailability of CVC longer than 16 cm. We could not assess the positioning of CVC by the radiological guidance for subclavian vein, since right IJV cannulation is the standard protocol of our institute.

CONCLUSIONS

We conclude that the merits of the radiological guidance for CVC insertion were more than Peres and Kanchi method. TOE guidance is beneficial in reducing the complications like perforation and abutment of CVC.

Tables

Table 1: Basic Demographics And Clinical Charac-teristics Comparison In All Three Groups.

	Kanchi Method (n=100) (mean ± SD)	Peres (n=100) (mean ± SD)	Radiological Land Mark (n=100) (mean ± SD)	p
Gender Male Female	 51 49	 34 66	 47 53	0.041
Age (years)	53.32 ± 12.30	51.47 ± 12.16	50.04 ± 12.19	0.199
Height (cm)	156.21 ± 4.23	155.43 ± 4.01	155.94 ± 3.89	0.384
Weight (kg)	62.6 ± 9.99	59.49 ± 6.75	61.60 ± 7.30	0.017
Distance from skin insertion to RA-SVC junction (A) (cm)	14.71 ± 0.76	16.74 ± 0.78	15.92 ± 1.18	<0.001
Length of CVC insertion (B) (cm)	12.99 ± 0.34	15.53 ± 0.40	14.78 ± 0.94	<0.001
Correlation between A & B	0.41	0.60	0.81	-

Number of cases below position	--	10	2	0.001
Position target zone below		1.37 ± 0.41	0.85 ± 0.64	0.157
Number of cases above position	28	24	10	0.004
Position target zone above	1.66 ± 0.72	1.08 ± 0.45	1.09 ± 0.64	<0.001
Optimal Position Yes No	 72 28	 77 13	 87 13	0.031
Abutment to Vascular Wall Yes No	 3 97	 3 97	 3 97	1.000
Angle trip Yes No	 2 98	 1 99	 3 97	0.607
Flow stream hitting vascular wall Yes No	 0 100	 5 95	 4 96	0.091

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