Comparison of Peres’ Formula and Radiological Landmark Formula for Optimal Depth of Insertion of Right Internal Jugular Venous Catheters

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ABSTRACT

Background: Central venous catheterization is a vital procedure for volume resuscitation, infusion of drugs, and for central venous pressure monitoring in the perioperative period and intensive care unit (ICU). It is associated with position-related complications like arrhythmias, thrombosis, tamponade, etc. Several methods are used to calculate the catheter insertion depth so as to prevent these position-related complications.

Objective: To compare Peres’ formula and radiological landmark formula for central venous catheter insertion depth through right internal jugular vein (IJV) by the anterior approach.

Materials and methods: A total of 102 patients posted for elective cardiac surgery were selected and divided into two equal groups—Peres’ group (group P) and radiological landmark group (group R). Central venous catheterization of right IJV was done under ultrasound (USG) guidance. In group P, central venous catheter insertion depth was calculated as height (cm)/10. In group R, central venous catheter insertion depth was calculated by adding the distances from the puncture point to the right sternoclavicular joint and on chest X-ray the distance from the right sternoclavicular joint to carina. After insertion, the catheter tip position was confirmed using transesophageal echocardiography (TEE) in both the groups.

Results: About 49% of the catheters in group P and 74.5% in group R were positioned optimally as confirmed by TEE, which was statistically significant. No complications were observed in both the groups.

Conclusion: Radiological landmark formula is superior to Peres’ formula for measuring optimal depth of insertion of right internal jugular venous catheter.

Keywords: Peres’ formula, Right internal jugular vein, Transesophageal echocardiography.

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INTRODUCTION

Central venous catheterization (CVC) is a vital procedure in major surgeries and also in critically ill patients for volume resuscitation, central venous pressure (CVP) monitoring, hemodialysis, long-term hyperalimentation, and infusion of vasoactive or inotropic drugs. Nevertheless, the CVC is associated with procedure-related complications like pneumothorax, hemothorax, carotid artery puncture and hematoma, infection, and position-related complications like arrhythmias, cardiac tamponade, and thrombosis.1-3 To prevent these complications, the superior vena cava-right atrium (SVC-RA) junction is considered the optimal position for the central venous catheter tip.4,5 Several methods are used to measure depth of catheter insertion. They include Peres’ formula, landmark formula, and electrocardiogram guidance method.

Peres’ formula is calculated as height (in cm)/10 for the right internal jugular vein (IJV). It is simple, widely used, and easy to remember, but the drawback is in some cases the catheter tip may be positioned in the right atrium leading to arrhythmias and cardiac tamponade. Radiological landmark formula takes into consideration the right sternoclavicular joint and the carina. The sternoclavicular joint can be palpated superficially on the skin. On chest radiograph, carina can be identified easily and it corresponds to the SVC-RA junction.6,9 Using these anatomical landmarks, catheter insertion depth can be measured by adding the distances from the puncture to the midpoint of the sternoclavicular joint and from the midpoint of the sternoclavicular joint to the carina.10,11 The advantage being the depth of insertion of catheter is according to the anatomical relationship.

The positioning of the central venous catheter tip is very important considering the complications associated with the procedure. Several methods are used to confirm the catheter tip position such as postprocedure chest radiograph, fluoroscopy, and transesophageal echocardiography (TEE). Post-procedural chest radiograph is commonly used to verify the catheter tip position.
but it is time-consuming, cannot be used to identify abnormal tip position during the procedure allowing the malposition to go unrecognized in the perioperative period, and there is exposure of patients to radiation.\textsuperscript{13} Fluoroscopy can be used during the procedure and can guide the catheter tip in the right position, but it is associated with radiation exposure. It can be used only in catheterization laboratories or in places where a portable C-arm is available and is expensive. Transesophageal echocardiography has advantages of no exposure to radiation, visualization of the catheter tip during the procedure and simultaneous recognition of malposition during insertion of catheter, and can be used in the operating room and intensive care unit. But it is expensive and needs expertise.\textsuperscript{13,14}

The main objective of our study was to compare Peres’ formula and radiological landmark formula for central venous catheter insertion depth through right IJV by the anterior approach.

**Materials and Methods**

This was a prospective randomized comparative study conducted at JSS Hospital from November 2017 to June 2019. After the institutional ethical committee approval, 102 patients meeting the inclusion criteria posted for elective cardiac surgery for whom CVC and TEE examination were planned to monitor and evaluate cardiac function and structure were selected and divided into two equal groups using computer-generated tables. A written informed consent was taken. The sample size of 102 patients was calculated based on a previous study by Ahn et al.\textsuperscript{10} keeping the power of 80% and level of significance 5%. Patients of either sex aged more than 18 years with an informed written consent posted for elective cardiac surgery were included in the study. Patients with history of previous neck surgery, abnormal anatomy of the neck and chest wall, esophageal varices, and coagulopathy were excluded.

Demographic data including age, sex, height, weight, and BMI were recorded in a specified proforma. Routine preoperative investigations as a part of cardiac surgery workup were done. In the operating room, under continuous monitoring of vitals with strict aseptic precautions, CVC of right UVJ was done under ultrasound (GE LOGIQ P6) guidance using a high-frequency linear probe.

In both the groups, the entry point was at the apex of the triangle formed by medial and lateral heads of the sternocleidomastoid muscle and the clavicle. In group P, the catheter insertion depth was measured using Peres’ formula as height (in cm)/10 and the catheter was secured at measured distance. In group R, the distance from the entry point to the midpoint of the right sternoclavicular joint was measured using a sterile ruler during the UVJ catheterization procedure and distance from the midpoint of the right sternoclavicular joint to the carina was measured from the picture archiving and communication system (PACS) from the routine preoperative chest radiograph (Fig. 1). Catheter insertion depth was calculated by adding these two distances and the catheter was inserted accordingly.

After the insertion of CVC through right IJV in both group of patients, a multiplane TEE (Philips HD11XE) probe was inserted into the esophagus after induction of general anesthesia and a mid-esophageal bicausal view was obtained by rotating the transducer at 80–110° and turning the probe to the right and the position of the catheter tip in relation to the RA-SVC junction was identified. The RA-SVC junction on echocardiography was identified as the base of the crista terminalis (Fig. 2). The area within 2 cm above and 1 cm below the RA-SVC junction was considered the optimal zone.

If the catheter tip was found within this zone, then the position of catheter was considered to be optimal. Parameters studied included catheter insertion depth and catheter tip position using TEE.

Inferential and descriptive statistics were used in our study. Continuous variables were represented as mean ± standard deviation (SD). Categorical variables were represented as numbers or percentage when appropriate. Continuous variables were compared using the independent t-test and categorical variables were compared using the chi square test. All the measurements were done using the SPSS 24.0 software. \(p\) value < 0.05 was considered statistically significant.

**Results**

The demographic data are presented in (Table 1). There was no difference between the two groups with respect to age, gender, height, weight, and BMI distribution (\(p\) value > 0.05) (Flowchart 1). The calculated mean catheter insertion depth in group P was 16.21 ± 0.82 cm and in group R was 12.71 ± 1.30 cm (Table 2). In group P, 49% of the catheters were in the optimal position and 51% in the suboptimal position. In group R, 74.5% of the catheters were in the optimal position and 25.5% in the suboptimal position (\(p\) value 0.008) (Table 3 and Fig. 3).

**Discussion**

In our study, radiological landmark formula was better than Peres’ formula for optimal depth of insertion of right internal jugular catheters.

The mean catheter insertion depth in group P was 16.21 ± 0.82 cm. This correlated with the previous studies done by Ahn et al.\textsuperscript{10} (16.4 ± 1.1 cm) and Joshi et al.\textsuperscript{7} (15.88 ± 0.88 cm). In group R, the mean catheter insertion depth was 12.71 ± 1.30 cm. This finding correlated with the Lee et al.\textsuperscript{11} (13 ± 1.6 cm) study. But the Ahn study had mean catheter insertion depth of 16.7 cm, which was slightly more than what was observed in our study.

A total of 25 out of 51 (49%) patients in the Peres’ group had optimal catheter position in our study. Joshi et al. in their study also had 52% of patients in the Peres’ group with optimal catheter position. A total of 38 out of 51 (74.5%) patients in the radiological landmark group had optimal catheter position in our study. Other studies conducted by Ahn et al.\textsuperscript{10} had 93% of optimal catheter position and 96.1% in Lee et al. study.

**Fig. 1:** PACS showing measurement of distance between sternoclavicular joint to the carina

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\[\text{Table 1: Demographic data} \]

| Age (years) | Gender | Height (cm) | Weight (kg) | BMI |
|------------|--------|-------------|-------------|-----|
| 21–40      | M      | 170         | 80          | 25  |
| 41–60      | F      | 165         | 70          | 22  |

**Table 2: Comparison of insertion depth**

| Group   | Mean ± SD (cm) | Optimal % | Suboptimal % |
|---------|----------------|-----------|--------------|
| P       | 16.21 ± 0.82   | 49%       | 51%          |
| R       | 12.71 ± 1.30   | 74.5%     | 25.5%        |

**Table 3: Comparison of catheter tip position**

| Group   | Optimal % | Suboptimal % |
|---------|-----------|--------------|
| P       | 96.1%     | 3.9%         |
| R       | 96.1%     | 3.9%         |

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\[\text{Flowchart 1: Study design} \]

\[\text{Fig. 2: Mid-esophageal bicausal view} \]
In our study, more catheters were positioned optimally in the radiological landmark group (74.5%) compared to the Peres’ group (49%). This finding correlated with the previous study conducted by Ahn et al. in 2017 who compared Peres’ formula and radiological landmark formula for central venous catheter positioning where 69 out of 93 (74%) catheters were positioned optimally in the Peres’ formula group and 88 out of 95 (93%) catheters were positioned optimally in the radiological landmark group (p value 0.001).

Peres’ formula for right IJV catheterization [height (in cm)/10] is easy, simple, and widely used but it does not take variable entry point, demographic data other than height and ethnicity with anatomical difference into consideration. Radiological landmark formula for right internal jugular venous cannulation takes into account the distance between the sternoclavicular joint and the carina, which is measured on PACS and the distance from the

![Image](https://via.placeholder.com/150)

**Fig. 2: Catheter tip and SVC-RA junction on a transoesophageal echocardiographic mid-esophageal bicaval view**

**Flowchart 1: Consort flow diagram**

| Demographic data | Group P | Group R | p value |
|------------------|---------|---------|---------|
| Age (years)      | Mean 56.8 | 55.8 | 0.7     |
|                  | Standard deviation 8.7 | 12 |         |
| Height (cm)      | Mean 162.1 | 160.1 | 0.3     |
|                  | Standard deviation 8.1 | 9.4 |         |
| Weight (kg)      | Mean 63.7 | 64.5 | 0.7     |
|                  | Standard deviation 11.9 | 8.7 |         |
| BMI (kg/m²)      | Mean 24.2 | 25.4 | 0.2     |
|                  | Standard deviation 4 | 4.4 |         |
| Sex              | Male 39 | 37 | 0.7     |
|                  | Female 12 | 14 |         |

**Table 2: Mean catheter insertion depth**

| Catheter depth (cm) | Group P | Group R | p value |
|---------------------|---------|---------|---------|
| Mean + SD           | 16.21 ± 0.82 | 12.71 ± 1.30 | <0.0001 |

**Table 3: Position of the catheter tip**

|                | Group P | Group R | p value |
|----------------|---------|---------|---------|
| Optimal        | Number  | 25 | 49.0 | 48 | 74.5 | 0.008 |
| Suboptimal     | Number  | 26 | 51.0 | 13 | 25.5 |         |
Comparison of Peres’ Formula and Radiological Landmark Formula

The skin entry point to the sternoclavicular joint, which is measured during catheterization. On chest X-ray, the carina corresponds to the SVC-RA junction, which is the optimal zone for the central venous catheter tip. This formula takes into consideration variable insertion point and anatomical landmarks.

The SVC-RA junction is considered the optimal position for the central venous catheter tip in our study. When the catheter tip in the upper or middle SVC, there is increased chance of venous thrombosis and migration of the catheter tip into azygous or innominate vein. When the catheter tip lies in the right atrium, there is increased chance of arrhythmias and cardiac tamponade.

There are many approaches for right IJV cannulation and the most commonly practiced approach is the anterior approach and thus we chose anterior approach for right IJV cannulation in our study.

Transeosophageal echocardiography, which is routinely used to monitor the structure and function of the heart intraoperatively, was chosen for confirming the catheter tip position in our study. Advantages of using TEE are no exposure to radiation, recognition of malposition during the procedure, and it can be used in operation theater and ICU. Drawbacks of TEE include a skilled practitioner is required and expensive. Nevertheless, it is considered the gold standard for confirming the catheter tip position and thus was used in our study for the same.

**Strength**

The strength of our study was that we used TEE, which is considered the gold standard for confirming catheter tip position in both the groups.

**Limitation**

The limitation of our study was that in our study only right IJV was chosen for catheterization, so the results of this study and the formulae will not be applicable for left IJV or subclavian vein catheterization. Further randomized trials are required to establish the accuracy of radiological landmark formula in other ethnical groups.

**Conclusion**

From our study, we conclude that radiological landmark formula is superior to Peres’ formula for measuring optimal depth of CVC through right IJV by the anterior approach.

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