

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

AR Manudeep¹, BP Manjula², US Dinesh Kumar³

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.

Indian Journal of Critical Care Medicine (2020): 10.5005/jp-journals-10071-23478

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).⁶ 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 atrium⁷ 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.^{8,9} 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

^{1,2}Department of Anaesthesia, JSS Academy of Higher Education and Research, Mysuru, Karnataka, India

³Department of Cardiothoracic and Vascular Anaesthesia, JSS Hospital, JSS Academy of Higher Education and Research, Mysuru, Karnataka, India

Corresponding Author: US Dinesh Kumar, Department of Cardiothoracic and Vascular Anaesthesia, JSS Hospital, JSS Academy of Higher Education and Research, Mysuru, Karnataka, India, Phone: +91-37722-37722, e-mail: drdinu80@gmail.com

How to cite this article: Manudeep AR, Manjula BP, Dinesh Kumar US. Comparison of Peres' Formula and Radiological Landmark Formula for Optimal Depth of Insertion of Right Internal Jugular Venous Catheters. *Indian J Crit Care Med* 2020;24(7):527-530.

Source of support: Nil

Conflict of interest: None

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.¹² 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.^{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 the previous study by Ahn et al.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 IJV 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 IJV 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 bicaval 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 \pm 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.¹⁰ (16.4 ± 1.1 cm) and Joshi et al.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.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. Joshi⁷ 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.¹⁰ had 93% of optimal catheter position and 96.1% in Lee et al.¹¹ study.

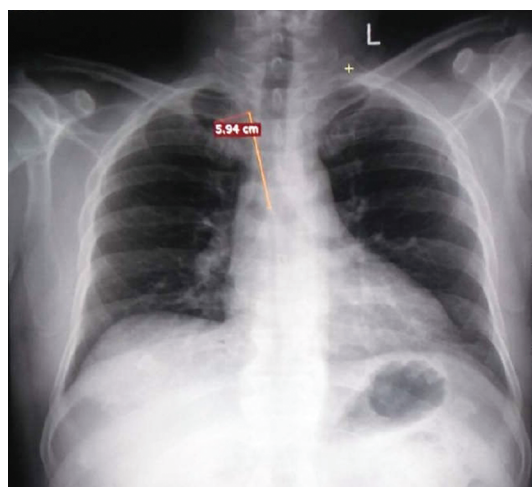


Fig. 1: PACS showing measurement of distance between sternoclavicular joint to the carina

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.¹⁰ 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

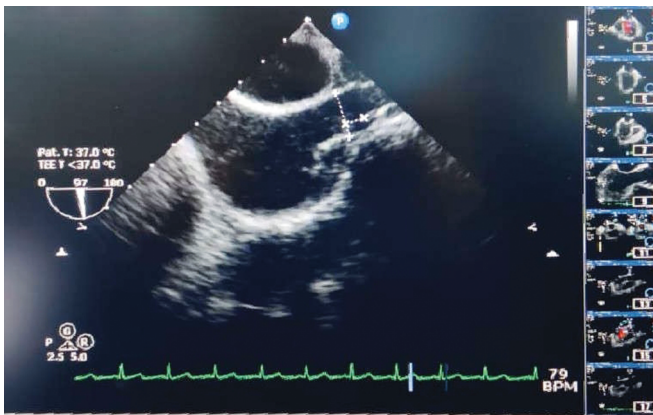


Fig. 2: Catheter tip and SVC-RA junction on a transoesophageal echocardiographic mid-esophageal bicaval view

Table 1: Demographic data

Demographic data	Group P	Group R	<i>p</i> 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/m ²)			
Mean	24.2	25.4	0.2
Standard deviation	4	4.4	
Sex			
Male	39	37	0.7
Female	12	14	

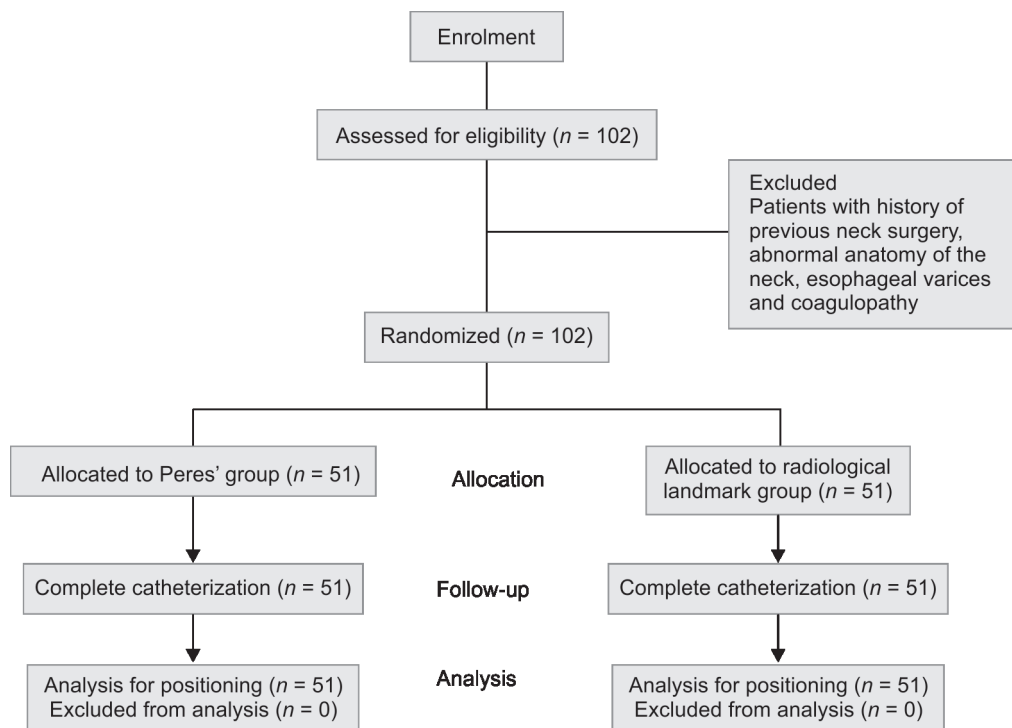
Table 2: Mean catheter insertion depth

	Group P	Group R	<i>p</i> value
Catheter depth (cm)	Mean + SD	Mean + SD	<0.0001
	16.21 + 0.82	12.71 + 1.30	

Table 3: Position of the catheter tip

	Group P		Group R		<i>p</i> value
	Number	%	Number	%	
Optimal	25	49.0	38	74.5	0.008
Suboptimal	26	51.0	13	25.5	

Flowchart 1: Consort flow diagram



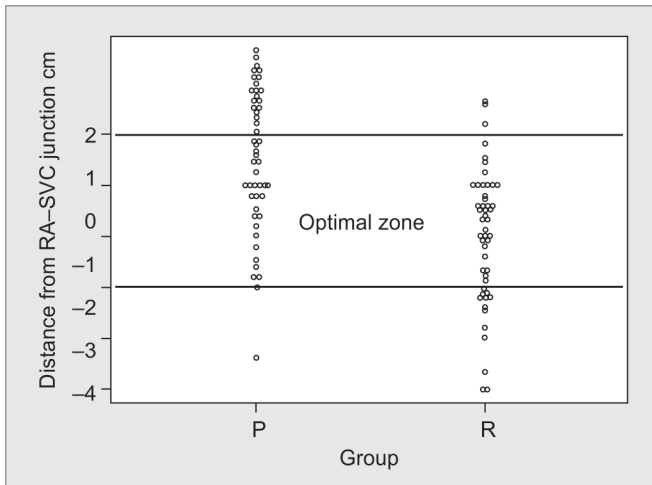


Fig. 3: Zero on the vertical axis represents SVC-RA junction. Negative values represent catheter tip placed above the SVC-RA junction and positive values below the junction

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.^{8,9} This formula takes into consideration variable insertion point and anatomical landmarks.¹¹

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.¹⁻³ But when the catheter tip lies at SVC-RA junction, there is less chance of these complications and proper monitoring of the central venous pressure can be done. Right IJV was chosen for catheterization in our study because the preferred site for central venous catheter insertion is right IJV for patients posted for elective cardiac surgery in our institute. It has predictable anatomical location; it is in line with the SVC and associated with least complications when compared to other sites. 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.

Transesophageal 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.^{13,14}

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.

ACKNOWLEDGMENTS

We acknowledge Dr Sumanth for his inputs on statistics. We also like to acknowledge the cooperation of patients and anesthesiologists.

REFERENCES

1. Chhabra L, Spodick DH. Complete heart block—an underappreciated serious complication of central venous catheter placement. *J Electrocardiol* 2012;45(6):790–792. DOI: 10.1016/j.jelectrocard.2012.06.005.
2. Robinson JF, Robinson WA, Cohn A, Garg K, Armstrong 2nd JD. Perforation of the great vessels during central venous line placement. *Arch Intern Med* 1995;155(11):1225–1228. DOI: 10.1001/archinte.1995.00430110149016.
3. Collier PE, Blocker SH, Graff DM, Doyle P. Cardiac tamponade from central venous catheters. *Am J Surg* 1998;176(2):212–214. DOI: 10.1016/S0002-9610(98)00171-8.
4. Vesely TM. Central venous catheter tip position: a continuing controversy. *J Vasc Interv Radiol* 2003;14(5):527–534. DOI: 10.1097/01.RVI.0000071097.76348.72.
5. Fletcher SJ, Bodenham AR. Safe placement of central venous catheters: where should the tip of the catheter lie? *Br J Anaesth* 2000;85(2):188–191. DOI: 10.1093/bja/85.2.188.
6. Peres PW. Positioning central venous catheters—a prospective survey. *Anaesth Intensive Care* 1990;18(4):536–539. DOI: 10.1177/0310057X9001800422.
7. Joshi AM, Bhosale GP, Parikh GP, Shah VR. Optimal positioning of right-sided internal jugular venous catheters: comparison of intra-atrial electrocardiography vs Peres' formula. *Indian J Crit Care Med* 2008;12(1):10–14. DOI: 10.4103/0972-5229.40943.
8. Schuster M, Nave H, Piepenbrock S, Pabst R, Panning B. The carina as a landmark in central venous catheter placement. *Br J Anaesth* 2000;85(2):192–194. DOI: 10.1093/bja/85.2.192.
9. Stonelake PA, Bodenham AR. The carina as a radiological landmark for central venous catheter tip position. *Br J Anaesth* 2006;96(3):335–340. DOI: 10.1093/bja/aei310.
10. Ahn J, Kim I, Yang J, Lee I, Seo D, Kim S. Transoesophageal echocardiographic evaluation of central venous catheter positioning using Peres' formula or a radiological landmark-based approach: a prospective randomized single-centre study. *Br J Anaesth* 2017;118(2):215–222. DOI: 10.1093/bja/aew430.
11. Lee J, Bahk J, Ryu H, Jung C, Jeon Y. Comparison of the bedside central venous catheter placement techniques: landmark vs electrocardiogram guidance. *Br J Anaesth* 2009;102(5):662–666. DOI: 10.1093/bja/aep046.
12. Wirsing M, Schummer C, Neumann R, Steenbeck J, Schmidt P, Schummer W. Is traditional reading of the bedside chest radiograph appropriate to detect Intra-atrial central venous catheter position? *Chest* 2008;134(3):527–533. DOI: 10.1378/chest.07-2687.
13. Andropoulos DB, Stayer SA, Bent ST, Campos CJ, Bezold LI, Alvarez M, et al. A controlled study of transesophageal echocardiography to guide central venous catheter placement in congenital heart surgery patients. *Anesth Analg* 1999;89(1):65–70. DOI: 10.1213/0000539-199907000-00012.
14. Chaney M, Minhaj M, Patel K, Muzic D. Transoesophageal echocardiography and central line insertion. *Ann Card Anaesth* 2007;10(2):127. DOI: 10.4103/0971-9784.37938.

