GSC Biological and Pharmaceutical Sciences

eISSN: 2581-3250 CODEN (USA): GBPSC2

Cross Ref DOI: 10.30574/gscbps

Journal homepage: https://gsconlinepress.com/journals/gscbps/

(RESEARCH ARTICLE)

Check for updates

Comparison of intra-atrial ECG with Peres' formula in assessing the accuracy of central venous catheter depth in the right internal jugular vein at the ICU

Andreas *, Bianca Jeanne, I Made Agus Kresna Sucandra and I Made Gede Widnyana

Department of Anesthesiology, Pain Management, and Intensive Care, Udayana University, Sanglah General Hospital Bali

GSC Biological and Pharmaceutical Sciences, 2026, 35(02), 220-225

Publication history: Received on 11 April 2026; revised on 17 May 2026; accepted on 19 May 2026

Article DOI: https://doi.org/10.30574/gscbps.2026.35.2.0194

Abstract

Introduction: Central Venous Catheterization (CVC) is a routine interventional procedure that plays an important role in the management of critical patients. Improper position of the central venous catheter (CVC) can cause serious complications, including perforation of the heart or large blood vessels. Methods that can be used to assist in the placement of CVC depth are the Peres formula and the use of intra-atrial ECG.

This study aims to determine the more precise depth accuracy between the use of intra-atrial ECG compared to the accuracy of the Peres formula in determining the correct CVC depth at Prof. Dr. IGNG Ngoerah General Hospital, Denpasar, Bali.

Materials and method: The method of this research is a Randomized Control Trial with a consecutive sampling technique. This study is an experimental clinical trial that divides subjects into 2 groups: the intra-atrial ECG assessment technique group and the group with the Peres formula. Every eligible subject was randomized so they had an equal chance of being selected into each group. Inclusion criteria: Indonesian race patients aged 18–65 years who will undergo jugular CVC placement according to indications and a height of 140–180 cm. Exclusion criteria: Patients with BMI > 40 kg/m^2, patients with arrhythmias (Atrial fibrillation, atrial flutter, ventricular fibrillation, supraventricular tachycardia), patients with severe heart failure, and patients with blood clotting disorders (prolonged hemostasis function). Descriptive analysis, proportion comparison analysis with the Chi-square test to determine the risk ratio (RR), 95% Confidence Interval (CI), and P-value at the limit of $\alpha < 0.01$ using SPSS statistical software.

Results and Discussion: The results for age showed the intra-atrial ECG group had a mean age of 40.94±14.43 years and the Peres group had a mean of 45.44±15.53 years. Gender in both groups was predominantly male. BMI results in the intra-atrial ECG group showed a normal mean BMI (22.76±2.59 kg/m^2), while the Peres group had an overweight mean (23.13±2.48 kg/m^2). CVC depth in the intra-atrial ECG group had a mean of 16.14±0.90 cm and in the Peres group a mean of 16.42±0.57 cm. Chi-Square results showed intra-atrial ECG has an RR of 2.3 (95% CI 1.25-4.17) and p 0.002 compared to the use of the Peres formula.

Conclusion: Intra-atrial ECG has an accuracy in assessing the depth of the central venous catheter in the right internal jugular vein two point three times greater than using the Peres formula in the ICU of Prof. Dr. IGNG Ngoerah General Hospital Denpasar.

Keywords: Intra-Atrial ECG; Peres Formula; CVC; Right Jugular Vein; Depth Accuracy

* Corresponding author: Andreas

1. Introduction

Central Venous Catheterization (CVC) is a routine interventional procedure that plays an important role in the management of critical patients. CVC has become standard clinical practice for access to infuse fluids, blood products, or vasoactive drugs into the central circulation and to monitor central venous pressure during the perioperative/intensive care period. [1]

Improper position of the central venous catheter (CVC) can cause serious complications, including perforation of the heart or large blood vessels. And several other significant complications, including cardiac arrhythmias, vascular injury, hydrothorax, hemothorax, hydromediastinum, and cardiac tamponade. Such complications can occur when the catheter tip is inserted into the heart chambers or its position is adjacent to the blood vessel wall at a steep angle. [1,2]

Although the optimal catheter tip position remains controversial according to short-term or long-term use and catheter performance, the US Food and Drug Administration has stated that the catheter tip should not be placed or allowed to migrate into the heart. [3,4]

If the catheter direction is not parallel to the long axis of the superior vena cava (SVC), the vessel wall can erode due to catheter tip friction. Additionally, venous thrombosis and incorrect catheter migration in the left brachiocephalic vein or small collateral vessels, such as the azygos vein, may occur if the CVC tip is in the upper and middle SVC. [5]

To prevent these risks and to ensure proper hemodynamic monitoring, the catheter tip should be in the lower SVC, near the junction of the right atrium and the SVC (RA-SVC junction). Furthermore, if the catheter tip is positioned in the lower SVC, near the RA-SVC junction, the catheter tip must float freely within the vessel lumen. [1,5]

Several methods have been used to verify the catheter tip position. One of the simplest is formula estimation using the patient's height. The use of CVC depth formulas such as the Peres formula has been frequently used. It is easy to use and easy to remember in traditional landmark-based central venous catheterization. [2] However, this method does not consider the varying needle insertion height points on the patient's neck, and several studies have found this formula to be inaccurate. The use of this formula at the researcher's hospital, Prof. Ngoerah, also has varied results, making researchers interested in finding a method that is easier, safer, and more accurate.

In most perioperative cases, the position is confirmed by post-procedural chest X-ray, not by real-time imaging. Post-procedural radiographic imaging is time-consuming, involves radiation exposure, and creates the possibility of unnecessary CVC repositioning and infection from repositioning. [2,3]

Several other methods such as transthoracic echocardiography are limited by ultrasound beam transmission to the SVC and practitioner skill, and are difficult to perform on obese patients or patients with pneumothorax. Likewise, the Transoesophageal echocardiography (TEE) method can verify the CVC position at the RA-SVC junction, but the procedure is invasive and not routinely performed. [2]

Intra-atrial ECG is a method that is safe, easy, and has a high accuracy level in determining CVC depth. The tools used are easily available and inexpensive, yet can significantly reduce CVC complication rates. Intra-atrial ECG tools use universal adapters like Certodyne while observing the P-wave, which can help serve as the CVC depth limit, but this method still has limitations: it is difficult to perform on patients with pacemakers or atrial fibrillation. [4]

Therefore, researchers are interested in comparing the superiority of the accuracy of using intra-atrial ECG compared to the Peres formula in determining the correct CVC depth, which will be confirmed using a post-procedural chest X-ray.

2. Method

This research is a study with a Randomized Control Trial using a consecutive sampling technique to determine the superiority of the accuracy of using intra-atrial ECG compared to the Peres formula in determining the correct CVC depth. This study is an experimental clinical trial that divides subjects into 2 groups: the intra-atrial ECG assessment technique and the group with the Peres formula. Every eligible subject was randomized so they had an equal chance of being selected into each group.

Inclusion criteria: Indonesian race patients aged 18–65 years who will undergo jugular CVC placement according to indications with a height of 140–180 cm.

Exclusion criteria: Patients who refuse the procedure, BMI > 40 kg/m^2, patients with arrhythmia (Atrial fibrillation, atrial flutter, ventricular fibrillation, supraventricular tachycardia), patients with severe heart failure, patients with blood clotting disorders (prolonged hemostasis function).

Drop out criteria: Patients who experience arrhythmias that appear during the CVC placement procedure and result in unresolved hemodynamic disturbances, patients who die before confirmation using chest X-ray.

2.1. Research Procedure

CVC placement was performed by positioning the patient supine with the head turned in the opposite direction from the CVC insertion site. Ensure the patient has no cervical injury. Perform a sterile procedure with a sterile gown and sterile gloves. Clean the skin surrounding the venous puncture site and place a sterile drape around this area. If the patient is conscious, local anesthesia of lidocaine 2% 40mg will be given at the venous puncture area. Priming is first performed on the CVC catheter and trocar needle using 0.9% saline. Use ultrasound to determine the position of the internal jugular vein. The trocar needle, which has been connected to a 5 ml syringe containing 0.9% saline, is inserted following the ultrasound direction while performing aspiration. The needle is inserted until venous blood is aspirated with free-flow. Insert the guide wire through the hole in the trocar needle. Then the trocar needle is removed and the guide wire remains in the vein. Then the dilator is placed, and the CVC catheter is inserted according to the determined depth.

In the first group, depth was measured using intra-atrial ECG. The Certodyn device is connected to the patient's ECG. The guide wire is pulled to the point where the length of the catheter and wire are equal. Then the Certodyn connector is attached to the guide wire. The wire is then inserted while observing p-wave changes on the ECG. If a change in p-wave morphology occurs, the wire is pulled until the ECG returns to normal.

In the second group, CVC depth was measured using the Peres formula. For placement in the right internal jugular, the formula is height (in cm) divided by 10. For placement in the left jugular vein, the formula is height (in cm) divided by 10 plus 4.

Fix the catheter with sutures and perform an aseptic procedure on the insertion area with betadine. Cover the wound with sterile gauze. Confirm the CVC location using chest X-ray. Record malposition and side effects that occur after placement.

2.2. Statistical Analysis

Descriptive Analysis: Descriptive analysis aims to describe the characteristics of subjects and research variables based on the treatment group. Numerical data scale variables are displayed as mean and standard deviation (SD) if the data distribution is normal; if not, median and interquartile range (IQR) will be displayed. Categorical data scale variables are displayed as relative frequency. Descriptive analysis results are presented in cross-distribution tables so that the comparability of subjects between groups can be assessed.

Proportion Comparison Analysis: Proportion comparison analysis aims to compare the occurrence of correct CVC depth accuracy at the RA - SVC junction in the group using intra-atrial ECG compared to the group using the Peres formula. Analysis is performed by creating 2x2 cross-tabulations; the statistical test used is the Chi-square test if expected cell assumptions are met; if not, Fisher's Exact Test is used.

Comparison of CVC depth accuracy at the RA - SVC junction in the intra-atrial ECG group compared to the Peres formula group is displayed as risk ratio (RR).

Conclusion drawing is based on the 95% Confidence Interval (CI) and P-value at the limit of $\alpha < 0.01$.

All data analysis stages above used the help of SPSS statistical software.

3. Results

In this study, 36 research subjects were obtained: 18 patients with the intra-atrial ECG procedure and 18 patients with the Peres procedure. The patient data characteristics are presented in Table 1.

Table 1 Research Characteristics

Variable	Intra-atrial ECG	Peres
Age (mean±SD)	40.94±14.43	45.44±15.53
Gender (%)		
Male	14 (77.8%)	13 (72.3%)
Female	4 (22.2%)	5 (27.7%)
BMI (mean±SD)	22.76±2.59	23.13±2.48
Height in cm (mean±SD)	163.72±4.96	164.17±5.75
Weight in kg (mean±SD)	60.11±7.69	62.78±9.74
Arrhythmia	0	0

SD: Standart deviation

The accuracy obtained from the results between the use of intra-atrial ECG compared to the group using the Peres formula is presented in Table 2.

Table 2 Bivariate Analysis Results

Variable	CVC Depth Accuracy (Correct)	CVC Depth Accuracy (Incorrect)	RR	95% CI	p-value
Intra-atrial ECG	16 (88.9%)	2 (11.1%)	2.29	1.25-4.17	0.002
Peres Formula	7 (38.8%)	11 (61.1%)			

The results of this study show that intra-atrial ECG has an accuracy 2.29 times more accurate (95% CI 1.25-4.17) and $p< 0.002$ compared to the use of the Peres formula. In this study, the possibility of the obtained confidence interval being wide is due to the smaller sample size, so if a large sample size were used, the confidence interval would become narrower. Likewise, the standard error will decrease as the sample size increases.

4. Discussion

Central venous access devices are used for fluid infusion, medication, and short-term and long-term monitoring. In operating rooms and intensive care units, central venous catheterization is often performed for various reasons, including monitoring during cardiac surgery, during anesthesia for congenital heart disease, and other major surgical procedures. Accuracy of CVC insertion depth is very necessary to reduce complications. The methods performed to help obtain accuracy of CVC depth are with the help of intra-atrial ECG and the use of the Peres formula. A study conducted by Sukumaran et al. obtained a 70% correlation between intra-atrial ECG and the Peres formula calculated using the Pearson correlation coefficient. [6,7]

In this study, age was found between the intra-atrial ECG procedure group and the Peres formula group, both being in their 40s; this is not much different from studies conducted on the use of the atrial ECG method with Peres in calculating CVC insertion depth, where the most results were in the 46-65 age range. CVC insertion results at Dr. Kariadi General Hospital Semarang also obtained 152 subjects with a mean age of 42.7±6.7 years. In the results at the NTB Provincial General Hospital in 2017, the most CVC placements were performed at a mean age of 47 years. CVC placement was most often performed on patients with diagnoses of severe sepsis and septic shock, with the most frequent age being 51-60 years, namely 10 (33%) patients. Older ages were found in the study by Joshi et al., where the age in the intra-atrial ECG

group was 59 ± 1.7 years and the Peres method group was 58.6 ± 0.95 years. Central venous catheters can be used to provide intravenous fluid infusion, blood product infusion therapy, and can also be used to monitor hemodynamics by ensuring central venous pressure (CVP) and central venous oxyhemoglobin saturation (ScvO2). [8,9,10]

Gender in both groups was predominantly male compared to female. Similar results were found by Sukamaran et al., 2023, who obtained 22 males (55%) in the intra-atrial ECG group and 24 (60%) in patients receiving the Peres procedure. In the study conducted by Joshi, more males were also found: the intra-atrial ECG group was 13/12 while the Peres group was 15/10. Different results were obtained in Silvania's study in 2015 at the ER of Dr. Hasan Sadikin Bandung, which found equal subjects between males and females. Gender was not found to be associated with the incidence of difficulty in CVC placement or post-placement CVC complications. [6,7,10,11]

BMI results showed that the intra-atrial ECG group had a normal mean BMI (22.76±2.59 kg/m^2), while the Peres group had an overweight mean (23.13±2.48 kg/m^2). The accuracy of the Peres formula is also low in patients with a BMI over 35 kg/m^2 (L. Salmela, 2004). In the study by Sukumaran et al., a BMI > 25 kg/m^2 was found with average heights (intra-atrial ECG group: 163.5 cm; Peres Group: 166.9 cm) and body weight (intra-atrial ECG group: 70.5 kg; Peres Group: 72.7 kg), comparable to the results of Joshi et al., height (intra-atrial ECG group: 157.96 ± 6.67 cm; Peres Group: 158.84 ± 8.78 cm) and weight (intra-atrial ECG group: 55 ± 1.58 kg; Peres Group: 55.6 ± 1.27 kg).

The CVC depth examined in both groups showed results that were not much different: the intra-atrial ECG group had a mean of 16.14±0.90 cm and the Peres group had a mean of 16.42±0.57 cm. The results of this study also do not differ from those conducted by Sukumaran et al. 2023, who found CVC placement depth in the intra-atrial ECG group was 15.075 ± 0.916 cm and the Peres group was 15.792 ± 0.882 cm. Shorter results were found in Joshi et al.'s study, which found the final insertion length of the intra-atrial ECG group was 12.24 ± 1.30 cm compared to the Peres group's 15.88 ± 0.88 cm.

The results of using the Peres formula method showed that only 7 people (38.8%) were accurate; this is in accordance with the study by Joshi et al. which found only 7 people (28%) were accurate. This value is lower than the study conducted in Turkey, which found the accuracy rate of the Peres formula for internal jugular vein placement was 74.4%. However, after multivariate examination, this number decreased to 68.5% in women (Peres, 1990). Sukumaran's research results showed an 80% success rate with the Peres method, with tachycardia complications occurring in 3 subjects (7.5%). In this study with the Peres formula, low accuracy was obtained because it is influenced by the height of Indonesians, who are generally shorter than the Caucasian race, differences in cardiac anatomy, and variations in the approach for internal jugular vein puncture.

The intra-atrial ECG method was found to have an accuracy of 88.9% and was 2.23 times more accurate (95% CI 1.25-4.17) and p 0.002 compared to the Peres method; this is almost similar to Salmela's 2004 study which found an accuracy rate exceeding 90% and can be performed easily, and the low total cost makes this technique widely used. Results were also similar to Joshi's study, which found accuracy in 23 subjects (92%). The result is lower compared to the study by Sukamaran, 2023, which found a 100% success rate for using intra-atrial ECG in CVC placement accuracy. The study reported 96% correct placement in the ECG group and 76% in the non-ECG group. [3,4,11]

Good quality intra-atrial ECG and clear P-wave display on the ECG monitor are very important for the success of CVC guidance and positioning. The disadvantage of this method is that it cannot be used on patients with atrial fibrillation or supraventricular arrhythmias. The P-wave with the highest peak can be used to place the CVC tip at the SVC/RA junction, a normal-shaped P-wave identifies the middle to upper SVC, and a biphasic P-wave pattern can be used to locate the RA. Based on this, a normal-shaped P-wave serves as correct positioning and avoids over-insertion in the ECG-guided group. The research results did not reach 100% because the researchers could not prevent malposition occurring due to patient movement and the subjectivity in reading intra-atrial ECG results.

5. Conclusion

Intra-atrial ECG has an accuracy in assessing the depth of the central venous catheter in the right internal jugular vein two point three times greater than using the Peres formula in the ICU of Prof. Dr. IGNG Ngoerah General Hospital Denpasar.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

References

[1] Ahn, J. H., Kim, I. S., Yang, J. H., Lee, I. G., Seo, D. H., & Kim, S. P. 2017. Transoesophageal echocardiographic evaluation of central venous catheter positioning using Peres' formula or a radiological landmark-based approach: a prospective randomized single-centre study.This Article is accompanied by Editorial Aew443. *British Journal of Anaesthesia*, 118(2), 215–222.

[2] Czepizak, C. A., O'Callaghan, J. M., & Venus, B. 1995. Evaluation of Formulas for Optimal Positioning of Central Venous Catheters. *Chest*, 107(6), 1662–1664.

[3] Gebhard, R. E., Szmuk, P., Pivalizza, E. G., Melnikov, V., Vogt, C., & Warters, R. D. (2007). The Accuracy of Electrocardiogram-Controlled Central Line Placement. *Anesthesia & Analgesia*, *104*(1), 65–70.

[4] Joshi, A. M., Bhosale, G. P., Parikh, G. P., & Shah, V. R. (2008). Optimal positioning of right-sided internal jugular venous catheters: Comparison of intra-atrial electrocardiography versus Peres' formula. *Indian J Crit Care Med*, *12*(1), 10–14.

[5] Karakitsos D, Labropoulos N, De Groot E,. 2006. Real-time ultrasound-guided catheterisation of the internal jugular vein: A prospective comparison with the landmark technique in critical care patients. [Accessed November 1, 2010];*Crit Care*. 10:R162.

[6] Kusminsky RE. 2007. Complications of central venous catheterization. *J Am Coll Surg*. Apr;204(4):681-96.

[7] L. Salmela, U. Aromaa, G. A. Gronert, W. Schummer, C. Schummer, J. Steenbeck, 2004. Intra-atrial ECG guidance for positioning central vein catheters, *BJA: British Journal of Anaesthesia*, Volume 92, Issue 4, April, Pages 599–601,

[8] Peres PW. 1990. Positioning central venous catheters—a prospective survey. *Anaesth Intensive Care*., 18:536-539.

[9] Plumhans C, Mahnken AH, Ocklenburg C, Keil S, Behrendt FF, Günther RW, Schoth F. 2011. Jugular versus subclavian totally implantable access ports: catheter position, complications and intrainterventional pain perception. Eur J Radiol. Sep;79(3):338-42.

[10] Sukumaran, M., Ali, A. A., & Joel, A. (2023). A Comparative Study Of Optimum Depth Of Tip Of Right Internal Jugular Venous Catheter Cannulation By Landmark And Atrial Ecg Method. *International Journal of Academic Medicine and Pharmacy*, 145–149.

[11] Wang L, Liu ZS, Wang CA. 2016. Malposition of Central Venous Catheter: Presentation and Management. *Chin Med J (Engl).* Jan 20;129(2):227-34.