

COMPARING ULTRASONOGRAPHY AND CHEST X-RAY FOR LOCALIZATION OF CENTRAL VENOUS CATHETER

NAWADAT Q*, KHALID MA, ATTA A

Department of Emergency Medicine, Shifa International Hospital Islamabad, Pakistan

*Correspondence author email address: drkhan1224@yahoo.com

(Received, 29th September 2022, Revised 21th May 2023, Published 6th July 2023)

Abstract: *This study aimed to compare the effectiveness of contrast-enhanced ultrasonography and chest X-rays for central venous catheter placement. A prospective study was conducted in the Radiology and Emergency Medicine Department from July 2021 to July 2022. A total of 100 patients scheduled for elective cardiac surgery and central venous catheter placement were included in the study. A central venous catheter was inserted using the Seldinger technique, and contrast-enhanced ultrasonography was performed to detect catheter placement. After the surgery, the patient was transferred to the intensive care unit, and a chest radiography was performed by a radiologist who was blinded to ultrasound results. There was concordance in 93 patients between ultrasound and radiography; both showed correct placement in 85 patients and misplacement in 8 patients. Ultrasonography showed 97% sensitivity, 68% specificity, 95% positive predictive values, and 85% negative predictive values. K statistics an interrater agreement of 0.70 between ultrasound and radiography ($p < 0.001$). Contrast-enhanced ultrasonography is a successful alternative to radiography for detecting central venous catheters.*

Keywords: Radiography, Central Venous Catheter, Ultrasonography, Catheter.

Introduction

Placement of a central venous catheter is a frequent intervention during multiple surgeries and in patients admitted to the intensive care unit. More than 15% of catheter placement complications include hematoma, catheter misplacement, punctured artery, and pneumothorax (Björkander et al., 2019; Jamshidi, 2019). Catheter misplacement poses a danger to the patient and can sometimes be fatal; hence, it is significant to detect the position of the catheter (Mushtaq et al., 2018). Chest radiography is a traditional method used to verify accurate catheter placement. Although this procedure is frequently performed, it is lengthy and involves exposing patients to excessive radiation (Chui et al., 2018; Subramanian et al., 2019).

Additionally, little evidence backs the effectiveness of exposing the patient to immediate radiography after the procedure. Radiological confirmation is not obtained during catheter placement in major surgeries. Therefore, post-operative chest radiography is performed, but this time gap can be lethal to the patient (Woodland et al., 2018). Several ultrasound techniques have been proposed to monitor catheter placement in real-time as an alternative to chest radiography.

This study was conducted to compare the effectiveness of contrast-enhanced ultrasonography and chest X-rays for the placement of central venous catheters.

Methodology

A prospective study was conducted in the Radiology and Emergency Medicine Department from July 2021 to July 2022. A total of 100 patients scheduled for elective cardiac surgery and central venous catheter placement were

included in the study. Patients younger than 18 years, those with a recent chest or abdominal surgery history, and those undergoing emergency catheter placement were excluded. Every patient provided informed consent to become a part of the study. The Ethical board approved the study design. General anesthesia was administered to all patients, and a central venous catheter was inserted using the Seldinger technique by an approach chosen at the anesthesiologist's discretion. Ultrasound guidance was not used during the procedure. After the catheter placement, contrast-enhanced ultrasonography was performed to detect catheter placement by a standard approach opted for by cardiologists for diagnosing patent foramen ovale (Vezzani et al., 2010). Two syringes were connected with a three-way stopcock containing 9ml saline and 1ml air. The contents of the syringes formed a homogenous mixture through the stopcock. The stopcock was attached to the catheter till its tip, and 5 ml solution was administered in the catheter. The microbubble test was interpreted by Vezzani and colleagues (Vezzani et al., 2010). If the placement of the catheter is correct, microbubbles with laminar flow from the superior vena cava were noted within 1-2 seconds of administration of the injection. Turbulent flow from the right atrium or inferior vena cava showed incorrect placement. If the catheter location was not confirmed, a second injection was administered. If no bubbles were seen in previous locations, axillary and jugular Doppler sonography was performed. Fluoroscopic guidance was used to detect the catheter before the surgery if the catheter could not be located in any of these locations.

After the surgery, the patient was transferred to the intensive care unit, and a chest radiography was performed by a radiologist blinded to ultrasound results. Correct catheter

[Citation Qandeel, N., Khalid, M.A., Atta, A. (2023). Comparing ultrasonography and chest x-ray for localization of central venous catheter. *Biol. Clin. Sci. Res. J.*, 2023: 305. doi: <https://doi.org/10.54112/bcsrj.v2023i1.305>]

placement was referred to as its detection in the superior vena cava or superior vena cava-right atrium junction. In any other positions, it was a catheter misplacement.

All the data was analyzed by SPSS version 23. Mean and standard deviation were used to present continuous data. Ultrasonography results were compared to radiographic results to obtain sensitivity, specificity, and predictive data. K1 statistic was used to calculate concordance between ultrasound and chest x-ray. A probability value of less than 0.05 was regarded as significant.

Results

The mean age of patients was 58 ±11 years. Out of 100 patients, most participants (90%) underwent CABG with central venous catheter placement. The catheters were inserted through the right internal jugular (88%), left internal jugular (2%), and right subclavian (10%) (Table I). There was a discrepancy in 7 patients between both findings, shown in Table II. Radiography showed correct extra-axial catheter placement in two patients, and ultrasound demonstrated a false negative. In the remaining five patients, ultrasound showed false positive results, and radiography showed intra-axial placement (false negative).

There was concordance in 93 patients between ultrasound and radiography; both showed correct placement in 85 patients and misplacement in 8 patients (Table III). Ultrasonography showed 97% sensitivity, 68% specificity, 95% positive predictive values, and 85% negative predictive values. K statistics an interrater agreement of 0.70 between ultrasound and radiography (p<0.001).

Table I: Patient characteristics of study patients

Characteristics	N
Gender	
Male	60 (60%)
Female	40 (40%)
Age, years	59 (11)
Weight, kilograms	68 (16)
Height, centimeters	167 (11)
BMI, kg/m2	26.1 (14)
Surgery type	
CABG	90 (90%)
Tricuspid valve replacement	1 (1%)
Aortic valve replacement	4 (4%)
Mitral valve replacement	4 (4%)
Aortic web	1 (1%)

Table II: Comparison of ultrasound and X-ray findings in some recorded cases

Patient	Age	Surgery	Catheter placement approach	Ultrasound result	X-ray result
1	59	Mitral valve replacement	Right internal jugular vein	Right atrium	Correct placement
2	69	CABG	Right internal jugular vein	Right atrium	Correct placement
3	59	CABG	Right internal jugular vein	Correct placement	Right atrium
4	60	CABG	Subclavian vein	Correct placement	Brachiocephalic vein
5	51	CABG	Right internal jugular vein	Correct placement	Right atrium
6	54	CABG	Left internal jugular vein	Correct placement	Right subclavian vein
7	58	CABG	Right internal jugular vein	Correct placement	Right atrium

Table III: Comparison of ultrasonography and radiography results in the study population

Contrast-enhanced ultrasonography	Radiography	
	Correct placement	Wrong placement
Correct catheter placement	85	5
Wrong placement	2	8

Discussion

We conducted this study to compare the efficacy of ultrasonography with radiography in the localization of venous catheters. The results indicated that ultrasonography detected catheter misplacements in 70% of cases in real time.

Other studies have also reported the effectiveness of ultrasonography compared to standard radiography for correct catheter placement and preventing post-operative complications due to time delay (Li et al., 2018; Smit et al., 2020; Smit et al., 2018). Raman et al. reported a near-perfect efficacy of ultrasonography in demonstrating catheter misplacements and complications like pneumothorax (Raman et al., 2019). Vezzani et al. compared radiography with B-mode and contrast-enhanced ultrasonography (Vezzani et al., 2010). The former combination could not detect 6 misplacements while the latter could detect all the cases; hence, CEUS is a better alternative method to radiography. Other studies have

supported our conclusion (Franco-Sadud et al., 2019; Pandurangadu et al., 2018).

Lacobone et al. also showed a high concordance between radiography and ultrasonography for catheter tip detection (Iacobone et al., 2020). However, the tip could not be visualized in 45% but was regarded as the correct placement. This lack of direct visualization does not show correct placement ideally.

Nakamuta et al. show similar results to our study (Nakamuta et al., 2018). They reported a 40% sensitivity and 98% specificity of contrast-enhanced ultrasonography compared to 97% and 68%, respectively. However, this study still recommends radiography as a standard procedure and uses ultrasonography for triage.

Our study has some limitations. Our study consists of a limited number of patients. We performed radiography a few hours after the surgery, so we could not compare the time effectiveness of x-ray and ultrasonography.

Conclusion

Contrast-enhanced ultrasonography is a successful alternative to radiography for detecting central venous catheters.

Declarations

Data Availability statement

All data generated or analyzed during the study are included in the manuscript.

Ethics approval and consent to participate

Not applicable

Consent for publication

Not applicable

Funding

Not applicable

Conflict of interest

The authors declared an absence of conflict of interest.

References

- Björkander, M., Bentzer, P., Schött, U., Broman, M. E., and Kander, T. (2019). Mechanical complications of central venous catheter insertions: A retrospective multicenter study of incidence and risks. *Acta Anaesthesiologica Scandinavica* **63**, 61-68.
- Chui, J., Saeed, R., Jakobowski, L., Wang, W., Eldeyasty, B., Zhu, F., Fochesato, L., Lavi, R., and Bainbridge, D. (2018). Is routine chest x-ray after ultrasound-guided central venous catheter insertion choosing wisely?: a population-based retrospective study of 6,875 patients. *Chest* **154**, 148-156.
- Franco-Sadud, R., Schnobrich, D., Mathews, B. K., Candotti, C., Abdel-Ghani, S., Perez, M. G., Rodgers, S. C., Mader, M. J., Haro, E. K., and Dancel, R. (2019). Recommendations on the use of ultrasound guidance for central and peripheral vascular access in adults: a position statement of the society of hospital medicine. *Journal of hospital medicine* **14**, E1-E22.
- Iacobone, E., Elisei, D., Gattari, D., Carbone, L., and Capozzoli, G. (2020). Transthoracic echocardiography as bedside technique to verify tip location of central venous catheters in patients with atrial arrhythmia. *The Journal of Vascular Access* **21**, 861-867.
- Jamshidi, R. (2019). Central venous catheters: Indications, techniques, and complications. In "Seminars in pediatric surgery", Vol. 28, pp. 26-32. Elsevier.
- Li, A., Jiao, J., Zhang, Y., Tian, L., Miao, J., Hao, X., Sun, Z., and Sun, Q. (2018). A randomized controlled study of bedside electrocardiograph-guided tip location technique & the traditional chest radiography tip location technique for peripherally inserted central venous catheter in cancer patients. *The Indian journal of medical research* **147**, 477.
- Mushtaq, A., Navalkele, B., Kaur, M., Krishna, A., Saleem, A., Rana, N., Gera, S., Chandramohan, S., Surapaneni, M., and Chopra, T. (2018). Comparison of complications in midlines versus central venous catheters: are midlines safer than central venous lines? *American journal of infection control* **46**, 788-792.
- Nakamuta, S., Nishizawa, T., Matsuhashi, S., Shimizu, A., Uraoka, T., and Yamamoto, M. (2018). Real-time ultrasound-guided placement of peripherally inserted central venous catheter without fluoroscopy. *The Journal of Vascular Access* **19**, 609-614.
- Pandurangadu, A. V., Tucker, J., Brackney, A. R., and Bahl, A. (2018). Ultrasound-guided intravenous catheter survival impacted by amount of catheter residing in the vein. *Emergency Medicine Journal* **35**, 550-555.
- Raman, D., Sharma, M., Moghekar, A., Wang, X., and Hatipoğlu, U. (2019). Utilization of thoracic ultrasound for confirmation of central venous catheter placement and exclusion of pneumothorax: a novel technique in real-time application. *Journal of Intensive Care Medicine* **34**, 594-598.
- Smit, J. M., Haaksma, M. E., Lim, E. H., Steenvoorden, T. S., Blans, M. J., Bosch, F. H., Petjak, M., Vermin, B., Touw, H. R., and Girbes, A. R. (2020). Ultrasound to detect central venous catheter placement associated complications: a multicenter diagnostic accuracy study. *Anesthesiology* **132**, 781-794.
- Smit, J. M., Raadsen, R., Blans, M. J., Petjak, M., Van de Ven, P. M., and Tuinman, P. R. (2018). Bedside ultrasound to detect central venous catheter misplacement and associated iatrogenic complications: a systematic review and meta-analysis. *Critical Care* **22**, 1-15.
- Subramanian, V., Wang, H., Wu, J. T., Wong, K. C., Sharma, A., and Syeda-Mahmood, T. (2019). Automated detection and type classification of central venous catheters in chest x-rays. In "Medical Image Computing and Computer Assisted Intervention—MICCAI 2019: 22nd International Conference, Shenzhen, China, October 13–17, 2019, Proceedings, Part VI 22", pp. 522-530. Springer.
- Vezzani, A., Brusasco, C., Palermo, S., Launo, C., Mergoni, M., and Corradi, F. (2010). Ultrasound localization of central vein catheter and detection of postprocedural pneumothorax: an alternative to chest radiography. *Critical care medicine* **38**, 533-538.



Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>. © The Author(s) 2023

[Citation Qandeel, N., Khalid, M.A., Atta, A. (2023). Comparing ultrasonography and chest x-ray for localization of central venous catheter. *Biol. Clin. Sci. Res. J.*, **2023**: 305. doi: <https://doi.org/10.54112/bcsrj.v2023i1.305>]