The Journal of Emergency Medicine, Vol. 57, No. 6, pp. 852–858, 2019

0736-4679/$ - see front matter

https://doi.org/10.1016/j.jemermed.2019.08.029

Ultrasound in Emergency Medicine

AN ALTERNATE IN-PLANE TECHNIQUE OF ULTRASOUND-GUIDED INTERNAL JUGULAR VEIN CANNULATION

Ganapathi Aithal, MD, DNB, FCAI,* Ganapathy Muthuswamy, MD, DA, FCAI,*† Zulaidi Latif, FRCA,* Vinod Bhaskaran, MD,* Haji Satry Haji Sani, FCAI,* Suresh Shindhe, MBBS,* Nurulhuda Binti A. Manap, MBBS,* Kaivalya Sadashiv Vadaje, MD,* Wardina Shumaimah Dato Paduka Buntar, BMBS,* and Rajendra Govindrao Daiwajna, FRCP*

*Department of Anaesthesiology, Raja Isteri Pengiran Anak Saleha Hospital, Jalan Putera Al-Muhtadee Billah, Bandar Seri, Begawan, Brunei Darussalam and †Anesthetics Department, Hamad General Hospital, Doha, Qatar

Corresponding Address: Ganapathi Aithal, MD, DNB, FCAI, Bandar Seri Begawan BA1712, Brunei Darussalam

□ **Abstract—Background: Commonly used ultrasound-guided internal jugular vein (IJV) cannulation techniques, short axis out of plane and long axis in-plane, have significantly reduced complications but failed to eliminate them because of technical difficulties. Objective: This article describes a new anteroposterior short axis in-plane technique that combines advantage of in-plane technique to track the needle tip and short axis view of visualizing nearby anatomical structures by placing the probe on the side of the neck, oriented anteroposteriorly, perpendicular to the long axis of neck. This view visualizes IJV and its relationship to the carotid artery in short axis. The puncture needle is passed in-plane anteroposteriorly from the anterior aspect of the neck. Visualizing the needle, carotid artery, and IJV in single frame minimizes complications. Methods: A prospective evaluative clinical trial was conducted in patients who require IJV cannulation for various reasons by performers experienced in ultrasound-guided IJV cannulations. The efficacy of the technique is indicated by 3 primary outcome measures: access time, number of attempts and success rate, and safety by secondary outcome measure, which is the incidence of mechanical complications. Results: Seventy-five patients were enrolled. The average number of attempts was 1.17 (standard deviation 0.44), the access time was 27.12 s (standard deviation 21.47), and the success rate was 100%. This technique had 12% incidence of posterior venous wall punctures and 2.66% misplacements and no other complications. Conclusion: Anteroposterior short axis in-plane technique is relatively novel and could be alternatively used safely and effectively in place of existing techniques for IJV cannulation.** © 2019 Elsevier Inc. All rights reserved.

□ **Keywords—APSAX; cannulation; in-plane; internal jugular; ultrasonography**

Reprints are not available from the authors.

INTRODUCTION

Internal jugular vein (IJV) cannulation is a common procedure to facilitate the care of critically ill patients. Two-dimensional ultrasound (US) is used to guide IJV cannulation with improved success rates and significantly reduced complications (1–4). Various techniques of US probe position and the needle approach have been described to improve the success rate and minimize complications (5–7). The long axis in-plane (LAX-IP) technique provides a better needle path, tip visualization, and helps in reducing complication rate compared with the short axis out-of-plane (SAX-OOP) technique (4). SAX US view gives a better visualization of the IJV and its relation to the carotid artery. The LAX-IP technique requires high skill to visualize both the carotid

Received: 3 June 2019; Final submission received: 29 July 2019;
Accepted: 13 August 2019

artery and the IJV at all times. Another pitfall of LAX-IP is that the US probe occupies the anterior part of the neck and therefore hinders the process of cannulation and the needle manipulation in obese patients, children, and patients with short necks. In addition, the side lobe artefacts in LAX-IP give the impression that the needle is falsely inside the vein when the needle is slightly out of plane of the US beam (6). Finally, it is difficult to be sure that the needle is in the center of the vein in the LAX-IP technique.

We describe a novel, anteroposterior SAX-IP (APSAX-IP) technique that combines the advantages of the in-plane technique and the SAX view. This technique overcomes some of the limitations of the standard LAX-IP technique. Limitation of space in patients with a short neck and hindrance to needle manipulation is overcome by placing the US probe on the lateral aspect of the neck anteroposteriorly. This probe orientation gives the SAX image, which shows the relationship of the IJV to the surrounding structures—especially the carotid artery—and avoids the side lobe artefact. In addition, the center of the vein can easily be identified in the SAX view. The primary aim of this study is to prospectively evaluate the APSAX-IP US-guided IJV cannulation with respect to ease of cannulation and complications.

MATERIALS AND METHODS

This study has been approved by the Medical and Health Research and Ethics Committee, Ministry of Health, Brunei Darussalam reference number MHREC/MOH/2018/2(1) dated March 22, 2018, and registered with Australian New Zealand Clinical Trials Registry (ACTRN12618000572268).

All patients ≥18 years of age requiring IJV cannulation and who were willing to join the study were enrolled. The primary physician, using clinical judgement and departmental guidelines, identified patients who needed IJV cannulation. Patients with previous surgery at the site of insertion, infection at the site of insertion, clotting abnormalities, the presence of thrombus within the IJV, abnormal IJV anatomy by US imaging (agenesis, strictures, or duplication), and patients with pre-existing catheters in the IJV were excluded from the study. Written informed consent was obtained before the procedure.

IJV cannulations were performed by a mixed cohort of practitioners from consultant to medical officers who are either intensivists or anesthesiologists with more than 1 year of experience in US-guided IJV cannulation. The operators were provided training in the APSAX-IP IJV cannulation technique using reading material, observation, and hands-on experience. All cannulations were performed either in the operating room or in the intensive care unit with standard monitoring (noninvasive blood pressure, electrocardiography, and pulse oximetry). The anesthetic technique used was decided by each patient's circumstances and indication of IJV cannulation. Surgical patients were cannulated under general anesthesia with or without paralysis, intensive care patients were cannulated under local anesthesia/sedation, and other patients who required ward care were cannulated under local anesthesia. The side of the cannulation was decided by the primary physician. The IJV is a superficial structure, and therefore we selected the high-frequency wide band linear array transducer from one of the following US transducers: 12L–RS (5.0–13.0 MHz frequency) from LOGIQ e (General Electric, Boston, MA) US machine or HFL38× (13–6 MHz frequency) or L25× (13–6 MHz frequency) from SonoSite S-Nerve US machine (Bothell, WA).

In each patient the IJV was scanned to evaluate the suitability for cannulation before the actual procedure. Under sterile conditions the IJV was punctured and cannulation was done with real-time US guidance using the APSAX-IP technique. Catheters were sutured and dressing applied with transparent sterile adhesives according to the standard protocols. Chest radiography was requested in all patients to confirm the position of the catheter.

The primary outcome measures that together indicate efficacy of the technique were access time, number of attempts, and success rate. The incidence of mechanical complications was considered as secondary outcome measure, which indicates safety of the technique. Access time is the time (in seconds) from starting of the skin puncture to the successful aspiration of venous blood through the needle. An attempt is considered as such if the needle was advanced forward without any backward movement. Every successive needle withdrawal with subsequent advance was considered as an attempt, whether or not a new skin puncture site was chosen. A maximum of 5 attempts were permitted, and after that it was considered as a failure. Cannulation was considered successful once the guidewire was successfully advanced inside the IJV and was considered a failure if the IJV could not be successfully punctured within 5 attempts or the physician was unable to advance the guidewire after successful puncture in those 5 attempts. If the cannulation was unsuccessful, the classical technique was used and cannulation was performed.

Description of Technique

Operator and US machine position. The operator's dexterity determines his or her position with respect to the patient to avoid the crossing of hands while holding the US probe with the nondominant hand and the needle with the

dominant hand. For example, a right-handed person, for right IJV cannulation, ideally, should stand on the left side of the patient and hold the US probe with the left hand while using the right hand for cannulation (Figure 1), and for left IJV cannulation, should stand at the head end of the patient (Figure 2). The US machine is kept in front of the operator to view the screen directly without straining the operator's neck.

IJV scanning method. Traditionally, the US probe is placed anteriorly over the neck to scan the IJV either in the short axis by keeping the probe above and parallel to the clavicle or in long axis by orienting the probe along the long axis of the IJV. However, in the APSAX-IP technique, the US probe is placed by the side of the neck and oriented anteroposteriorly on the side of cannulation (Figures 1 and 3). It is important to hold the US probe perpendicular to the long axis of neck without tilting or angulation. The operator will have the same perspective of the image by orienting the probe marker anteriorly on both sides of the neck. This view shows the short axis of the IJV and carotid artery, which is like the classical short axis view rotated 90° counter-clockwise. On the screen, the top part of the image is the lateral aspect of the neck where the US probe is placed and the left part of the image shows anterior the aspect of the neck (Figures 1 and 3) where the needle can be seen.

IJV cannulation technique using APSAX-IP. In the APSAX-IP technique, the standard Seldinger technique is used for IJV cannulation except the US probe position. To keep the needle as parallel to the US probe as possible and to enter the center of the vein, the needle entry point on the anterior aspect of the neck is away from the probe at a distance approximate from the transducer footprint to the center of the vein. This distance is measured in the US image using the calipers from the transducer footprint to the midpoint of the IJV (Figure 1). This measurement is

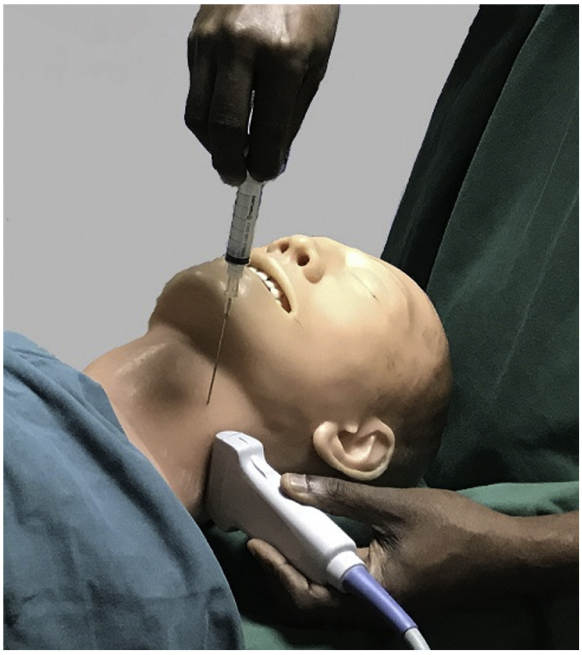

Figure 2. Position of a left-handed operator. CA = carotid artery; IJV = internal jugular vein; SCM = sternocleidomastoid.

used as the approximate needle entry point away from, in line with, and parallel to the US probe over the anterior neck by visual assessment (Figures 1 and 3). The needle can be seen entering at the left side of the screen toward the center, which results in vertical puncture of the vein. Depending on the thickness of the neck and because of the indentation caused by the needle, the transducer footprint may lose contact with the skin. The needle can be redirected by moving the needle tip laterally or medially for up and down movement on the screen and not by tilting the needle in craniocaudal direction. As the vein is punctured vertically, the guidewire is directed toward the heart by tilting the needle tip caudally. US is used to confirm the direction of the

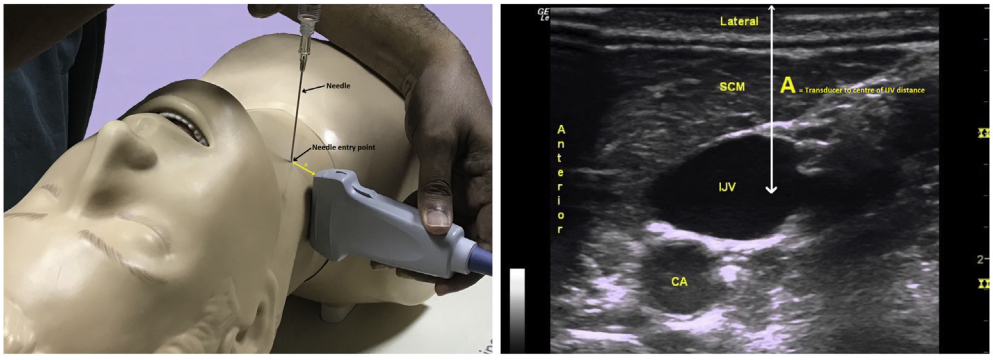

Figure 1. The anteroposterior short axis in-plane technique showing orientation of the ultrasound probe, needle direction, and the entry point. *A* is the distance from the center of the internal jugular vein (IJV) to the transducer footprint used to identify the needle entry point. CA = carotid artery; SCM = sternocleidomastoid.

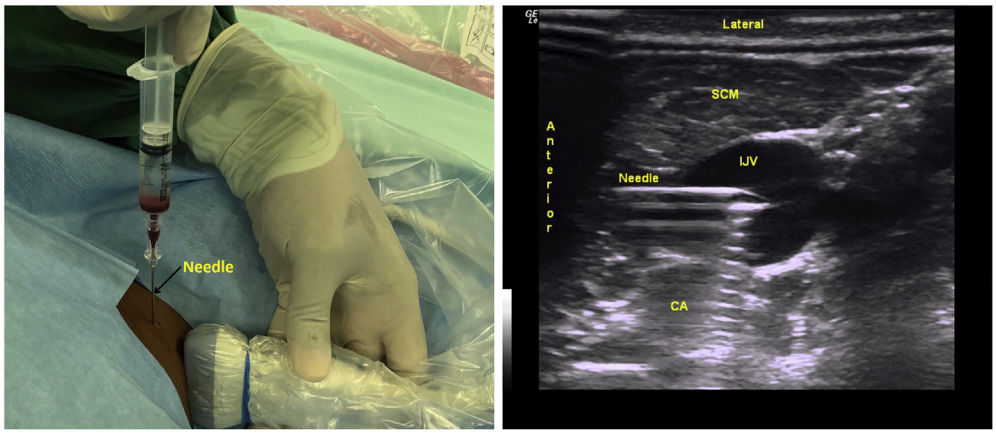

Figure 3. The anteroposterior short axis in-plane technique showing the needle within the internal jugular vein (IJV). CA = carotid artery; SCM = sternocleidomastoid.

guidewire and its presence inside the IJV by locating it just above the clavicle.

RESULTS

Seventy-five patients were enrolled in the study from March to August 2018. Patient characteristics and outcome measures data are presented using number and percentages for categorical variables and mean and standard deviation for quantitative variables. There were 45 men and 30 women between 22 and 88 years of age. The average weight was 74.68 kg (range 40–158 kg). There were 45 right-sided and 30 left-sided IJV cannulations. Cannulation was successful in every patient, for a success rate of 100%. The average number of attempts was 1.17 (standard deviation 0.44) and the success rate was 85.33% (64 patients), 12% (9 patients), and 2.66% (2 patients) on the first, second and third attempts, respectively. The average access time was 27.12 s (standard deviation 21.47). No major mechanical complications like arterial puncture, major hematoma, or pneumothorax occurred because of the technique. There was, however, a 12% (9 cannulations) incidence of posterior venous wall punctures (PVWPs) that did not result in any major complications. Although there was 100% success in needle placement, there were misplacements of catheters in 2 patients (2.66%), both left-sided IJV cannulations. One catheter directly went toward the cranium immediately after entering the vein and the other catheter reflected back to the IJV from the junction with the subclavian vein.

DISCUSSION

The use of ultrasound has significantly reduced the mechanical complications of IJV cannulation. There are many approaches to US-guided IJV cannulation, each with their own advantages and disadvantages (1–4). Previous studies have mentioned various techniques for needle entry and catheter placement through the IJV (5–7). However, limitations and associated complications persist while using real-time ultrasound. To overcome these complications, our study further simplified the technique in terms of visualizing the needle placement.

Traditional US-guided cannulation from the available literature supports SAX-OOP being commonly used followed by the LAX-IP approach and the oblique axis (OAX) approach (6,7). The LAX-IP approach tracks the needle as it enters the IJV and is considered the better technique to avoid complications. However, it is difficult to practice because of the many inherent problems, such as the need for a high level of skill, anatomical limitations, and the difficulty in viewing the artery and the vein in the same view.

This study on the APSAX-IP technique, in which the US probe is placed laterally, addresses some of these limitations. The average access time of 27.12 s (SD 21.47), the average number of attempts of 1.17 (SD 0.44), and the 100% success rate means that APSAX-IP is not a difficult technique to practice. As an in-plane needling technique, it can potentially avoid major mechanical complications related to IJV cannulation because the image shows clearly the relationship of the IJV with the surrounding structures, especially the carotid artery. In our study there is no incidence of carotid artery puncture. The added advantage of a laterally placed US probe is that it will not interfere with cannulation procedure on the anterior aspect of the neck and the needle can be inserted parallel to the US probe (in-plane) and perpendicular to the US beam, resulting in a bright image of the entire needle (Figure 4). It is easier to align the needle with the US beam because the distance from the skin to the IJV is short.

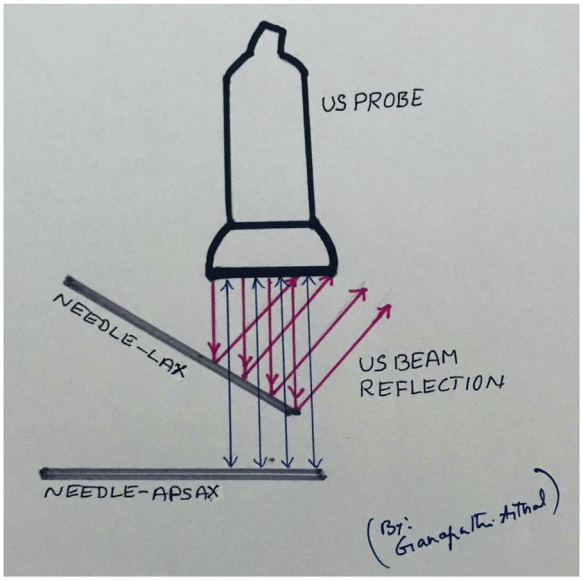

Figure 4. Ultrasound (US) beam reflection and needle orientation in the long axis (LAX) and anteroposterior short axis (APSAX) views.

In a prospective, randomized comparative study of 3 transducer approaches comparing SAX, LAX, and OAX approaches to IJV cannulation, Batllori et al. evaluated the success rate and complications (7). They involved investigators who are well trained and proficient in using US and concluded that OAX and SAX have better cannulation quality outcomes than LAX, and incidence of PVWP is higher in SAX than OAX and LAX. In our study using the APSAX-IP technique, we had an average number of attempts of 1.17 (SD 0.44), which is lower than SAX (1.51 [SD 0.97]), LAX (1.92 [SD 1.26]), and OAX (1.37 [SD 0.84]), and the first-pass success rate is higher (85.33% vs. 69.9% in SAX, 52% in LAX, and 73.6% in OAX). Moreover, Phelan and Hagerty OAX as an alternate approach for US-guided cannulation (8). This view uses the superiority of the short axis view by visualizing all of the important surrounding structures (artery and vein) in an oblong view while allowing for continuous real-time visualization of the needle. However, 2 meta-analyses did not find any difference between SAX, LAX, and OAX in the first-pass success rate, mean time to success, puncture success rate, or number of attempts except for a reduced incidence of arterial puncture (9,10).

Chittoodan et al. conducted a randomized controlled trial of SAX and LAX performed by operators well experienced in using US in which they concluded that SAX is the better technique in terms of a higher first-pass success rate and fewer needle passes (11). Our technique had a better outcome compared with LAX of Chittoodan et al. in terms of the number of attempts (1.17 $\pm$ 0.44 vs. 1.24 $\pm$ 0.56 in LAX), first-pass attempt success rate (85.33% vs. 78% in LAX), and carotid puncture rate (0% vs. 4% in LAX) (11). Tammam et al. prospectively studied venous cannulations in patients who were critically ill and patients undergoing hemodialysis with SAX-OOP and LAX-IP techniques (12). All investigators were well trained in US. APSAX-IP is comparable to SAX-OOP and LAX-IP in terms of the success rate (100%) and the number of attempts (1.17 $\pm$ 0.44 vs. 1.13 $\pm$ 0.35 in SAX vs. 1.17 $\pm$ 0.38 in LAX) (12). However, the access time with our technique is shorter than LAX-IP of above study (27.12 s vs. 52.7 $\pm$ 11.74 s).

Carotid artery punctures are known, even with US-guided IJV cannulations and may lead to serious complications (4,6,13). The carotid punctures reported with SAX view in previous studies were 0.5%, 1.1%, and 1.5% (4,6,13). In our study, by virtue of APSAX-IP technique, both the carotid artery and the IJV are clearly visualized in a single frame and the needle is advanced in-plane, which avoids carotid artery punctures. Therefore, we did not have any incidence of arterial punctures. We noticed a 12% incidence of PVWPs. The incidence of PVWP is higher in SAX-OOP (11%) than LAX-IP (0%) or OAX-IP (1.4%) approaches according to Batllori et al., and it is 21% in the study by Srinivasan et al. (7,14). US does not eliminate the incidence of PVWP. In the APSAX-IP technique, the operator can avoid carotid artery puncture by directing the needle away from the carotid artery. This is not possible with SAX-OOP because of the inability to track the needle and LAX-IP because of the inability to visualize the carotid artery.

The published literature mentions a central venous catheter misplacement rate between 5–7%, while in our study there were 2 (2.66%) misplacements, both in left-sided IJV cannulations (15,16). In 1 patient, the catheter went up from the insertion site toward the cranium; in patient 2, the catheter reflected into the IJV from the junction with the subclavian vein.

Our approach is relatively novel and has not been described in the literature. Therefore, novice operators were provided with hands-on training.

Limitations

In APSAX-IP, aligning the needle with the thin US beam can be challenging for novice operators using the in-plane technique. This study was conducted in a single center without a control group, and the sample size is small. Also, because this study was done in an operating theater and intensive care unit, the applicability of this technique in other settings such as emergency departments needs further consideration. We assessed only major complications like arterial puncture and pneumothorax, while the minor complications, such as temporary bleeding from

the insertion site and minor hematomas, were not examined. We did not monitor the central venous catheter–related blood stream infection rate because we primarily wanted to study the safety of the technique in terms of success of cannulation and immediate major complications. We did not compare our technique with any other techniques presently in practice. We believe that further randomized prospective studies with a larger number of patients and comparisons with other techniques are warranted.

CONCLUSION

APSAX-IP is a relatively novel technique and could be alternatively used safely and effectively in place of existing techniques for IJV cannulation. Additional study is needed to compare its technical difficulties and advantages over other in-plane techniques and applicability to other practice settings.

Acknowledgments—We thank Dr. Manjunath Prabhu for his advice in drafting the article. Our thanks to the Department of Anaesthesiology, Critical Care Medicine and Nephrology, Raja Isteri Pengiran Anak Saleha Hospital, Bandar Seri Begawan, Brunei Darussalam for their support in conducting the study. This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

REFERENCES

1. Bodenham A, Babu S, Bennet J, et al. Association of Anaesthetists of Great Britain and Ireland Safe vascular access 2006. Anaesthesia 2016;71:573–85.
2. Troianos C, Hartman G, Glas K, et al. Special articles: guidelines for performing ultrasound guided vascular cannulation: recommendations of the American Society of Echocardiography and the Society of Cardiovascular Anesthesiologists. Anaesth Analg 2012;114:46–72.
3. National Institute for Clinical Excellence. Guidance on the use of ultrasound locating devices for placing central venous catheters. Technology Appraisal Guidance No. 49. London: National Institute for Clinical Excellence; 2002:1–34.
4. Turker G, Kaya F, Gurbet A, et al. Internal jugular vein cannulation: an ultrasound-guided technique versus a landmark-guided technique. Clinics (Sao Paulo) 2009;64:989–92.
5. Hind D, Calvert N, McWilliams R, et al. Ultrasonic locating devices for central venous cannulation: meta-analysis. BMJ 2003;327:361.
6. Karakitsos D, Labropoulos N, De Groot E, et al. Real-time ultrasound-guided catheterisation of the internal jugular vein: a prospective comparison with the landmark technique in critical care patients. Crit Care 2006;10:R162.
7. Batllori M, Urra M, Uriarte E, et al. Randomized comparison of three transducer orientation approaches for ultrasound guided internal jugular venous cannulation. Br J Anaesth 2016;116:370–6.
8. Phelan M, Hagerty D. The oblique view: an alternative approach for ultrasound-guided central line placement. J Emerg Med 2009;37:403–8.
9. Lv Y, Liu H, Yu P, et al. Evaluating the long-, short-, and oblique-axis approaches for ultrasound-guided vascular access cannulation. J Ultrasound Med 2019;38:347–55.
10. Miao S, Wang X, Zou L, et al. Safety and efficacy of oblique-axis plane in ultrasound-guided internal jugular vein puncture: a meta-analysis. J Int Med Res 2018;46:2587–94.
11. Chittoodan S, Breen D, O'Donnell B, et al. Long versus short axis ultrasound guided approach for internal jugular vein cannulation: a prospective randomised controlled trial. Med Ultrason 2011;13:21–5.
12. Tammam T, Shafey E, Tammam H. Ultrasound-guided internal jugular vein access: comparison between short axis and long axis techniques. Saudi J Kidney Dis Transpl 2013;24:707–13.
13. Leung L, Duffy M, Finckh A. Real-time ultrasonographically-guided internal jugular vein catheterization in the emergency department increases success rates and reduces complications: a randomized, prospective study. Ann Emerg Med 2006;48:540–7.
14. Srinivasan S, Govil D, Gupta S, et al. Incidence of posterior wall penetration during internal jugular vein cannulation: a comparison of two techniques using real-time ultrasound. Indian J Anaesth 2017;61:240–4.
15. Wang L, Liu ZS, Wang CA. Malposition of central venous catheter: presentation and management. Chin Med J 2016;129:227–34.
16. Roldan CJ, Paniagua L. Central venous catheter intravascular malpositioning: causes, prevention, diagnosis, and correction. West J Emerg Med 2015;16:658–64.

ARTICLE SUMMARY

1. Why is this topic important?

Standard techniques of ultrasound (US)-guided internal jugular vein (IJV) cannulations have inherent difficulties, and complications still persist.

2. What does this study attempt to show?

This study introduces an alternative in-plane US-guided IJV cannulation technique to improve both safety and efficacy by combining the advantages of both a short axis view and an in-plane technique.

3. What are the key findings?

This study shows that anteroposterior short axis in-plane US-guided IJV cannulation may be reasonably easily practiced with a high success rate and the major complications may be further reduced.

4. How is patient care impacted?

Anteroposterior short axis in-plane US-guided IJV cannulation has the potential to improve patient safety.