Original Article

Proximal PenHolding Method – A Variant to Enhance Safety of UltrasoundGuided Central Venous Cannulation: A Prospective Pilot Study

Devendra Gupta, Gaurav Misra, Rudrashish Haldar, Shashi Srivastava, Anil Agarwal

Department of Anaesthesiology, Sanjay Gandhi Post Graduate Institute of Medical Sciences, Lucknow, Uttar Pradesh, India

Abstract

Aims: A significant incidence of Posterior Vessel Wall Puncture (PVWP) was reported during ultrasound guidance (USG) for internal jugular vein (IJV) catheterization. We studied a new technique of USGIJV cannulation to minimize or avoid PVWP, thereby decreasing overall complication rate, irrespective of the operators' experience level. **Materials and Methods:** After ethical approval, a prospective study was conducted on adult patients of either gender between 18–65 years of age, belonging to the American Society of Anesthesiologists Physical Status I–III, undergoing general anesthesia and requiring USG-guided IJV cannulation. After induction of general anesthesia and intubation, USG-guided IJV cannulation was done using technique of "proximal pen-holding method" in patients placed in supine position with neck rotated in 15° rotation to the opposite side. The primary outcome was defined as success rate of USG-guided IJV cannulation and incidence of PVWP. The secondary outcome was the incidences of complications such as arterial puncture, adjacent tissue damage, and performer's ease of the procedure (0–10 scale; 0 denoting no ease and extreme difficulty and 10 denoting extreme ease and no difficulty). **Results:** In 135 patients, right IJV puncture, guidewire, and central line insertion were achieved in single attempt without any PVWP by nine operators which included two anesthesia consultants and seven senior registrars. No complications were reported and ease of procedure were rated as median (interquartile range) of 10 (10). **Conclusions:** The "proximal pen-holding method" for real-time USG-IJV cannulation helped in avoiding PVWP with lesser complication rate and greater performer's ease.

Keywords: *Central venous catheters, internal carotid artery, internal jugular vein*

Introduction

Real-time two-dimensional imaging ultrasound guidance (USG), considered as the standard of care for insertion of central venous catheters (CVCs) in the internal jugular vein (IJV) in adults and children, has advantages of a greater likelihood of success, fewer complications, and decreased procedural duration.[1]

Conventional technique to cannulate the IJV under USG involves holding the sterile ultrasound probe in the nondominant hand to obtain a short-axis (SAX) view of the vessels and the plunger of the syringe needle assembly in the dominant hand [Figure 1]. A clinician punctures the skin and soft tissues while visualizing the needle tip ultrasonographically and aims to enter the vessel while applying constant gentlenegative aspiration pressure. Flow-back of venous blood in the syringe confirms correct intravascular entry.

The use of ultrasound allows direct visualization of the IJV and internal carotid artery, the vein being superficial to the artery with some degree of overlap in many cases.[2] In this scenario, any posterior vessel wall puncture (PVWP) that occurs can result in arterial injury. The incidence of PVWP with USG-guided IJV cannulation was reported as high as 34% in a simulated model.[3] The complications may occur more often with less experienced operators who have a greater tendency to overshoot, resulting in PVWP of IJV, and apply aspiration while withdrawing the needle.[3]

We suggested and studied a simple variation of the existing technique which may help physicians to puncture the IJV under USG with ultrasound while minimizing or avoiding PVWP and thereby decreasing overall complication rate among irrespective of the operators' experience level.

How to cite this article: Gupta D, Misra G, Haldar R, Srivastava S, Agarwal A. Proximal penHolding method – A variant to enhance safety of ultrasoundGuided central venous cannulation: A prospective pilot study. Ann Card Anaesth 2019;22:379-82.

Address for correspondence:
Dr. Rudrashish Haldar, Department of Anaesthesiology, Sanjay Gandhi Post Graduate Institute of Medical Sciences, Rae Bareilly Road, Lucknow - 226 014, Uttar Pradesh, India.
E-mail: rudrashish@yahoo.com

Video Available on: www.annals.in

Access this article online

Website: www.annals.in

DOI: 10.4103/aca.ACA_124_18

Quick Response Code:

Materials and Methods

After approval of the Ethics Committee (2016-127-IP-92) and registration in the Clinical Trial Registry (CTRI/2017/06/008800), this prospective study was conducted after written informed consent from the patients. Adult patients of either gender between 18 and 65 years of age, belonging to the American Society of Anesthesiologists Physical Status I–III, undergoing general anesthesia and requiring USG-guided IJV cannulation were included. Patients with untreated coagulopathy, known vascular abnormalities, skeletal abnormalities (e.g., cervical spine disorders), previous surgery over neck area, existing thyroid or neck swelling, localized neck infection, and any history of neck surgery were excluded from the study.

A thorough preanesthetic examination of the patient was conducted, and the procedure explained to the patients a day before surgery. Once wheeled in operation room, all patients were monitored with heart rate, noninvasive blood pressure, and pulse oximetry (SpO_2). General anesthesia was administered using the standard technique in all the patients.

After induction of general anesthesia and intubation using the standard technique, patient being in supine position, the neck was positioned in 15° rotation to the opposite side of site for IJV cannulation. Portable ultrasound machine (MyLab TWICE XVG machine, EsaoteSpA, Genoa, Italy), with 7.5 MHz linear ultrasound probe in short-axis (SA) view, was used for the procedure. Suggested method (proximal pen-holding method) which is a simple modification of the conventional method of ultrasound-guided central venous cannulation was employed. After completion of the procedure, the surgery was allowed to proceed.

Pen-holding method [Figure 2]

In proximal pen-holding method, the palm rests over the patient's jaw while holding the needle in a pen-holding fashion on the one hand and USG probe on the other hand. The area of the neck is scanned by linear probe of the ultrasound and appropriate site of the puncture is chosen. An assembly of 18-gauge needle with a 5 ml syringe is held by the dominant hand in a pen-holding manner with palm resting on the jaw and keeping the IJV image in the middle of USG screen. Skin and subcutaneous tissue were pierced with needle first after identification of IJV under USG. A controlled pressure was applied which was enough to create an indentation by needle tip on the anterior wall of the vein [Figure 2]. Finally, the anterior wall of the vein was punctured with a well-controlled force.

The appearance of echogenic dot (cross-section image of needle) and disappearance of indentation of anterior wall of the vein in USG image and the return of venous blood inside the syringe on aspiration confirmed correct placement of needle in the lumen of vein. A guide-wire was passed through the needle inside the lumen of the vein and the needle was removed. A CVC (Certofix® B. Braun Melsungen AG, Germany) was inserted by railroading it over the wire and advanced inside the lumen of IJV [Video 1].

This procedure was performed by anesthesia consultants and senior registrars who had successfully accomplished at least 25 USG-guided IJV cannulations each on previous occasions. All the participants were educated about the new technique through didactic instructions including visual demonstration of new technique and practicing session on the on the phantom model before the study.

An independent observer who was a senior resident in anesthesiology with 3 years of post-MD clinical experience was present during the procedure to record the results. The primary outcome was defined as success rate of USG-guided IJV cannulation and incidence of PVWP. The secondary outcome was the incidences of complications such as arterial puncture, adjacent tissue damage, and performer's ease of the procedure (0–10 scale; 0 denoting no ease and extreme difficulty and 10 denoting extreme ease and no difficulty).

Figure 1: Conventional technique of ultrasound-guided internal jugular vein cannulation

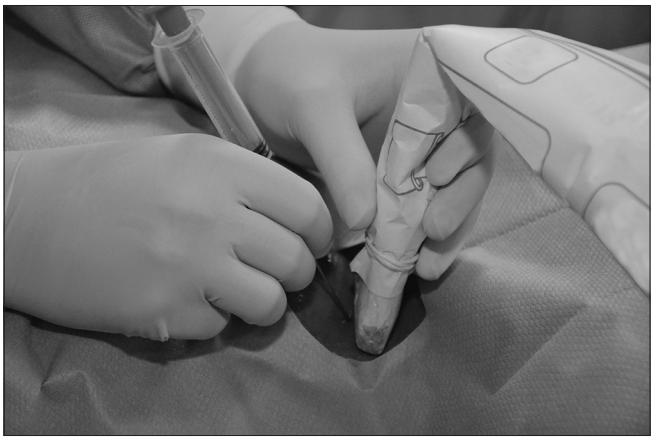

Figure 2: Pen-holding technique of ultrasound-guided internal jugular vein cannulation

Normally distributed continuous data were presented using mean ± standard deviation. Comparison of means was done using independent *t*-test. Mann–Whitney U-test was used to compare the median. To test association/difference in proportion, Chi-square test was used. Identification of PVWP with presumption prevalence of 2.5% (with 95% confidence) required 118 participants for this pilot study.

Results

A total of 162 patients were evaluated from November 2016 to May 2017. Twenty-seven patients were excluded because of deranged coagulation parameters (1), previous history of neck surgery (3), and thyroid swelling (23). Finally, 135 patients were enrolled in this study and thus subjected to statistical analysis. Patient demographics and clinical characteristics are summarized in Table 1. There was no significant difference between the relationship of the IJV with common carotid artery (CCA) as compared to age (P = 0.929), distance from skin to midpoint of IJV (P = 0.942), and ease of procedure (P = 0.719) [Table 2].

This procedure was performed by nine operators (15 procedures by each operator) which included two anesthesia consultants and seven senior residents. In the 135 patients, right IJV puncture was achieved in a single attempt without any PVWP. Guide-wire insertion and central line placement were accomplished successfully in the first attempt in all the cases. Complications such as arterial puncture and surrounding tissue damage were not observed in any case under study. Performers rated the ease of procedure as median (interquartile range) of 10 (10).

Table 1: Demographics and clinical characteristics: Parameters have been expressed as mean±standard deviation or median (interquartile range)

Parameters	Value (*n*=135)
Age (years), mean±SD	42.21±13.15
Weight (kg), mean±SD	57.35±11.06
Height (cm), mean±SD	159.21±6.24
BSA (m^2), mean±SD	1.59±0.17
Male/female, *n* (%)	60/75 (44.4 vs. 55.6)
Distance of midpoint of IJV from skin (cm), mean±SD	1.49±0.01
Relationship of IJV with CCA	
Lateral versus anterolateral, *n* (%)	119 versus 16 (88.1 vs. 11.9)

SD: Standard deviation, BSA: Body surface area, IJV: Internal jugular vein, CCA: Common carotid artery

Discussion

The objective of this study was to evaluate the efficiency and safety of the pen-holding technique during USG-guided IJV cannulation. The present prospective observational pilot study demonstrated that the use of "pen-holding method" for real-time USG-guided IJV cannulation provided a 100% success rate of CVC insertion in the first attempt without any incidence of PVWP and greater performer's ease.

USG-guided central venous cannulation relies on hand-eye coordination.[4] With the clinician's mind and eyes preoccupied with the ultrasound monitor, there exists the possibility of overshooting due to application of excessive force over the syringe needle assembly. In comparison to the conventional technique of holding the syringe distally, the pen-holding method described here places the hand in its natural position and relatively close to the needle tip, thus providing more control in confined spaces with compact anatomy, such as in the head and neck. As suggested in the present study, holding the needle proximal to the bevel end allows higher degree of control and maneuverability, thereby avoiding overshoot of the needle and inadvertent injury to the deeper vessels and structures.

Since this technique gives greater tactile sensation of the texture of skin and subcutaneous tissues of variable nature in different patients, it allows the operators to control their force of insertion of needle with less possibility of overshooting. In addition, direct contact with the proximal needle shaft improves the tactile appreciation and indentation of anterior wall of IJV while piercing the soft tissues and entering the vessel lumen. The respiratory variations in vessel size and smaller vessel size in hypovolemia may influence USG-guided IJV cannulation in live patients;[5] however, using pen-holding technique allows better control of movement (maneuverability) and speed of needle insertion with a close watch over the track of the needle tip in real-time ultrasound, thus providing greater safety margin. Therefore, subtle modifications in the conventional methods in accordance with technological progression can aid in improving the overall efficacy of techniques. Vogel *et al.* observed no difference in PWP while using long-axis (LA) or short-axis (SA) view approach (21% and 25%, respectively) during USG-guided IJV cannulation. However, maintaining

Table 2: The relationship of the internal jugular vein with common carotid artery as compared to age, distance from skin to midpoint of internal jugular vein, and ease of procedure expressed as mean±standard deviation

Parameters	Relationship of IJV with CCA		*P*
	Lateral (*n*=119)	Anterolateral (*n*=16)	
Age (years)	42.25±13.21	41.94±13.06	0.929
Distance from skin to midpoint of IJV (cm)	1.49±0.02	1.49±0.019	0.942
Ease of the procedure (VAS 0-10)	9.90±0.32	9.94±0.25	0.719

VAS: Visual analog scale, IJV: Internal jugular vein, CCA: Common carotid artery

the needle in the plane of the ultrasound beam may be challenging during LA approach, especially for novice ultrasound operators.[6] We used short-axis (SA) view during ultrasound-guided IJV cannulation with pen-holding method and did not encounter any posterior wall puncture.

Despite the proven safety of real-time USG-guided CVC, mechanical complications such as arterial puncture, arterial cannulation, and pneumothorax still occur in up to 4.6% cases.[3,7] Because it is common for the IJV lumen to be compressed during advancement of the puncture needle, both anterior and posterior walls of the IJV are likely to be pierced almost simultaneously and necessitate withdrawal of the needle back to the lumen of the vein.[8] Many a time, the right IJV usually lies anterior or anterolateral to the CCA and posterior wall puncture during IJV catheterization may result in CCA puncture.[9] A pursuit of developing safer and reliable techniques to avoid posterior venous wall puncture has been undertaken continuously.[10] Lim *et al*. suggested that the bevel-down approach is helpful in avoiding posterior IJV wall injury and posterior wall hematoma during IJV catheterization.[11] Morita *et al.* described skin traction method to facilitate IJV catheterization in infants and neonates weighing <5 kg by enlarging the IJV and preventing vein collapse.[12] Wu and Zang describe a novel puncture point-traction method that has been developed to facilitate right IJV cannulation, in which it is attempted to retain the puncture point of the skin directly above the right IJV in its original position by the traction of surgical suture.[13]

We accepted the fact that training of USG-IJV cannulation provided by simulated phantom model improves eye-hand coordination and increases confidence and safety.[14] Thus, prior experience using new technique on a simulated phantom model would offer better understanding of this approach to get successful vessel cannulation without posterior wall penetration when applied in the live patients. We strongly recommend practicing the new technique on simulated model before performing it on live patients to get the best result and less complication.

However, the drawback of this method is the momentary loss of contact of the clinician's fingers with the syringe needle assembly while shifting the grip from needle to the plunger. At this point, chances of dislodgement of needle tip exist. In addition, the efficacy of this method may be negated in pediatric population and patients who are volume depleted. Nonetheless, since USG allows real-time visualization of the needle tip, any misplacement can be rapidly detected and rectified. As with any other skill-based procedure, training is essential for development of expertise in this method. We would also like to reiterate that larger trials involving larger number of procedures performed by different levels of anesthesiologists (in training or otherwise) needs to be performed for proving the suitability and validity of this technique.

Conclusions

Thus, we conclude that the "pen-holding method" for real-time ultrasonographic-guided IJV cannulation helps in avoiding posterior venous wall puncture and results in greater success rate, lesser complications and performer's ease; however, larger-sized randomized controlled studies are required before any concrete recommendation of this technique can be made.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Hind D, Calvert N, McWilliams R, Davidson A, Paisley S, Beverley C, *et al.* Ultrasonic locating devices for central venous cannulation: Meta-analysis. BMJ 2003;327:361.
2. Maecken T, Marcon C, Bomas S, Zenz M, Grau T. Relationship of the internal jugular vein to the common carotid artery: Implications for ultrasound-guided vascular access. Eur J Anaesthesiol 2011;28:351-5.
3. Moon CH, Blehar D, Shear MA, Uyehara P, Gaspari RJ, Arnold J, *et al.* Incidence of posterior vessel wall puncture during ultrasound-guided vessel cannulation in a simulated model. Acad Emerg Med 2010;17:1138-41.
4. Weiner MM, Geldard P, Mittnacht AJ. Ultrasound-guided vascular access: A comprehensive review. J Cardiothorac Vasc Anesth 2013;27:345-60.
5. Srinivasan S, Govil D, Gupta S, Patel S, Jagadeesh KN, Tomar DS, *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.
6. Vogel JA, Haukoos JS, Erickson CL, Liao MM, Theoret J, Sanz GE, *et al.* Is long-axis view superior to short-axis view in ultrasound-guided central venous catheterization? Crit Care Med 2015;43:832-9.
7. Leung J, 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.
8. McGee DC, Gould MK. Preventing complications of central venous catheterization. N Engl J Med 2003;348:1123-33.
9. Blaivas M, Adhikari S. An unseen danger: Frequency of posterior vessel wall penetration by needles during attempts to place internal jugular vein central catheters using ultrasound guidance. Crit Care Med 2009;37:2345-9.
10. Turba UC, Uflacker R, Hannegan C, Selby JB. Anatomic relationship of the internal jugular vein and the common carotid artery applied to percutaneous transjugular procedures. Cardiovasc Intervent Radiol 2005;28:303-6.
11. Lim T, Ryu HG, Jung CW, Jeon Y, Bahk JH. Effect of the bevel direction of puncture needle on success rate and complications during internal jugular vein catheterization. Crit Care Med 2012;40:491-4.
12. Morita M, Sasano H, Azami T, Sasano N, Fujita Y, Ito S, *et al.* A novel skin-traction method is effective for real-time ultrasound-guided internal jugular vein catheterization in infants and neonates weighing less than 5 kilograms. Anesth Analg 2009;109:754-9.
13. Wu T, Zang H. Puncture point-traction method: A novel method applied for right internal jugular vein catheterization. Exp Ther Med 2016;12:307-11.
14. Barsuk JH, McGaghie WC, Cohen ER, Balachandran JS, Wayne DB. Use of simulation-based mastery learning to improve the quality of central venous catheter placement in a medical intensive care unit. J Hosp Med 2009;4:397-403.