Ultrasound guided Deep Vein cannulation: “Perpendicular Insertion Technique (PIT)”, an edge over “Conventional Insertion Technique (CIT)”

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ABSTRACT

Introduction: The use of ultrasound imaging before or during vascular cannulation greatly improves first-pass success and reduces complications, but this skill must then be combined with manual dexterity to perform the three dimensional (3D) procedure of placing a catheter into the deep veins while analyzing the 2D images. Hence this study is an attempt to still decrease the above mentioned limitation of guided deep vein cannulation by slight modification in the insertion technique. Aims and objectives: Aims to compare the ultrasound guided deep vein cannulation by conventional insertion technique(CIT) v/s ultrasound guided perpendicular insertion technique (PIT). Main comparison parameters here are number of attempts required, time taken for successful insertion, vessel counter puncture, arterial puncture and other known mechanical complications of deep venous cannulation. Material and method: Prospective, non randomized cross sectional study, done over 200 patients in two arms. Data-analysed by epi2k and state-9 software. Results: Total number of insertions were 64 by CIT v/s 136 by the PIT. Mean of number of attempts required were 1.918 with the CIT v/s 1.106 for the PIT method. Mean of time of cannulation was 78.62 + 18 sec with CIT while it was 66.98 + 12 sec for PIT and this was statistically significant(\(P = 0.041\)). Incidence of vessel counter-puncture was much lower in PIT as compared to CIT (6.1 % v/s 16.2%). 5.9% cannulation done by CIT had arterial puncture v/s 0.8% with the PIT. Not a single episode of any other mechanical complications with either of the method. Conclusion: USG guided perpendicular method is less time consuming, less number of attempts are required and there are less chances of arterial picture or vessel counter puncture.

Key Words: Attempts, Emergency Medicine Department, perpendicular method, ultrasound-guided

INTRODUCTION

Ultrasoundography was introduced into clinical practice in the early 1970s and is currently used for a variety of clinical indications. Miniaturization and advancements in computer technology have made ultrasound (US) affordable, portable, and capable of higher solution imaging of both tissue and blood flow.

The use of US imaging before or during vascular cannulation greatly improves first-pass success and reduces complications.[1]

This skill set must then be paired with human dexterity to perform the three-dimensional procedure of placing a catheter into the target vessel while analyzing the two-dimensional images.[2]

Few studies have also shown variable success in different ultrasound-guided (USG) approach and related complications.[1,2]

Hence, this study is an attempt to decrease limitations of guided deep vein cannulation by slight modification in the insertion technique.

MATERIALS AND METHODS

Study design

Prospective cross-sectional nonrandomized study.
**Study population**
Patients admitted in Intensive Care Unit setting in a tertiary care hospital attached to teaching institute.

**Method**
Two-hundred deep vein cannulation procedures (including, internal jugular vein [IJV] both left and right, subclavian [SC] and femoral veins) were studied.

Most resident doctors and faculties (other than the author) performed USG guided deep vein cannulation by either by long axis (LAX), oblique axis or short axis (SAX) insertion technique with 45° angular approach. We will call it conventional insertion technique (CIT) (“CIT”) now onwards in this article.

Author cannulated deep veins in SAX view with “perpendicular insertion technique (PIT).”

All the operators in both the arms are trained in guided cannulation technique, have done more than 100 successful insertions and are having more than 1-year experience of working in Emergency Medicine Department.

Ethical Committee approval taken and all the patients consent where taken.

Perpendicular method of deep vein cannulation (PIT).

**Step 1**
Routine preparation including paining, draping was done first. USG with high frequency (6-8 MHz) Ultrasound probe (Sonosite, Micromax, SonoSite Inc., Bothell, WA, USA) was used. Application of local anesthesia, wherever required, was given. The deep veins were located in SAX view, preferably in the center of the screen.

**Step 2**
First of gentle pressure was given over the skin under the probe with the index finger. The indentation in the form of hypoechoic shadow over the vein as seen on US [Figure 1] confirms that the operator’s finger was just above the vein. Then, the author inserted the introducer needle just perpendicularly to the probe where indentation was seen (straight above the vein, just needle touching the probe). The author could see nicely the needle piercing the vein and entering into it. Then, we just angulated the needle in the appropriate direction (direction of the vein course) [Figure 2].

**Step 3**
Guide-wire insertion, dilatation of the track and multi-lumen catheter introduction was done in routine sequence (as per modified Seldinger’s method). Stitches were taken and dressing done.

Time from introduction of the needle (piercing the skin) to removal of guide-wire was taken recorded as the “time required to cannulate the vessel” in the preformatted worksheet.

A number of attempt, arterial puncture, vein counter-puncture, or any complication; any change over in the technique were recorded.

After more than 3 attempts the procedure was abandoned, other site and other technique was planned.

**Statistical analysis**
Data were entered into pre-formatted “Excel sheet” (Office 2000, Microsoft) and analysed using epi2K (WHO) software and STATA-9 (StataCorp LP) software. ANOVA, parametric test for inequality of the population mean, was applied for finding significance of the difference in results on both the arms.

Nonparametric data were compared using the Kruskal-Wallis test, and multiple comparisons were done applying the Mann-Whitney test for individual pairs of groups. \( P < 0.05 \) was taken to be statistically significant for all parametric and categorical data in this study.

**RESULTS**
Total number of insertions done was 64 by CIT, 136 by the PIT. 88% insertions were done in IJV (right IJV 78%, left IJV 10%), 11% in SC vein (10% in right and 1% in left SC vein), 1% in femoral veins. Mean of the age of patients was 50 years ± 37 years mean body mass index was 29 ± 6.2 kg/m².

Mean of numbers attempts required were 1.918 ± 0.8 with the CIT vs. 1.106 ± 0.9 with the PIT. 6% cases required 3 attempts by...
CIT. Number of attempts required in both the groups is shown in Graph 1. In 4% cases changeover was required from CIT to PIT.

Mean of the time taken for cannulation was 78.62 ± 18 s with CIT while it was 66.98 ± 12 s for PIT and this was statistically significant (P = 0.041) [Table 1].

Incidence of vessel counter-puncture was much lower in PIT when compared to CIT (6.1% vs. 16.2%), and this was statistically significant (P = 0.020, P < 0.05).

Four out of 64 (5.9%) cannulation done by CIT had arterial puncture in the first attempt while only 1 out of 132 (0.8%) had an incidence of arterial puncture. And this difference was again statistically significant (P = 0.02768, P < 0.5).

Comparison of the above mentioned parameters is nicely shown in Table 1, which clearly states that in experienced had the PIT, is better than the CIT.

Not a significant incidence of pneumothorax, hemothorax or any known mechanical complications of deep venous cannulations was noted in any of the methods.

**DISCUSSION**

Cannulation of veins and arteries is an important aspect of patient care for the administration of fluids and medications and for monitoring purposes. Depending on the site and patient population, landmark techniques for vascular cannulation are associated with a 60-95% success rate, with a mechanical complication rate of 5-19%.[1]

Mechanical complications may occur more often with less experienced operators, challenging patient anatomy (obesity, cachexia, distorted, tortuous or thrombosed vascular anatomy, congenital anomalies such as persistent left superior vena cava), compromised procedural settings (mechanical ventilation or emergency), and the presence of comorbidity (coagulopathy, emphysema).[1,2]

Central venous catheter mechanical complications include arterial puncture, hematoma, hemothorax, pneumothorax, arterial-venous fistula, venous air embolism, nerve injury, thoracic duct injury (left side only), intraluminal dissection, and puncture of the aorta.[3]

The most common complications of IJV cannulation are arterial puncture and hematoma.[2] The use of US imaging before or during vascular cannulation greatly improves first-pass success and reduces complications.

A prospective randomized SC vein cannulation study favored the USG over the landmark-guided approach, with a higher success rate (92% vs. 44%), fewer minor complications (1 vs. 11), and fewer vein punctures (1.4 vs. 2.5) and catheter kits (1.0 vs. 1.4) per attempted cannulation.[2]

Two-dimensional images commonly display either the SAX or LAX of the target vessel, each with its advantage or disadvantage in terms of directing the cannulating needle at the correct entry angle and depth.

The SAX approach yielded a faster cannulation time compared with the LAX approach, and the novice operators perceived the SAX approach as easier to use than the LAX approach.[3]

The advantage of the SAX view is better visualization of surrounding structures and their relative positions to the needle.[3] There is usually an artery in close anatomic proximity to most central veins.[4] Identification of both vascular structures is paramount to avoid unintentional cannulation of the artery. In addition, it may be easier to direct the cannulating needle toward

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**Table 1: Study parameters, comparing both the study arm conventional technique (CIT) v/s perpendicular insertion technique (PIT)**

| Parameters compared/method used | Perpendicular insertion method (PIT) | Conventional insertion method (CIT) |
|---------------------------------|-------------------------------------|-----------------------------------|
| Total number of insertions done  | 136                                 | 64                                |
| Means of time of cannulation     | 66.98 ± 12 sec                      | 78.62 ±18 sec                     |
| 1st attempt success rate         | 88.15%                              | 72%                               |
| Rate of arterial puncture        | 0.80%                               | 5.90%                             |
| Venous counter puncture          | 6.10%                               | 16.20%                            |
| Means of number of attempts required | 1.106                           | 1.918                             |
the target vessel and coincidentally away from surrounding structures when both are clearly imaged simultaneously.

Few studies have stated the success rate of the first attempt to be 73% and the rate of arterial punctures (1.39%).[^5]

The accidental penetration of the posterior vessel wall can occur despite the use of US when the SAX imaging view is used for guidance.[^2,^6]

An US vein diameter <7 mm (cross-sectional area <0.4 cm^2) is associated with decreased cannulation success.[^6]

The author thought the reasons of these limitations of the CIT and found that the distance “ab” [in Figure 3] is very much empirical. The angle of insertion [“β” in Figure 3] is also very much empirical, especially in two-dimensional view. These leads to failed attempt, counter picture etc., in the CIT.

Three-dimensional US may circumvent the spatial limitations of two-dimensional imaging by providing simultaneous real-time SAX and LAX views along with volume perspective without/altering transducer location, allowing simultaneous views of neck anatomy in three orthogonal planes.[^7] However, this is not commonly available in erectile dysfunction.[^7]

Some probes allow the use of a needle guide, which directs the needle into the imaging plane and defined depth as viewed on the display screen. A limitation of the needle guide is that the needle trajectory is limited to orthogonal orientations from the SAX imaging plane. Again this is not commonly available.[^7,^8]

As shown in Figure 3 (case B), because of three-dimensional spatial error, the needle can go below or above the vein and chances of counter puncture is also there. However, in two-dimensional views it may still look inside the vein concerned.

Hence, the author thought of trying PIT [Figure 4]. Here, the needle is introduced just perpendicularly and just touching the probe, hence both the limitations of the CIT are taken care of.

The result of the present study is very encouraging.

Mean number of attempts were 1.918 ± 0.8 with the CIT vs. 1.106 ± 0.1 for the PIT. 6% cases required 3 attempts by CIT and in 4% cases changeover was done from CIT. These more number of attempts and changeover were due to the spatial limitations of two-dimensional imaging.[^9]

Mean time of cannulation was 78.62 ± 18 s with CIT while it was 66.98 ± 12 s for PIT. In the present study, the time difference between the two methods was statistically significant (P = 0.034, P < 0.05). By the CIT, this time of cannulation is more or less similar to the time mentioned in other studies.[^7,^8] However, the author could find very few groups doing the PIT.[^8]

Incidence of vessel counter-puncture was much lower in PIT when compared to CIT (6.1% vs. 16.2%), and this was statistically significant (P = 0.020, P < 0.05), again this is due to the spatial limitations of two-dimensional imaging in CIT.[^9]

Four out of 64 (5.9%) cannulation done by CIT had arterial puncture in the first attempt while only 1 out of 132 (0.8%) had an incidence of arterial puncture. This difference was statistically significant (P = 0.02768, P < 0.05), again this is due to the spatial limitations of two-dimensional imaging and that can be minimized by PIT. Comparing few studies this complication is very less, in our study, may be due to better training and instruments available now.[^7]

Comparing other studies not a single incidence of pneumothorax or hemothorax was noted in any of the methods employed. This may be because of better training and instruments available now.[^7]

**Conclusion**

This study concludes that less time taken for insertion, less number of attempts required, less chances of vessel counter...
picture, less incidences of arterial puncture are clear advantages of the PIT over the CIT.

LIMITATIONS OF THE STUDY

Smaller number of patients in the present study, particularly for SC and femoral veins and hence needs a study on a bigger scale. However, this study can be done on the varied group of patients and multicenter can be more conclusive. This study needs be done in using three-dimensional USG and also using ultrasound machine with needle guard. This method is also required to be studied in pediatrics patients on large scale.

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