Original article

Comparison of Complications and the Rate of Success of Central Venous Catheters with Ultrasound Guidance or Conventional Methods in Emergency Department

Seyyed Hosein Montazar1, Fatemeh Jahanian1, Seyed Mohammad Hosseininejad1, Hamed Amini Ahidashti1, Farzad Bozorgi1*, Iran Goli Khatir1, Hamid Reza Omrani1

1. Departemant of Emergency Medicine, Mazandaran University of Medical Sciences, Sari, Iran

*Correspondence: **Farzad Bozorgi,** Departemant of Emergency Medicine, Mazandaran University of Medical Sciences, Sari, Iran. Email: bnf.nr70@gmail.com

Abstract:

Introduction: This study compares Complications and the Rate of Success on the catheterization by ultrasound and Conventional method in emergency department.

Methods: This is a descriptive and analytical study. The statistical population of the study is all patients who referred to the Emergency Department of Imam Khomeini Hospital in Sari and require central venous catheter placement through internal jugular vein.

Findings: The patients participated in the study consisted of 200 cases, 100 patients in the ultrasound group and 100 cases in the conventional group who underwent intravenous catheterization. There was no significant difference between the two groups in terms of gender and age. The most common reasons for catheterization were shock, MT and ESRD. The number of attempts to catheterize by ultrasound was significantly lower than the conventional method (P <0.0001). The mean pain intensity in the ultrasound group was significantly lower than the control group (P = 0.006). Statistical analysis indicated that the likelihood of complications in the conventional method is 2.91 times that of ultrasound (OR: 2.91, 95% CI: 1.63-5.17, P <0.0001). Although the success rate in ultrasound was approximately 4.26 times the conventional method, this difference was not statistically significant (OR: 4.26, 95% CI: 0.88-20.59, P = 0.052).

Conclusion: As suggested by the results of the study, the incidence of complications in the use of ultrasound during catheterization is significantly reduced, and the number of attempts to catheterize and the patient's pain are reduced, which increases the patient's satisfaction.

Keywords: Central venous catheterization, Ultrasound, complications.

Introduction:

The National Institute for Clinical Excellence (NICE) guidelines formulated in September 2002 and reviewed in August 2005 recommended two-dimensional imaging ultrasound (US) guidance as the preferred method of both elective and emergency central venous cannulations.(1) A commissioned meta-analysis by NICE including 18 randomized control trials comparing US with the landmark method for central venous access concluded that US was more effective than landmark for all outcomes for cannulation of the internal jugular vein, and the relative risks of failed attempts, complications, and failed first attempts were 86%, 57%, and 41%, respectively.(2, 3) Complications of central venous cannulation include arterial

puncture, pneumothorax, neck or mediastinal haematoma, and haemothorax.(4, 5) US has been shown to decrease all of these in a series of individual studies and in two meta-analyses. It has also been shown to decrease time to cannulation and the number of attempts.(4-6) The superiority of US over the landmark method has been demonstrated in a range of clinical settings, including paediatrics,(7-9) renal medicine,(10, 11) intensive care,(12, 13) and the emergency department.(14, 15) However, there are surprisingly few studies involving anaesthetists or patients presenting for routine surgery.

The uptake of NICE guidelines across the UK has been variable and inconsistent16 and to our knowledge ours is the first study to date that has looked at the impact of implementation of these guidelines and the direct effects on complication rates. Our tertiary referral centre has had an ongoing audit looking at complications associated with central venous cannulation since February 2005, and results before introduction of routine US guidance in October 2005 showed a complication rate of 10.5% .

This study compares Complications and the Rate of Success on the catheterization by ultrasound and Conventional method in emergency department.

Methods:

This is a descriptive and analytical study. Statistical population of the study is all patients referring to the Emergency Department of Imam Khomeini Hospital in Sari who needed placement of central venous through internal jugular vein. Therefore, the researcher obtained ethical approval from the University Ethics Committee and patient or patients' companions.

Patients were selected randomly in a computerized manner. Thus, patients who needed catheterization were randomly assigned by a computer to two treatment groups (i.e., a Conventional catheterization group based on anatomical areas and an ultrasound group who underwent sonography using ultrasound-guided technique).

Inclusion criteria: All patients who need a central venous catheter and had the following conditions:

1. Inability to access to the patient's peripheral veins.

2. The patients without contraindication such as coagulation disorder to catheterization.

3. Gaining written informed consents from patients or patients companions.

4. It was necessary to control central venous pressure, for example, the patient got a septic shock, or after a successful recovery, when the patient requires a continuous central venous pressure monitor due to a cardiac arrest.

Moreover, the patient and companions were explained that ultrasound for catheterization does not cause any harm to the patient.

Anatomical abnormalities at internal jugular vein.

The sample was calculated according to the study conducted by Dr. Khaninzadeh et al. [19], using the following formula. With regard to a = 0.01 and b = 0.1 in this formula, n = 95. In order to achieve more reliable results, five additional cases were considered in each group, and 100 patients were included in the ultrasound catheterization group and 100 patients in the catheterization group without ultrasound.

Patients requiring central venous catheterization in the Emergency Department were cathedrated by the emergency medical assistant of the last year of study who had received the necessary training. After getting permission from the University Ethics Committee, a written and informed consent was completed by all patients or companions. Then, demographic data was inserted in the questionnaire by the emergency medical assistant who was cooperating in the project and catheterization was done by the assistant of the last year of medicine and supervised by the project executive.

100 patients were catheterized by Conventional method and another 100 patients underwent bedside ultrasound for central venous catheter placement. The patients were catheterized after local anesthesia with 5 to 10 cc lidocaine 2%. The success rate of the cases who underwent bedside ultrasound and the effect of ultrasound on increasing the success rate of catheterization, reducing the complications of catheterization and reducing the frequency of needles and damage to other elements around the vein were analyzed.

Data was analyzed by SPSS 16 through descriptive and analytical methods. The mean and standard deviation were used to describe the statistical data and frequency was employed to describe qualitative data.

Normal distribution of quantitative data was tested, and Leven test was used to examine the homogeneity of the variances in the groups.

Chi-square and or Fisher test were used to test the gender difference, arterial puncture, nerve injury and catheter success of the two groups. P-value was considered to be significant at 0.05.

This study was conducted on the basis of Helsinki's Statement and after getting permission from the University Ethics Committee and obtaining written or verbal consent from the patient or companions.

Complications due to catheterization include arterial injury, hematoma, pneumothorax, hemotoxoma, nerve damage, arrhythmia, embolism, rupture of the vena cava and heart and tamponade, and post-surgical infection.

Findings:

Participants of the study included 200 patients, of which 100 patients underwent catheterization of the internal jugular vein through ultrasound-guided technique (ultrasound group) and 100 cases without ultrasound-guided technique (control group).

Of the 200 patients, 114 were male (57%) and 86 of them (43%) were female.

57 patients (57%) of the ultrasound group and 57 patients (57%) of the control group were male. There was no statistically significant difference between the two groups in terms of gender (p = 1).

The mean age of the patients in the study was 62.87 ± 19.6 years (7 to 98 years, Median = 65.5). The mean age of patients in the ultrasound group was 62.22 ± 19.91 years (13 to 98 years, Median = 65), and the mean age of the control group was 63.53 ± 19.37 years (7 to 90 years, Median = 66.5), which was not statistically significant (p < P = 0.638).

Table 1 presents early diagnosis of patients by groups. As seen in the table, the most common reasons for catheterization of the internal jugular vein were shock, MT and ESRD. There was not a statistically significant difference between the reason for catheterization of the two groups (P = 0.55).

The number of attempts to insert needles was as follows: one in 66 cases (33%), two times in 73 cases (36.5%) and more than two times in 61 cases (30.5%). The number of attempts to catheterize through ultrasound included: one in 54 patients, two times in 35 patients and more than two times in 11 patients. In the control group, 12 patients were catheterized at the first attempt. However, 38 patients were catheterized after 2 attempts, and more than 2 attempts were made to catheter 50 patients. The number of attempts to catheterize by ultrasound was significantly lower than the conventional method (P <0.0001).

The catheter was successfully inserted in 190 patients. The success rate in the ultrasound group was 98%, with only 2 cases of unsuccessful catheterization. The success rate of the control group was 92%, of which 8 were unsuccessful. Although the success rate in ultrasound group was approximately 4.26 times the conventional method, this difference was not statistically significant (OR: 4.26, 95% CI: 0.88-20.59, P = 0.052) (Table 3).

The mean total pain intensity was 3.05 ± 1.0 (1 to 5, Median = 3). The mean pain intensity in the ultrasound group was 2.86 ± 1.03 (1 to 5, Median = 1.0), which was significantly less than the pain intensity in the control group (mean = 3.25 ± 0.93, 1 to 5, Median = 3) (P = 0.006).

In total, complications were observed in 94 patients. The incidence of complications respectively was arterial injury in 69 cases (34.5%), arrhythmia in 27 cases (13.5%), hematoma in 23 cases (11.5%), pneumothorax in 5 cases (2.5%), nerve damage in 4 cases (2%), and hemothorax in 1 case (0.5%). The overall incidence of complications was 34% and 60% in the ultrasound group and control group, respectively. Statistical analysis indicated that the probable incidence of complications in the conventional method is 2.91 times that of ultrasound method (OR: 2.91, 95% CI: 1.63-5.17, P <0.0001). Table 2 reports the incidence of complications based on the type of complication and the groups.

Discussion:

Although most guidebooks today recommend ultrasound-guided technique for catheterization, there is still a large amount of catheterization that is perfomed with

Conventional anatomy landmarks that results from lack of adequate training and sometimes lack of adequate facilities . Approximately 40 studies and 7 meta-analyses have confirmed the usefulness of ultrasound in catheterization, and so far, no study has been conducted that preferred the use of the anatomical markup for catheterization by ultrasonography (16)

As seen in the results, there was no statistically significant difference between the two groups in terms of age and gender. The most common reasons for catheterization were shock, MT, and ESRD, with 82% of patients in the ultrasound group and 87% patients in the control group. There was no statistically significant difference between the two groups in terms of the type of disease that the patient was undergoing catheterization. This made the two groups more homogeneous and minimized the interference of the results. In terms of the number of attempts to catheterize, catheterization at the first step in the ultrasound group was 54 cases and in the control group 12 cases, which was significantly higher in the ultrasound group. In total, there were significant differences in the number of attempts for catheterization in the two groups. The most common complication was arterial injury in the two groups. Overall, the complications rate was 34% in the ultrasound group and 60% in the control group, which also had a statistically significant difference. The success rate of catheterization was higher in the ultrasound group (98%) than in the control group (92%).

Fragou et al.'s study concluded that ultrasound method was preferred over Conventional method of the use of anatomical markup in terms of the greater success rate, less frequency of attempts for catheterization and less complications (17)Recent meta-analysis results published by Cochrane databases have also confirmed the usefulness of ultrasound in catheterization in terms of more success and fewer complications(16). The results obtained from the present study are also fully consistent with other studies conducted in this area.

Several studies showed that the success rate of using ultrasound was significantly higher than that of the Conventional method(7, 18). Our study also indicated that the success rate in the ultrasound group was more successful than the Conventional one, but the success was not statistically significant due to the shortage of ultrasound facilities and lack of proper and adequate training on ultrasound techniques and greater focus on the teaching of the use of anatomy landmarks and using it as the main method. Other studies had more success in the ultrasound group; however, their success was not significant(19).

Conclusion:

As demonstrated by the study results, the incidence of complications in the use of ultrasound during catheterization is significantly reduced, and the number of attempts to catheterize and the patient's pain are reduced, which increases the patients and companions' satisfaction. In addition, proper training in the field of ultrasound would make this method more successful.

It is suggested to conduct a comparative study in order to assess the ability of emergency medical assistants and surgical assistants to better explore their qualifications. It is also better to study in a wider and more multicentre statistical population in order to achieve more reliable results. Moreover, it is recommended to perform separately catheterization in different diseases, since pain as one of the criteria of patient satisfaction, cannot be studied in patients with reduced consciousness and homogeneous results are not obtained from the study. The last suggestion is that emergency medical assistants should have sufficient training on the use of ultrasound in catheterization and even other procedures and training should become a regular program.

References:

1. National Institute for Clinical ExcellenceGuidance on the use of ultrasound locating devices for placing central venous catheters TAGN, 2002September http://www.nice.org.uk.
2. 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(7411):361.
3. Abboud P-AC, Kendall JL. Ultrasound guidance for vascular access. Emergency Medicine Clinics of North America. 2004;22(3):749-73.
4. Randolph AG, Cook DJ, Gonzales CA, Pribble CG. Ultrasound guidance for placement of central venous catheters: a meta-analysis of the literature. Critical care medicine. 1996;24(12):2053-8.
5. Keenan SP. Use of ultrasound to place central lines. Journal of critical care. 2002;17(2):126-37.
6. Slama M, Novara A, Safavian A, Ossart M, Safar M, Fagon J-Y. Improvement of internal jugular vein cannulation using an ultrasound-guided technique. Intensive care medicine. 1997;23(8):916-9.
7. Verghese ST, McGill WA, Patel RI, Sell JE, Midgley FM, Ruttimann UE. Ultrasound-guided Internal Jugular Venous Cannulation in Infants A Prospective Comparison with the Traditional Palpation Method. Anesthesiology: The Journal of the American Society of Anesthesiologists. 1999;91(1):71-7.
8. Leyvi G, Taylor DG, Reith E, Wasnick JD. Utility of ultrasound-guided central venous cannulation in pediatric surgical patients: a clinical series. Pediatric Anesthesia. 2005;15(11):953-8.
9. Chuan WX, Wei W, Yu L. A randomized-controlled study of ultrasound prelocation vs anatomical landmark-guided cannulation of the internal jugular vein in infants and children. Pediatric Anesthesia. 2005;15(9):733-8.
10. Nadig C, Leidig M, Schmiedeke T, Höffken B. The use of ultrasound for the placement of dialysis catheters. Nephrology, dialysis, transplantation: official publication of the European Dialysis and Transplant Association-European Renal Association. 1998;13(4):978-81.
11. Koroglu M, Demi˙ r M, Koroglu B, Sezer M, Akhan O, Yi˙ ldi˙ z H, et al. Percutaneous placement of central venous catheters: comparing the anatomical landmark method with the radiologically guided technique for central venous catheterization through the internal jugular vein in emergent hemodialysis patients. Acta Radiologica. 2006;47(1):43-7.
12. Gualtieri E, Deppe SA, Sipperly ME, Thompson DR. Subclavian venous

catheterization: greater success rate for less experienced operators using ultrasound guidance. Critical care medicine. 1995;23(4):692-7.

13. Karakitsos D, Labropoulos N, De Groot E, Patrianakos AP, Kouraklis G, Poularas J, et al. Real-time ultrasound-guided catheterisation of the internal jugular vein: a prospective comparison with the landmark technique in critical care patients. Critical Care. 2006;10(6):R162.

14. Hrics P, Wilber S, Blanda MP, Gallo U. Ultrasound-assisted internal jugular vein catheterization in the ED. The American journal of emergency medicine. 1998;16(4):401-3.

15. 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. Annals of emergency medicine. 2006;48(5):540-7.

16. Wigmore TJ, Smythe JF, Hacking MB, Raobaikady R, MacCallum NS. Effect of the implementation of NICE guidelines for ultrasound guidance on the complication rates associated with central venous catheter placement in patients presenting for routine surgery in a tertiary referral centre. BJA: British Journal of Anaesthesia. 2007;99(5):662-5.

17. Fragou M, Gravvanis A, Dimitriou V, Papalois A, Kouraklis G, Karabinis A, et al. Real-time ultrasound-guided subclavian vein cannulation versus the landmark method in critical care patients: a prospective randomized study. Critical care medicine. 2011;39(7):1607-12.

18. Veenstra DL, Saint S, Saha S, Lumley T, Sullivan SD. Efficacy of antiseptic-impregnated central venous catheters in preventing catheter-related bloodstream infection: a meta-analysis. Jama. 1999;281(3):261-7.

19. Randolph AG, Cook DJ, Gonzales CA, Andrew M. Benefit of heparin in central venous and pulmonary artery catheters: a meta-analysis of randomized controlled trials. Chest. 1998;113(1):165-71.

Tables and Charts:

Table 1: Early diagnosis of patients by the study groups.

Early diagnosis	Ultrasound group	Control group	
Shock	35 (35%)	39 (39%)	0.55
MT	31 (31%)	29 (29%)	
ESRD	16 (16%)	19 (19%)	
Hepatic failure	6 (6%)	2 (2%)	
After recovery	3 (3%)	3 (3%)	

Peritonitis	2 (2%)	5 (5%)	
Falls from height	2 (2%)	2 (2%)	
Cancer	3 (3%)	1 (1%)	
Sepsis	2 (2%)	0	

Table 2: The incidence of complications based on the type of complication and the study groups. General comparison of ultrasonography with conventional method for intragranular venous vein catheterization

0.001	2.85 (1.55-5.24)	46 (46%)	23 (23%)	**Arterial injury**
0.043	2.04 (1.77-2.35)	4 (4%)	0	**Nerve damage**
0.17	4.12 (0.45-37.57)	4 (4%)	1 (1%)	
0.316	2.01 (1.74-2.31)	1 (1%)	0	
0.046	2.53 (0.99-6.45)	16 (16%)	7 (7%)	**Hematoma**
0.846	1.09 (0.70-2.45)	14 (14%)	13 (13%)	
<0.0001	2.91 (1.63-5.17)	60 (60%)	34 (34%)	
P value	OR (95%CI)	Control group	Ultrasound group	
0.001	2.85 (1.55-5.24)	46 (46%)	23 (23%)	

0.043	2.04 (1.77-2.35)	4 (4%)	0	
0.17	4.12 (0.45-37.57)	4 (4%)	1 (1%)	
0.316	2.01 (1.74-2.31)	1 (1%)	0	
0.046	2.53 (0.99-6.45)	16 (16%)	7 (7%)	
0.846	1.09 (0.70-2.45)	14 (14%)	13 (13%)	
<0.0001	2.91 (1.63-5.17)	60 (60%)	34 (34%)	