Original Article

Comparison Between Ultrasound Guidance and the Landmark Technique for the Internal Jugular Vein Cannulation in Adult Patients by Anesthesia Residents or Inexperienced Operators

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ABSTRACT

Background: The cannulation of the internal jugular vein is done to access the central vein for hemodynamic monitoring and other purposes. A safe internal cannulation of the jugular vein is performed using anatomical landmarks on the surface of the skin or using the ultrasound-guided method. In this study, we compared the ultrasound-guided technique and the anatomical landmark method for the internal insertion of the jugular vein catheter by anesthesia residents on adult patients in terms of the rates of their success rate and complications.

Methods: In this study, 90 patients were divided into 2 equal groups. The anatomical landmark technique was used in the first group and ultrasound guidance in the second group to cannulate the internal jugular vein. In both methods, the number of attempts, the rate of failure, the rate of carotid rupture, and the rate of complications such as pneumothorax, hematoma, and arrhythmias were documented.

Results: There was no statistically significant difference between the 2 groups vis-à-vis the number of the attempts to catheterize each patient (P=0.352). Cannulation failure was reported in only 1 patient in each group, and there was no significant difference between the 2 groups (P=0.062). The results demonstrated no significant difference between the groups (P=0.750) concerning the rate of complications of the internal jugular vein catheterization.

Conclusions: Neither of the methods of ultrasound guidance and anatomical landmarks had a significant superiority in terms of the success rate and the complications of the insertion of the internal jugular vein catheter. The reason for the absence of a significant difference between the 2 groups in the above parameters was the anesthesia residents' insufficient personal skills in performing ultrasound. ***(Iranian heart Journal 2018; 19(3): 30-37)***

KEYWORDS: Ultrasound, Anatomical criteria, Central vein catheterization

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Catheterization is often regarded as a critical component of pre- and postoperative care in severely ill patients for diagnostic or therapeutic purposes. Approximately, 6 million central venous catheterizations are done each year in Europe and the United States. [1] The benefits of these central venous catheters include their ability to record the central venous pressure or other hemodynamic parameters, their ability to infuse very strong drugs (eg, catecholamines) or highly stimulating ones (eg, chemotherapy drugs and parenteral nutritional solutions), and their ability to confer dialysis treatment in cases of renal failure.

The internal jugular, subclavian, and femoral veins are usually used to access the central vein. The femoral vein catheterization has always been an attractive way to access the central vein because it is accessible in most patients and suitable for various indications. It also has fewer complications during the insertion. [2] However, the disadvantages include the inability to perform hemodynamic invasive monitoring and higher risks of thromboembolic and infectious complications. [3] Consequently, access to the central vein is preferred using the internal jugular vein or the subclavian vein.

The catheterization of the internal jugular vein is performed in critically ill patients in order to access the central vein for hemodynamic monitoring; the long-term administration of fluids, antibiotics, and venous parenteral nutrition; and hemodialysis. A safe internal cannulation of the jugular vein is done by using anatomical landmarks on the surface of the skin before finally passing a needle through a hypothetical vein line. Since 1966, many techniques have been developed based on anatomical landmarks. [4, 5] The complications of this technique depend on factors such as the body mass index, the location of the attempt to access the vein, and the physician's experience. [6, 7] In addition, failure in the cannulation of the internal jugular vein occurs in 19.4% of cases. [6]

It has been posited that ultrasound guidance can be beneficial by improving the success rate, decreasing the number of needle entry points, and reducing complications in the insertion of the central vein catheters. [8, 9] Ultrasound may also be used in patients whose central vein is difficult to access or in those who are more likely to develop complications later on. [10]

Today, the use of an ultrasound device by specialists is rising rapidly. On the other hand, most patients who require a central vein are critical and meticulous care should be taken to perform the procedure in the shortest time possible and with the fewest complications. Various studies have been conducted to compare the use of the ultrasound-guided method and the anatomical landmark technique on the central venous veins—especially the internal jugular vein—and the majority of them have favored ultrasound guidance. [11]

In the current study, we evaluated the use of an ultrasound device by anesthesia residents without a great deal of experience in the 2 methods of ultrasound guidance and anatomical landmarks to access the internal jugular vein. Additionally, factors such as time reduction, the number of attempts (the number of needling), the success rate of the venous access, and the complications were investigated. [12-14]

METHODS

Permission to conduct the study was obtained from the institutional ethics committee. The research conditions were described to the study participants, and written consent was obtained. In this clinical trial (registration number: IRCT2014112520079N1), patients were selected via simple randomized sampling. The inclusion criteria comprised patient satisfaction, required collaboration for the internal jugular vein cannulation, age over 18 years, and not having coagulation disorders. The exclusion criteria consisted of pregnancy, sensitivity to topical anesthetics, infection or burning of the neck region for the internal jugular vein cannulation, peripheral vascular disease,

coagulopathy, obesity, abnormal anatomy, intravenous drug addiction, and thrombosis.

The study population was comprised of 90 patients, who were divided into 2 equal groups. The anatomical criteria were used in the first group, while the ultrasound-guided method was implemented in the second group for the cannulation of the internal jugular vein. The investigator prepared the patients, placed their neck in the right position for cannulation, and prepped and draped their neck. Required monitoring for the patients—including blood pressure control via a noninvasive method for 5 minutes, electrocardiography, and continuous arterial oxygen saturation with pulse oximetry—was established. Oxygen was supplied to the patients with masks or nasal cannulae.

Under the sterile condition and using the vertices of a triangle at the site of the junction, the sternocleidomastoid muscle became numb with 2 cc of xylocaine 2% by the researcher.

In the anatomical landmark technique, a 2-cc syringe with a 22-gauge needle at an angle of 45° was guided toward the nipple. As soon as blood was removed from the internal jugular vein, a 19-gauge needle tip, which was connected to a 10-cc syringe, was directed toward the path of the 22-gauge needle. After the withdrawal of blood from the internal jugular vein, a guide wire was entered into the internal jugular with the needle. Subsequently, the central venous catheter was entered into the central vein after the dilation of the path. Next, the route of the catheter was checked, and the catheter itself was fixed to the skin.

In the ultrasound-guided method, a linear probe was implemented. The device was set at a depth of 4.5 cm. Gel was laid on the probe, which was also coated with sterile covers. The anatomy of the aforementioned area—including the carotid artery and the internal jugular vein—and the capability of compression in the jugular vein were checked first. Afterward, the jugular vein was cannulated with the in-plane technique within the space between the 2 ends of the sternocleidomastoid muscle with a 10-gauge needle, which was connected to a 10-cc syringe. As soon as blood was drained, a guide wire was entered and dilatation was done. Finally, the catheter was inserted through the guide wire. After the catheter was checked, it was fixed to the neck skin.

In the present study, no patient was excluded for being a so-called "difficult stick" due to peripheral vascular diseases, coagulopathy, obesity, abnormal anatomy, injection drug addiction, or thrombosis. In both techniques, the number of attempts, the rate of failure, and the rate of complications such as pneumothorax, hematoma, and arrhythmias were recorded. In case of premature ventricular contractions or any other arrhythmias, the guide wire was removed until the arrhythmia was eliminated. The duration of the anatomical landmark method, from the insertion of the 22-gauge needle until the removal of blood with the 19-gauge needle, was accurately recorded by the investigator. Additionally, the duration of the ultrasound guidance method, from the placement of the SONO probe on the skin until the withdrawal of blood from the 19-gauge needle, was carefully recorded by the assistant or the researcher.

Sample Size

The sample size was determined to be 90 patients using the standard deviation of reference studies and the following formula in which 45 individuals were considered to be in each group:

$$n = \frac{2(Z_1 - {}^{\alpha}/_{2} + Z_1 - \beta)^2 Q^2}{d^2}$$

Method of Data Collection and Analysis

The patients' demographic data and other variables were measured or extracted and subsequently recorded in a form. The collected data were analyzed with SPSS. The comparative value of the data was considered statistically significant with a *P* value less than 0.05.

RESULTS

The study population consisted of 90 patients: 31 (68.9%) men and 14 (31.1%) women in the anatomical landmark method group and 33 (73.3%) men and 12 (26.7%) women in the ultrasound guidance group. The data analysis with the χ^2 test showed no significant difference between the 2 groups (*P*=0.810) (Fig. 1). The mean age of the patients was 57.2±16.8 years in the anatomical landmark method group and 55±16.5 years in the ultrasound-guided method group. The one-way analysis of variance (ANOVA) indicated that there was no significant age difference between the 2 groups (*P*=0.122).

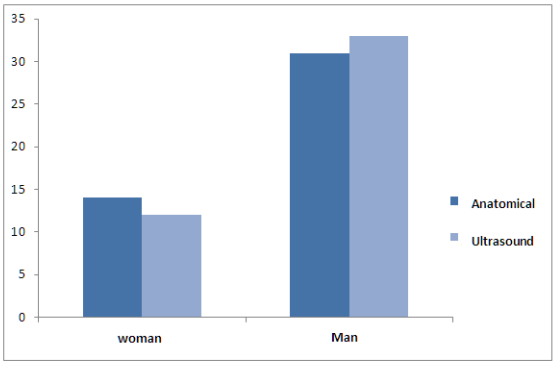

Figure 1. Gender segregation of the patients in the 2 groups

The mean body mass index was 25.9±3.3 in the anatomical landmark technique group and 27.4±3.3 in the ultrasound guidance group; there was no significant difference between the 2 groups (*P*=0.460).

The average cannulation time of the patients was calculated with a chronometer. The mean time was 41.6±32.4 seconds in the anatomical landmark technique group and 65.4±31.3 seconds in the ultrasound-guided method group. Despite the 24-second interval between the 2 groups, the data analysis showed no significant difference between them (*P*=0.662).

The results revealed that cannulation had failed in only 1 patient in each group, and there was no statistically significant difference between the 2 groups (Fig. 2).

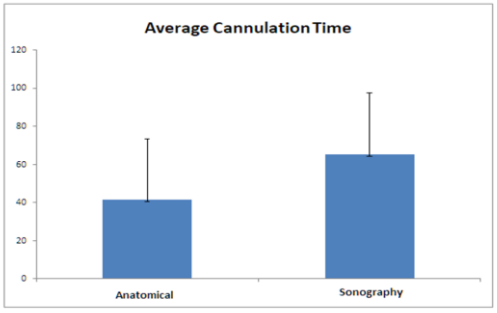

Figure 2. Average time of the internal jugular vein cannulation in the patients of the 2 studied groups

In this study, the number of attempts to catheterize each patient was also recorded. The mean number of attempts was 2±2.1 in the anatomical landmark technique group and 1.6±0.8 in the ultrasound guidance group. The ANOVA showed no significant difference between the 2 groups in this regard (*P*=0. 352).

The cases that led to the severity of the patient's cannulation were also recorded. In the anatomical landmark technique group, 1 (2.2%) patient suffered peripheral vascular disease, 1 (2.2%) patient was addicted to drug injection, 14 (31.1%) patients had coagulation problems, and 3 (6.6%) patients had short necks. In the ultrasound guidance group, 2 (4.4%) patients were addicted to drug injection, 7 (15.5%) patients had coagulation problems due to the use of medication, and 4 (8.9%) patients had short necks. The data analysis showed no significant difference between the 2 groups in this regard (*P*=0.225) (Fig. 3).

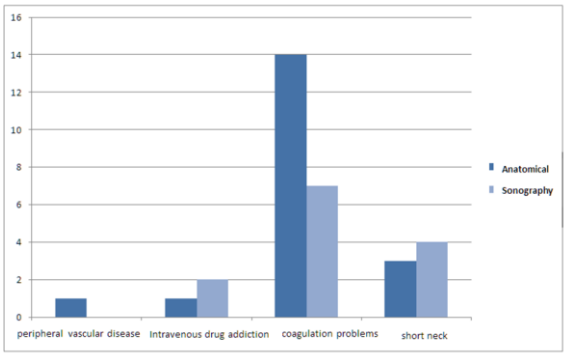

Figure 3. Different cases leading to difficulty in the cannulation of the internal jugular vein in the patients of the 2 studied groups

The complications of the internal jugular vein catheterization were evaluated in the 2 groups. In the anatomical landmark technique group, 4 (9.9%) patients had hematoma, 4 (9.9%) patients had the carotid rupture, and 3 (6.6%) patients had arrhythmias. In the ultrasound-guided method group, 4 (8.9%) patients suffered hematoma, 4 (9.9%) patients experienced carotid rupture, and 2 (4.4%) patients developed arrhythmias. The ANOVA showed no significant difference between the 2 groups (*P*=0.750) (Fig. 4).

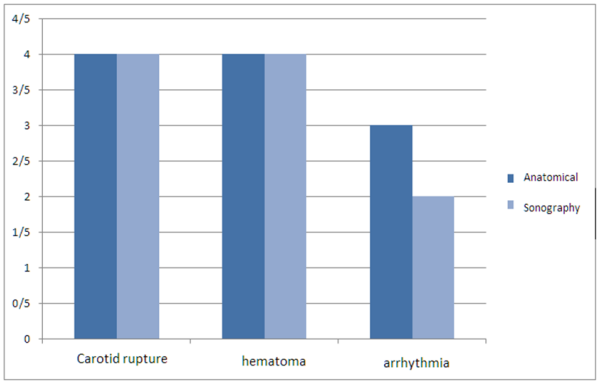

Figure 4. Complications of the internal jugular vein cannulation in the patients of the 2 studied groups

The reason for the absence of significant differences between the 2 study groups in the above parameters was that the anesthesia residents had insufficient personal skills in the ultrasound-guided technique. Moreover, there were no ultrasound devices in all the centers which could be commonly used. Residents use the anatomical criteria commonly for the catheter insertion; therefore, the complications in this group are not significantly higher than those in the ultrasound method.

DISCUSSION

In the present study, neither of the methods of ultrasound guidance and anatomical landmarks had a significant superiority in terms of the success rate of the internal jugular vein catheterization. Nonetheless, the use of the anatomical criteria reduced approximately one-third of the time compared with the ultrasound method, although this difference failed to constitute statistical significance (*P*=0.062).

Contrary to the hypothesis that the use of ultrasound guidance, by comparison with the anatomical landmark technique, facilitates the insertion of the internal jugular vein catheter, ultrasound did not significantly improve the procedure with respect to the cannulation time, the success rate of cannulation, and the incidence of carotid rupture. The results of most of the studies in this area are not concordant with those obtained in the current study. In all the previous investigations, ultrasonography had a significant advantage over the anatomical landmark method with regard to the success rate, cannulation time, and complication rates.

Be that as it may, Hayashi et al [8] indicated that ultrasound guidance prior to the internal jugular vein cannulation failed to confer any superiority relative to the anatomical criteria, which is in part consistent with the results of the present study. It has been proven in previous studies that the use of ultrasound guidance increases the success of the internal jugular vein cannulation and reduces the incidence of arterial rupture. Some researchers have recommended the application of the ultrasound-guided method to determine the correct location of the internal jugular vein before the insertion of catheters. [15] Furthermore, the superiority of the method of ultrasonography over anatomical landmarks has also been proven in a study by Nadig et al. [16]

In a study by Leung et al, [2] the cannulation of the internal jugular vein was assessed in 130 critical patients in the emergency department and the results showed that catheterization with ultrasound had a higher rate of success and fewer complications. The results obtained in a study by Turker et al [13] on 380 patients who needed the internal jugular vein catheters showed that the use of ultrasound resulted in less access time and a lower rate of acute complications. In a similar study by Karakitsos et al [12] on 900 severely ill patients who were equally subjected to jugular venous cannulation

via conventional and sonographic methods, it was reported that catheterization with ultrasound guidance was more successful than the traditional method. The ultrasound-guided technique should, therefore, be employed as a selective method in this group of patients.

Gordon et al [17] evaluated 869 patients who underwent the internal jugular vein cannulation under ultrasound guidance and found that ultrasound-guided cannulation was superior to blind techniques as not only did it boost the success rate and the likelihood of successful catheterization in the first attempt but also it reduced the rate of acute complications.

Mey et al [18] evaluated the ultrasonography technique for accessing the central vein through the internal jugular vein in 493 patients and showed that this method had a high success rate and a low rate of complications. The authors also concluded that difficulty in cannulation due to individual risk factors such as thrombocytopenia, obesity, and dyspnea could be easily managed with the application of ultrasound guidance and argued that the success rate and the severity of the complications depended not only on the experience of the physician carrying out the cannulation but also on the experience of the physician performing the ultrasound.

In the current study, the internal jugular vein cannulation via the clinical criteria was successful in 97.8% of the cases. This finding is consistent with studies in which the success rate of this technique was estimated to be between 85% and 99%. [4, 6, 9, 17, 19] The success rate of the internal jugular vein catheterization using anatomical landmarks in the study by Turker et al [13] was about 97.3%. The success rate of cannulation in the study by Karakitsos et al [12] was 99.4% in the anatomical landmark group and 100% in the ultrasound group. The success rate of ultrasound in the present study was 97.8%, which was equal to that of the anatomical landmark method. This finding does not chime in with the results previously reported on the subject. [2, 12, 13, 15, 18]

When the mechanical side effects of cannulation—namely carotid rupture, hematoma, pneumothorax, and hemothorax—were only considered, 5 (11.1%) patients in the anatomical landmark group and 7 (15.5%) patients in the ultrasound guidance group developed complications in the present study. In contrast, in the study by Turker et al, [13] 8.4% of the patients in the anatomical landmark group and 1.6% of the cases in the ultrasound guidance group suffered mechanical complications caused by cannulation. In the study by Karakitsos et al, [12] the side effects occurred in 23.1% of the patients in the anatomical landmark group and in 1.5% of the cases in the ultrasound guidance group. In the study by Leung et al, [2] in total, 10.8% of the patients—comprising 4.6% in the ultrasound guidance group and 16.9% in the anatomical landmark group—were involved with some complications. Even in the study by Hayashi et al, [15] whose results are somewhat consistent with those of the present study, the rates of the incidence of the carotid rupture in the anatomical landmark and sonography groups (3. 3% and 1%, respectively) were lower than those in the present study (8.9% in both groups).

A comparison between the results of the aforementioned studies and ours shows that the complication rate of the ultrasound guidance technique in our study was high. On the other hand, whereas all those investigations reported a significant difference between the 2 methods, we found an equal rate of mechanical complications in our 2 groups. Personal skills in using ultrasound may be one of the possible reasons for such a difference.

Indeed, personal skills in the insertion of the central venous catheter play an important role in the success rate of this process. According to recent studies, the ultrasound-guided technique causes a significant decrease in the success rate of this procedure. [9, 20, 21]

In a study by Troianos et al, [20] central venous catheters were inserted under ultrasound

guidance in all the patients in less than 3 minutes, which is consistent with the results of the current study. Furthermore, all the cases in the ultrasound group were subjected to cannulation, with even less time than that in the mentioned studies (<140 s). Nevertheless, there was a rise in the rate of complications despite this higher speed. In addition, the rate of complications in the anatomical landmark method group was almost the same or even lower than that reported by previous investigations. [2, 12, 13, 15, 17, 18] A possible cause for the high rates of complications in the current study may be the non-elimination of the so-called "difficult-stick" patients from the study given that such patients have been excluded from most similar studies.

The most important complication of the internal jugular vein cannulation is the carotid rupture. In the present study, 8.9% of the cases experienced this condition in both the anatomical landmark and ultrasound guidance groups. About 10.6% of the patients in the study by Karakitsos et al [12] also suffered this complication.

CONCLUSIONS

The results of the present study run contrary to those reported by the previous investigations which indicated the superiority of the ultrasound-guided technique over the anatomical landmark method. [2, 8, 9, 12, 13, 17, 18, 20, 21] This disparity in the results may be in consequence of the landmarks having been used, the differences in the planning of the studies, and the skill levels of the operators carrying out the procedure.

Although the use of ultrasound guidance was not superior to the traditional methods, we would recommend its utilization in patients who lack appropriate landmarks.

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