CLINICAL SCIENCE

INTERNAL JUGULAR VEIN CANNULATION: AN ULTRASOUND-GUIDED TECHNIQUE VERSUS A LANDMARK-GUIDED TECHNIQUE

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OBJECTIVES: To compare the landmark-guided technique versus the ultrasound-guided technique for internal jugular vein cannulation in spontaneously breathing patients.
METHODS: A total of 380 patients who required internal jugular vein cannulation were randomly assigned to receive internal jugular vein cannulation using either the landmark- or ultrasound-guided technique in Bursa, Uludag University Faculty of Medicine, between April and November, 2008. Failed catheter placement, risk of complications from placement, risk of failure on first attempt at placement, number of attempts until successful catheterization, time to successful catheterization and the demographics of each patient were recorded.
RESULTS: The overall complication rate was higher in the landmark group than in the ultrasound-guided group ($p < 0.01$). Carotid puncture rate and hematoma were more frequent in the landmark group than in the ultrasound-guided group ($p < 0.05$). The number of attempts for successful placement was significantly higher in the landmark group than in the ultrasound-guided group, which was accompanied by a significantly increased access time observed in the landmark group ($p < 0.05$ and $p < 0.01$, respectively). Although there were a higher number of attempts, longer access time, and a more frequent complication rate in the landmark group, the success rate was found to be comparable between the two groups.
CONCLUSION: The findings of this study indicate that internal jugular vein catheterization guided by real-time ultrasound results in a lower access time and a lower rate of immediate complications.

KEYWORDS: Central venous cannulation; Jugular vein; Ultrasonography; Landmark; Complication.

INTRODUCTION

Internal jugular vein (IJV) catheterization is commonly attempted to obtain central venous access for hemodynamic monitoring (such as central venous pressure), long-term administration of fluids, antibiotics, total parenteral nutrition, kemoterapics, and hemodialysis. Many anatomical landmark (LM)-guided techniques for IJV puncture have been described.[1,2] Complications, including death, are influenced by patient factors such as Body Mass Index (BMI), site of attempted access, and operator experience.[3] It has been suggested that ultrasound (US) guidance could improve the success rate, reduce the number of needle passes, and decrease complications.[4,5] Although the ultrasound method has been favorably compared to the landmark technique, its widespread use has been hampered by the unavailability of equipment, such as the specially designed ultrasound device, and the lack of trained personnel.

Cannulation of the IJV is usually preferred because of its anatomical position and large diameter in the Trendelenburg position. Moreover, the minimal likelihood of obstructions along its route to the right atrium facilitates the introduction

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of various sizes of catheters using the external anatomical landmark method.

The purpose of this study was to determine whether ultrasound guidance could improve the success rate and decrease the complication rate of IJV catheterization compared to the landmark technique.

METHODS

This prospective study was approved by the Uludag University Medical Faculty, Bursa-Turkey ethics committee (15 April 2008, 2008-8/28), and written consent was obtained from all participants. A total of 380 patients were enrolled in between April and November, 2008. Patients with local or systemic infection, known vascular abnormalities, untreated coagulopathy (international normalization ratio > 1.5 and platelets < 50000/mm^3) were excluded from the study. Patients were randomly assigned to one of two groups: the LM group, in which cannulation was attempted via the landmark technique, and the US group, in which cannulation was attempted using ultrasound guidance.

The landmark technique

Patients were placed in a supine position with the head rotated at a 30^0 angle in the Trendelenburg position. The operator, who was a senior medical student in their final year, wore gown, cap, mask, and sterile gloves. The skin was cleaned with povidone-iodine before the placement of sterile drapes. After infiltration with 1% lidocaine, the IJV was located with a 'finder' needle connected to a 2-ml syringe. The needle was advanced through the skin at a 45^0 angle in the direction of the right nipple. The return of venous blood into the syringe confirmed entry into the vessel, and the finder needle was then used to guide a 16-gauge, 10 cm needle connected to a 10-ml syringe. A guide-wire was then placed through the needle into the vein, and the needle was removed. A central venous catheter (Certofix® B. Braun Melsungen AG, Germany) was placed over the wire and advanced into the IJV.

The ultrasound technique

The area was prepared as described in the landmark technique section above. Before the procedure, the position of the IJV was determined using a 7.5 MHz linear ultrasound probe (PLT 704 AT Toshiba Tokyo, Japan) and ultrasound (Aplio, Toshiba Tokyo Japan). After choosing the proper position, the skin was infiltrated with %1 lidocaine, and the IJV was located with an 18-gauge needle guided by the ultrasound probe. When the needle appeared to be in the vessel, evidenced by the ultrasound and the return of venous blood into the syringe, a guide-wire was placed through the needle into the vein and the needle was removed. A central venous catheter (Certofix® B. Braun Melsungen AG, Germany) was placed over the wire and advanced into the IJV.

Demographic characteristics, such as age, gender, physiological score (ASA), coagulation parameters (such as platelet numbers), and clinical parameters were recorded for all patients.

The measured outcomes were the access time, the number of attempts for successful placement, and catheter complications, such as carotid artery puncture, skin hematoma, brachial plexus injury, pneumothorax, and hemothorax.

Access time was defined as the time between the first skin puncture and the aspiration of venous blood into the syringe. Successful placement was defined as the observation of the catheters in the proper position by X-ray and functional determinants (i.e., no difficulty in the infusion or aspiration of venous blood).

Statistical Analysis

We estimated a 0.90 probability [standard deviation (SD)] that a patient who received IJV catheterization using the US-guided technique would have lower attempt numbers and complications. Assuming that the number of attempts would be compared using the Wilcoxon's rank sum test with a two-sided, 10% level of statistical significance and 90% power, we calculated that at least 167 patients for per group were required. Data are presented as mean ± SD or as the number of patients per category. A chi-square test was used to compare categorical variables, and a Student's t-test was used to compare independent means. *P*-values < 0.05 were considered statistically significant.

RESULTS

The characteristics of the 380 patients studied are summarized in table 1.

Table 1 - Characteristics of the patients

	The LM group (n = 190)	The US group (n = 190)
Age (years)	45.9 ± 13.5	49 ± 15.9
Gender (% male)	62.63%	64.21%
BMI (kg.m^{-2})	24.2 ± 5.2	23.7 ± 5.8
Side of catheterization (% right)	94.73%	90.52%

Data are presented as mean ± SD or %.

There were no significant differences between the two groups for age, BMI, gender, the side of catheterization, or the risk factors for difficult venous cannulation (such as prior catheterization, limited sites for access attempts, known vascular abnormalities, untreated coagulopathy, and skeletal deformity).

In all except 189 patients in the US group, the IJV was visualized and cannulated. One of the patients in the ultrasound group had an abnormality of the vascular track (thrombus visualized in the vena cava superior behind the azygos vein), which resulted in an unsuccessful attempt. During the US-guided procedure, the IJV can be visualized before the vessel is actually penetrated. Using this approach, a single-wall puncture can be made by the needle to the anterior wall. A short stabbing motion of the needle at this point will tend to puncture the anterior wall without opposing it to the posterior wall, thereby avoiding a double wall puncture. Single wall punctures were achieved in all cases in the US group.

Bleeding through the insertion site developed in two patients in the US group as an immediate complication of catheter placement. None of the patients developed a pneumothorax, hemothorax, or inappropriate position of the catheter in the US group.

The overall complication rate was higher in the LM group compared to the US group ($p < 0.01$). Carotid puncture and hematoma were the most frequent complications in the LM group compared to the US group ($p < 0.05$). None of the minor complications required any specific intervention other than compression of the puncture site (Table 2).

Finally, the number of attempts for successful placement was significantly higher in the LM group compared to the US group, which explains the significant increase in access time in the LM group ($p < 0.05$ and $p < 0.01$, respectively). Although the LM group had a higher number of attempts, a longer access time, and a more frequent complication rate, the success rate was comparable between the two groups (Table 2).

Table 2 - Comparison of ultrasound and landmark techniques in internal jugular vein cannulation

	LM group (n = 190)	US group (n = 190)
Average number of attempts	1.42 ± 0.92	1.08 ± 0.33*
Complications	8.42 ± 0.44	1.57 ± 0.14†
Carotid puncture	9 (4.73%)	1 (0.5%)*
Hematoma	7 (3.68%)	2 (1%)*
Hemothorax	0%	0%
Pneumothorax	0%	0%
Access time (seconds)	236 ± 110	95 ± 136†
Success rate	185 (97.36%)	189 (99.47%)

Access time and the average number of attempts are shown as mean ± SD. Success rate, carotid puncture, hematoma, hemothorax, pneumothorax, and side of catheterization are shown as both the absolute number of the patients and their percentage in their group.
*$p < 0.05$ versus the LM group; †$p < 0.01$ versus the LM group

DISCUSSION

This prospective study demonstrated the superiority of US-assisted cannulation of the IJV compared to the external landmark technique.

Most studies in the literature have used only US guidance in placing central venous catheters.[6] These studies, however, were conducted on critically ill or mechanically ventilated patients.[7] We studied 380 patients, all of whom had spontaneous breathing. All catheters were inserted to give total parenteral nutrition solution and chemotherapeutics or to measure the central venous pressure for i.v. fluid management. Some authors have recommended the US-guided technique in order to identify the location of the IJV before insertion of the needle.[6] In addition, the superiority of the real-time US guidance over the traditional landmark technique has already been shown by Nadig et al.[8]

The skill of the individual placing the central venous catheter plays an important role in the success rate. According to previous reports, the US-guided technique allowed a marked reduction of the access time.[9-11] Central venous catheters were placed within 3 minutes for all patients with US guidance.[10] In our study, the access times of the groups were statistically different, which is consistent with previous studies.

As previously described, the complication rate varied with the experience of the physician. The rate of 14.3% was determined in an inexperienced group in a study by Sznajder et al.[12]

The use of real-time US guidance prevents the insertion of the catheter into a vein complicated by thromboses or into a small vein.[13] In our study, catheterization was not successful in one patient in the ultrasound group due to an abnormality of the vascular track (thromboses visualized in the vena cava superior behind the azygos vein). Using the landmark technique, we found that the success rate of IJV catheterization was 97.3%, which is consistent with previous reports (ranging from 85% to 99%).[14-16]

Arterial puncture of the carotid artery is the most frequent complication of IJV catheterization because of its close anatomical proximity to the IJV. The number of attempts for finding the IJV was strongly associated with the overall rate of complications.[17] Mansfield et al.[18] reported that the complication rate was 4.6% if the catheter

insertion was successful on the first attempt. The rate, however, increased to 63.8% for two or more attempts. Yeum et al.[19] retrospectively analyzed 150 patients who required IJV catheterization, showing that arterial puncture of the common carotid artery occurred in 11.3% of the cases. In our study, the rate of carotid artery punctures was 5% with the landmark technique and 0.5% with the US-guided technique. Schummer et al.[20] recently reported an intra-arterial catheter misplacement case during IJV catheterization. Surgical exploration of the neck showed that the carotid artery remained intact, but the introducer sheath had passed the posterior wall of the right IJV and then entered the inferior thyroid artery.[20]

The procedural complexity of transducer sterility and the requirement for an experienced staff are drawbacks of using the US-guided technique for IJV catheterization.

The findings of this study indicate that IJV catheterization with the guidance of real-time ultrasound results in better success rates and lower immediate complications.

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