Original Research

Anatomical surface landmark versus ultrasound guided approach for internal jugular vein catheterization in adult patients: A prospective randomized clinical trial

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ABSTRACT

Introduction: Central venous catheterizations(CVC) are frequently carried out by anesthesiologists. This procedure is mainly meant for obtaining central venous pressure, administer long-term fluids, blood, and inotropes, aspirate air emboli, and administer total parenteral nutrition.

Aims: To compare the use of ultrasound guided technique versus surface anatomical landmark techniques in terms of success rate, number of times required for internaljugular vein cannulation, and complications.

Materials and Methods: 90 adult patients age between 20-70years who were scheduled for major elective surgeries participated in this prospective randomized study. After inducing anesthesia, the CVC was placed by an experienced team using sterile technique and was randomly divided into 2 groups of 45 each. internal jugular vein (IJV) cannulation was performed on a group AG patient using the anatomical surface landmark technique and for patients of group UG, ultrasound-guided technique was used to cannulize the internal jugular vein.

Results: The success rate for cannulation on first attempt was 66.7% in Group AG and 88.9% in Group UG. The mean duration of placement time in Group AG was 539.96 ± 64.24 seconds and in Group UG was 322.47 ± 11.05 seconds (p value <0.001). Carotid punctures were notedin ten patients in AG group and none in UG group (p value 0.001) which was statistically highly significant. Hematoma were developed in five patients of AG group.

Conclusion: We concluded that the ultrasound guided technique offers faster access with higher first attempt success rate and fewer complications compared to anatomical landmark technique.

Keywords: Internal jugular vein, Ultrasound, Central venous catheterizations

INTRODUCTION

One of the frequent procedures carried out in operating rooms and intensive care units (ICU) is central venous catheterization (CVC). Patients need central venous catheters for a variety of procedures, including blood sampling, parenteral nutrition, hemodialysis, multiple drug administrations, vasopressor infusion, and central venous pressure monitoring. [1-3]Internal jugular vein is located superficially, so visualized easily by ultrasound, have a straight course with larger diameter on trendelenburg position. [4,5] Internal jugular vein catheterization also avoids many of the complications.[6] When there are a natomical variations and neck deformities, landmark s urface technique is associated with a number of challe nges.This might necessitate additional tries along with longer time to cannulate the vein. Before and during the procedure, an ultrasound guidance aids in visualising the target vein and adjacent anatomical structures. [7,8] Higher success rate and lesser possibilities for complications with better patient compliance found in ultrasound guided technique. [9,10,]The purpose of this study was to determine whether ultrasound guidance will help to improve the success rate and decrease the complication rate of IJV

catheterization compared to the landmark technique. Our major emphasis was on patient safety and prevention of iatrogenic complications.

MATERIALSANDMETHODS

This prospective, randomizedclinical trial was conducted from July 2018 to September 2019 in human subjects and in accordance with the principles of the Declaration of Helsinki (2013). After receiving Institutional Ethical Committee clearance and registering the trial with the Clinical Trials Registry India (no.CTRI/2019/05/019053), this study was conducted on 90adult patients with American Society of Anesthesiologists (ASA) Grade I & II, age between 20-70years, who were scheduled for elective major surgeries.Written informed consents were obtained from all patients.Patients having a history ofmedication allergies, bleeding disorder and on anticoagulant treatment, abnormal neck anatomy, known vascular abnormality, emphysematous patients were excluded from thetrial.A total of 90patients were enrolled, and a computer-generated randomization table was used to divide the min to two study groups of 45patients each. Thesealed envelopes were prepared by a designated consultant (not included in study protocol), who opened it just before the start of the study and choose the method of internal jugular vein (IJV) cannulationas per the code on the envelops. The attending anesthesiologist kept a record of the patients which were divulged on completion of the study.

The study groups were as under:

Group AG: Internal jugular vein cannulated by using anatomical surface landmark technique.

Group UG: Internal jugular veincannulated by using ultrasound guided technique.

Standard monitors such as an ECG, a pulse oximeter, and a noninvasive bloodpressure monitor were attached in the operating room and baseline parameters were collected. Infusion of crystalloid solution began after establishing an 18-gaugeintravenous cannula. Propofol (2-3mg/kg), fentanyl (1µg/kg), and vecuronium (0.1mg/kg) were used to induce general anesthesia. After intubation, head positioned by turning to opposite side up to 30^0 angle and 15-20˚ trendelenburg position to attain venous engorgement during the procedure. To allow for neck hyperextension, a roll of towels was placed under the shoulders. Asepsis was done from the ear lobe to the nipple, the entire right side of the neck and chest area with disinfectant and covered with sterile drape.The internal jugular vein catheterization in this study was done by anesthesiologist who have performed at least teninternal jugular veincannulations in both the landmark and ultrasonographic techniques in adult patients before participating in the study. We allowed a maximum of three attempts of procedure at the catheter site. The observations were noted by another anesthesiologist who weren't aware about the aim and outcome to study.In Group AG, prior to preparation and draping for the procedure, anatomical landmarks such as the sternal notch, cricoid cartilage, clavicle, and carotid artery (CA) pulsation were assessed. The apex of the triangle formed by the clavicular and sternal heads of the sternocleidomastoid (SCM) muscle.An introducer needle along with attached 5 ml syringe was slowly inserted lateral to the carotid artery while continuously applying negative pressure and directed toward the ipsilateral nipple. Retracting the pulsating carotid artery required the use of the left index and middle fingers. Entry into the internal jugular vein was confirmed when free-flowing, dark venous blood was returned from the vein through the needle.Through the side port of the introducer needle, J-wire was inserted. The introducer needle was removed while leaving the guide wire in place once the guide wire had been adequately and correctly inserted into the jugular vein. The vessel was dilated. The double-lumen CVP catheter was then inserted over the J-wire for the desired length after the dilator was removed.After the J-wire was removed, the catheter was connected to the infusion tubing, flushed with saline, and fastened with sutures and sterile plasters.In Group UG, ultrasound guided catheterization is done with a device that uses a linear transducer between 5 and 10 MHz. Asepsis was accomplished using sterile gel and a sterile probe cover. The targeted vein was on the side of the neck, and the ultrasound probe was placed with its long axis at a 90-degree angle. To achieve a short axis out of plane approach, the needle was inserted at the probe's midpoint along its long axis. The carotid artery and the internal jugular vein were identified as the vein's compressibility and the artery's visible pulsations, respectively. An introducer needle with a 5 ml syringe was inserted through a needle guide to cannulate the internal jugular vein while under continuous real-time ultrasound imagining. After this point catheterization procedure that followed was the same as what was done in anatomical landmark group.

The following parameters were assessed

1. Success rate defined as the rate of successful placement of catheter inside internal jugular vein in a single needle attempt.
2. Number of needleattempts defined as the number of times the needle was withdrawn and redirected till successful internal jugular vein cannulation.
3. Time taken for catheter placement defined as time takenfrom first needle entry to successful aspiration of venous blood.
4. Complications (arterial puncture, hematoma, pneumothorax, hemothorax, subcutaneous emphysema, catheter malposition).
5. The incidence of infection while the catheter was in done by inspection of the puncture site took place there. Pairing quantitative or qualitative blood cultures from a peripheral vein and from

the central venous catheter were used to diagnose catheter-related blood stream infection (CRBI).

6. Chest X-rays were taken to determine where central venous catheter's tip is located and to check for pneumothorax and hemothorax. Complicated situations were handled in accordance with accepted protocol.

STATISTICAL ANALYSIS

Prior to the study, a power analysis was performed to calculate the success rate of central venous catheterization of internal jugular vein(primary outcome) where 10 pilot cases were conducted in each group. The sample size of 80 patients was determined using a power of 80%,beta error of 0.2, alpha error of 0.05, and to detect a differenceofproportion of 0.12 between thegroups.After completion of study, data were compiled and analyzed using Statistical Package of Social Sciences (version 21.0, SPSS Inc., USA). Continuous variables were expressed in terms of mean and standard deviation (SD), whereas categorical variables were expressed in terms ofpercent. To compare two groupsmeans, an unpaired student t test and to compare intra group means ANOVA was used. The Chi-square test was used to determine the relationship between category variables. Statistical significance was set at $P<0.05$.

RESULTS

Regarding demographic parameters, including age, gender, weight, height, BMI, American Society of Anesthesiologists physical status, both the groups were comparable without any statistically significant difference. [Table 1]There was a statistically significant difference between the two groups in terms of success rate of cannulation on first attempt. (P=0.011) [Table 2] In order to successfully cannulate a patient, the mean number of needle attempts in the UG group was 1.11±0.32 and, in the AG group was 1.33±0.48 (p=0.011). In comparison to the UG group, attempts were higher in the AG group. [Table 3]There was a statistically significant difference in the mean catheter placement time between the groups (P<0.001). It was found that the catheter placement time was shorter in UG group (322.47±11.05 seconds) than that of the AG group (539.96±64.24 seconds) [Table 4].However, the overall complication rate was greater in the anatomical landmark group compared to the ultrasound group. Ten patients (22.1%) had carotid artery punctures, and five patients (11.1%) had hematomas at the puncture site in AG group.There was not any complication in the UG group. [Table 5]

Table1: Demographic Data

Variables	Group UG (N=45)	Group AG (N=45)	Pvalue
Age(yrs.)	42.6 ±13.3	45.1± 13.6	0.378
Gender (M/F)	(19/26)	(25/20)	0.206
BMI(kg/m2)	23.89±1.20	23.38± 1.68	0.118

Values are presented as mean ± SD or number only. M= Male, F= Female, P>0.05, not significant

Table 2: Success rate of internal jugularvenous catheterization in different groups

Successful IJV	Group UG (n=45)	Group AG (n=45)	P
Yes	40 (88.9%)	30 (66.7 %)	0.011
No	05 (11.1%)	15 (33.3 %)	

UG=Ultrasound group, AG= Anatomical landmark group
Data is expressed in N (%).

Table 3: Comparison of number of attempts for internal jugular venous catheterization in different groups

Number of attempts	Group UG(n=45)	Group AG (n=45)	P
One	40	30	
Two	05	15	0.011
Mean±SD	1.11±0.32	1.33±0.48	

UG=Ultrasound group, AG= Anatomical landmark group
Data is expressed in Mean±SD.

Table 4: Comparison of placement time of IJV in different groups

Placement time (Seconds)	Group UG (n=45)	Group AG (n=45)	P
	322.47±11.05	539.96±64.24	<0.001

UG=Ultrasound group, AG= Anatomical landmark group

Table 5: Complications of IJV cannulation in different groups

	Group UG (n=45)	Group AG (n=45)	P
Arterial puncture	0	10(22.2%)	0.001
Haemaroma formation	0	05(11.1%)	0.021
Pneumothorax	0	0	NA
Infection	0	0	NA
others	0	0	NA

UG=Ultrasound group, AG= Anatomical landmark groupData is expressed in N (%).

DISCUSSION

Peters et al. published the first study on the use of an u ltrasoundoppler sonographic device to locate the subcl avian vein in 1982. [11] Legler and Nugent used an ultrasonic Doppler sonographic to find the internal jugular vein for the first time in 1984.[12] According to National Institute of Clinical Excellence (NICE) recommendations, 2D ultrasonography should be considered in most clinical situations when central venous cannulation is necessary. [13]The success rate in the current study using the ultrasound technique was 88.9% and using the anatomical landmark technique was 66.7%, which is in accordance with the success rate documented in the previous studies. [9,14,15]In a study done by Shrestha et al., the ultrasonic technique group had a first attempt success rate of 63% and the anatomical landmark technique group had a first attempt success rate of 32% which was highly significant. [16]Contrast to the present study, some previous studies have not found any significant difference between the groups while comparing the success rate of techniques of internal jugular cannulation. [17]This might be due to diverse study populations, and variable definitions of successful cannulation were adapted in different study groups.In present study, the average number of catheterization attempts was 1.33±0.48 for the anatomicallandmark techniqueand 1.11±0.32 for the ultrasound technique. The difference was statistically significant (P=0.011).SazdovDet al. found in investigation of 400 patients, that successful catheterization required an average of 1.52 attempts in the anatomicallandmark group and 1.25 attempts in the ultrasound group. [18]The difference was statistically significant (P<0.05).The results of previous studies are also comparable to our study. [10,19]In this study, the mean duration for catheter placement or catheterization time was 322.47±11.05 seconds using an ultrasonic technique and 539.96±64.24 seconds for an anatomical landmarktechnique. Statistics showed that this difference was very substantial. There was significant prolongation of placement time in anatomical technique group which is consistent with earlier investigations. [16,20] In this study, the overall complications were higher with the anatomical landmark technique compared with the ultrasound technique,which wasstatistically significant (P<0.05).In the present study, carotid puncture was observed in 22.2% of patients with the anatomical landmark technique.Hematoma formation occurred only in 11.1% of patients who belonged to the anatomical landmark group, which was managed by external compression. Incidence of carotid artery puncture and hematoma were in accordance with previous studies using similar techniques. [21-24] No other complications were observed in this study.Lorente L et al. studied the incidence of catheter related local infection (CRLI) and catheter-related bloodstream infection (CRBSI) with central venous catheters (CVCs) according to different access sites. Author found that femoral central line was associated with a significantly higher incidence of CRLI and CRBSI than jugular and subclavian vein catheterization. [25]Catheters inserted in the jugular, subclavian, and femoral sites have different infection rates, although no randomized experiment has adequately examined these rates. [26,27]In a prior study, 33% of patients in critical care had venous thrombosis found by ultrasound imaging, and 15% of these patients had catheter-related thrombosis. [28]It is crucial to possess the necessary cognitive skills, an awareness of the process, and physical dexterity to safely carry out this invasive treatment to successfully gain central access. [29]The safety of the ultrasound guided technique may be particularly important in patients at an increased risk for pneumothorax, patients with hematological or neoplastic disease and uncooperative or very obese patients. [30]The drawbacks of this study included a small sample size, unblinded evaluation of results, and no measurement of the IJV diameter. So,a greater number of patients and a larger study duration are required for establishing a concept.

CONCLUSION

In conclusion, ultrasound guided technique offers faster access with high success rate, safe with a smaller number of attempts and complications for internal jugular cannulation in comparison to anatomical landmark technique. These findings imply that this strategy might be chosen in challenging situations or when access issues are likely.

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