

# Evaluation of the Safety and Effectiveness of Ultrasound-guided Internal Jugular Vein Catheterization in Critically Ill Patients

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## Abstract:

**Background:** Central venous catheterization is a frequently performed procedure in intensive care units (ICU) for diagnostic and therapeutic purpose. As an invasive procedure it carries some risk and should be performed with few attempts. Traditionally this procedure is performed blindly by considering body surface landmark, but this procedure can be done with the help of ultrasound machine as an alternative of landmark procedure.

**Objectives:** Evaluation of the safety and effectiveness of USG-guided internal jugular vein(IJV) catheterization in critically ill patients.

**Methods:** This prospective observational study was conducted in the ICU of Dhaka Medical College Hospital, from May 2017 to October 2018. Patients scheduled for central venous catheterization via the IJV were included based on selection criteria and randomly allocated into two groups of 50 patients each using card sampling. Group A received ultrasound-guided catheterization, while the landmark technique was used in Group B.

**Results:** The analysis revealed that in the ultrasound group 49 out of 50 (98.0%) patients were successfully catheterized while the landmark method was successful in 45 out of 50 (90.0%) patients. Successful catheterization by first attempt was possible in 29 patients of group A, where as it was 5 in group B. The average number of attempts for successful catheterization in Group A was 1.7 (SD=0.2) and in the landmark group it was 2.8 (SD=0.1). On the average, 4.9 minutes (SD=1.3) were needed for catheterization in ultrasound group. The time was significantly increased in the landmark group 11.4 (SD=5.8). Total number of complication was 2 in Group A and it was 8 in Group B. After considered all the above parameter, by using four points safety and effectiveness rating scale, safety and effectiveness mean score was 10.3 for Group A and 8.2 for Group B.

**Conclusion:** Two-dimensional ultrasound offers improved safety and quality when compared with an anatomical landmark technique for IJV catheterization.

**Keywords:** Carotid Artery, Critically Ill, Internal Jugular Vein, Intensive Care Unit.

## Introduction:

Central venous catheterization is one of the important procedure commonly perform in modern clinical practice. Previously it was only used for drug or fluid administration but now a day's its indications have significantly extended including hemodynamic monitoring, total parental nutrition, renal replacement therapy, plasma exchange, measurement of pulmonary artery pressure, transvenous pacing etc<sup>1</sup>. The catheter may be placed in a large vein in the neck (internal

jugular vein, external jugular vein), upper chest (subclavian vein, axillary vein), groin (femoral vein), or through veins in the arm (also known as a PICC line, or peripherally inserted central catheter). However, this procedure is not out of risk such as it can cause arterial puncture instead of the vein , might result in a hematoma which can become infected or can lead to compression of the carotid artery and other complications like pneumothorax, thrombosis, embolism, nerve injury. For this the procedure should be performed cautiously with as few attempts as possible<sup>2</sup>.

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Which central venous access will be suitable for which patient is based on the rate of failure and the severity of complication. Two recent papers shows that, internal jugular access is associated with a low rate of severe mechanical complications in the intensive care unit as compared with subclavian access, and it is preferable for short-term access (<5–7 days) and for haemodialysis catheters<sup>3</sup>. Traditionally, central venous catheterization is performed by using the anatomic landmark technique where the operator use 'landmarks' on the body surface to find the correct place to insert catheters. For this blind procedure, chance of success is less but chance of complication is more. In an attempt to increase success rate, to decrease complication and minimize morbidity, the ultrasound-guided technique has been proposed<sup>4</sup>.

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Anatomically, the Internal Jugular Vein is in an anterolateral position with respect to the internal carotid artery (ICA), covered by the sternocleidomastoid muscle (SCM). It ends behind the internal edge of the clavicular bundle of the SCM, near the medial end of the clavicle where it joins the subclavian vein to form the venous brachiocephalic trunk. During cannulation after puncturing the internal jugular vein, the catheter is introduced using Seldinger technique<sup>5</sup>. From the anatomy of Internal Jugular Vein it is clear that, it is easy to puncture the carotid artery, easy to injure the lung and surrounding nerves. During the blind procedure, the operator must consider all of these things. For this, despite being an experienced clinician, who performs central venous catheterization, the classical anatomic landmark method is associated with a small but potentially significant morbidity<sup>6</sup>.

The ultrasound-guided technique is another alternative method for central venous catheter placement. In this method, the needle is advanced under ultrasonographic guidance (real-time), allowing its safe introduction into the internal jugular vein, while the carotid artery is visible during the procedure. US probes best suited for central venous catheter placement are small linear array probes with high frequency transducer (5-15MHz). These probes usually have a scanning surface of about 20 -50 mm and allow high-resolution imaging of superficial anatomic structure. In most ultrasound-guided techniques, a 7.5 MHz linear-array ultrasound probe connected to a real-time ultrasound is used, covered with gel and wrapped in a sterile plastic sheath. By using real-time ultrasonography, the operator can measure the depth and caliber of the internal jugular vein, evaluate its patency and recognize any thrombi within it<sup>7</sup>. From the operating mechanism of USG, it is distinct that it has the ability to help the operator to reduce the chance of unsuccessful attempt and complication.

For proper functioning, the ultrasound-guided technique requires the appropriate devices and an adequately trained operator. However, it has many important advantages. Position of Internal Jugular Vein could not be accurately predicted in 5.5% of patients by external landmark<sup>8</sup> and this vein shows a great variability in its anatomic position relative to carotid artery<sup>7</sup>, in such cases USG will allow direct visualization of the great vessels of the neck. Moreover, the diameter of this vessel also shows great variability and the operator may choose to insert the catheter from the other side if the jugular vein has a small diameter (< 7 mm) or if it is stenosed (for example, after previous catheter insertion and administration of chemotherapy via this route<sup>9,10</sup>).

Interestingly, in the study by Forauer et al (2000), 35% of patients had a significant ultrasound finding before the procedure and necessitated a change in the access approach in 75%<sup>9</sup>. Thus, ultrasound-guidance techniques ensure less number of attempts and patient safety and significantly increase the overall success rate of central vein catheterization. The increased success rate has as a result the significant decrease of the operating time. At the same time, the puncture/injury of the carotid artery and the double-wall

puncture can be avoided<sup>11</sup>.

In selected groups of patients the safety of the ultrasound-guided technique may be especially important, such as un-cooperative or very obese patients (where the location of the anatomic landmarks may be difficult), haemodynamically compromised patients, in patients with increased risk for pneumothorax (patients under mechanical ventilation with high PEEP or with chronic obstructive pulmonary disease), but also in patients with hematological or neoplastic disease (where catheter placement involves an additional risk due to disease- or treatment-related thrombocytopenia or other disorders of hemostasis<sup>10,12</sup>). Obviously, the increased success rate and safety result in significant decrease of patient's discomfort, and thus this method is much more appealing for both the patient as well as the clinician. So it is clear that ultrasound-guided technique is a safe, highly effective and cost-efficient method in achieving central venous access and is associated with high patient satisfaction. Therefore, the purpose of the present study was to observe the outcome in terms of success at first attempt, number of attempts, successful catheterization, complication and catheterization time of Internal Jugular Vein by anatomical landmark versus USG-guided technique. For the benefit of comparison the total outcome of both groups was finally compared by newly synthesized four-point safety and effectiveness rating scale. So the result obtained from this study, may encourage and help the intensivist to manage critically ill patients rapidly, safely and precisely by the help of advanced technique and thus may influence patient management and outcome.

#### Materials and methods:

This prospective observational study was conducted in the ICU of Dhaka Medical College Hospital (DMCH), at the Department of Anesthesia, Analgesia, Palliative & Intensive Care Medicine from May 2017 to October 2018. Two groups of patients, 50 patients in each group were allocated by card sampling. The group-A had received ultrasound-guided catheterization and group-B by landmark technique. The placement of the central venous catheter (CVC) for each group was done by the same experienced physician who was experienced in CVC catheterization through the subclavian and femoral access by traditional landmark method, but had zero experience in catheterization of Internal Jugular Vein by both anatomical landmark and ultrasound procedure. Study patients were selected based on the following inclusion & exclusion criteria and success rate, operating time, complications (pneumothorax, puncture of carotid artery, hematoma formation), success at first attempt, number of attempts to achieve central venous catheterization of both groups were recorded.

All patients admitted to critical care unit and planned for central venous catheter insertion during the study period were included in the study if they were  $\geq 18$  years. They were excluded if refused to participate in the study, if they had previous history of CVC insertion on same side, abnormal coagulation profile, local infection, burn, trauma, mass at the site of insertion, intraluminal thrombosis, or patients with pregnancy, cardiac arrest, or heart failure.

**Anatomic landmark technique:** The operator first identified the triangular area at the base of the neck created by the separation of the two heads of the sternocleidomastoid muscle. The Internal Jugular Vein and carotid artery run through this triangle. The operator first locates the carotid artery pulse in this triangle. Under sterile aseptic precaution; the intended venipuncture site was anaesthetized by subcutaneous infiltration with local anesthetic solution (2% Lignocaine). With the finger of the left hand gently resting on the carotid arterial pulse retracted towards the midline and away from the Internal Jugular Vein. The probe needle is then inserted at the apex of the triangle and the needle is advanced towards the ipsilateral nipple at 45° angles from the skin. After puncturing the internal jugular vein, the catheter is introduced using the Seldinger technique<sup>13</sup>.

**Ultrasound guided technique:** The chosen insertion site was prepared with 2% chlorhexidine. Maximum barrier precaution like sterile gloves, gown, drape and mask were used to decrease the risk of bacterial colonization. A portable ultrasound scanner array probe with 7.5MHz ultrasound machine is used. The transducer was covered with ultrasound gel and wrapped in a sterile plastic bag. Sterile physiological saline solution is spread on the patient's skin to eliminate the air interface between the skin and the plastic bag. The carotid artery was visualized as a thick-walled, pulsatile and non-compressible by probe with no changes with respiration whereas internal jugular vein was visualized as thin-walled, non-pulsatile, and compressible by probe and decrease in diameter on inspiration. After positioning the vein in the center of ultrasound screen, the vessel is punctured under direct vision using 18 gauge needles. Backflow of dark colored blood is noted then preceded as modified Seldinger technique<sup>1</sup>.

The position of the patient throughout the study was supine with 15 degree Trendelenburg position and neck tilt to opposite site in the range of 15-20 degree in both techniques of insertion of internal jugular vein catheterization. The ideal placement of catheter tip is parallel to Superior Vena cava, just below the inferior border of clavicle, above 2-3 ribs.

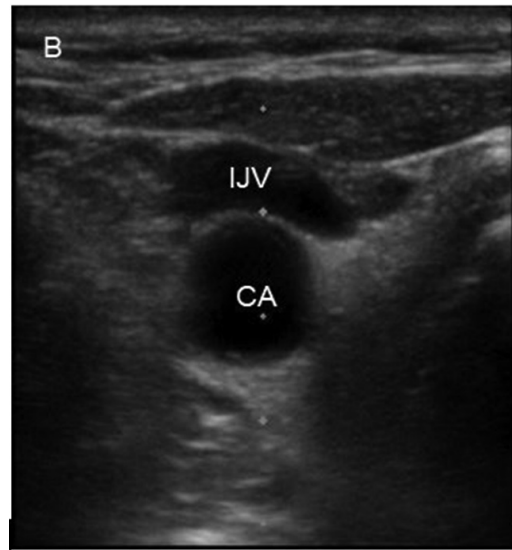
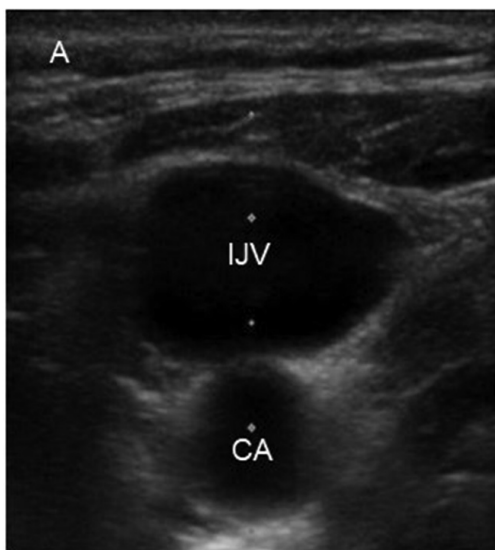


Figure 1A: Short axis view of Internal Jugular Vein by USG

1B: Compressed view of Internal Jugular Vein by USG

**Successful catheterization:** A maximum of three attempts were allowed for a successful catheterization at the catheter site. An unsuccessful attempt had declared when after skin puncture, needle advancement and needle withdrawal there wasn't a return of venous blood from the targeted vein. After three unsuccessful attempts the procedure had declared unsuccessful.

**Catheterization time:** Time was measured from skin puncture of the first prick to the end of final catheter placement, including all the attempts to do the catheterization and circumstances in between them, not including the suturing and fixation time. A stop watch was used to record the time.

**Complications:** Mechanical complications like arterial puncture, pneumothorax and hematoma were recorded. A pulsatile flow of bright red blood from the needle was a sign of arterial puncture. In such cases the needle was withdrawn from the skin and manual pressure for at least 5 minutes were applied by a sterile cotton ball to achieve hemostasis.

Hematoma formation on the skin access site bigger than 1 cm in diameter was recorded. It was examined by inspection and palpation. A measuring scale was used to measure the diameter.

An USG examination of the lungs was made as early as possible after the procedure to check for pneumothorax, which can be detected by the presence of 'Barr code sign' in the lung field. Then chest x-ray was done to check the catheter's position and confirmation of pneumothorax

**Number of attempts:** Total 4 attempts to do the catheterization were allowed. If catheterization was not possible by 4th attempt, then the case was excluded from the study. Success at first attempt was also recorded.

#### 4 (four) points safety and effectiveness rating scale:

For CVC placement different type of scale has been used in the study center. After consulting with senior physician this 4

(four) points safety and effectiveness rating scale was included in the present study. Before this current study, such type of scale for IJV catheterization was not used by any other studies. The scale was mainly composed by the main outcome variable of the study.

*Safety and effectiveness scale:* Four points' safety and effectiveness scale

Effectiveness scale	Variables	Points
1. Number of attempts for successful catheterization	1	4
	2	3
	3	2
	4	1
2. Time to complete the catheterization (min)	0-3	4
	3.1-5.0	3
	5.1-7.0	2
	>7.1	1
Safety scale	No complication	4
	Hematoma	3
	Carotid artery puncture	2
	Pneumothorax	1

It has two parts: safety part and effectiveness part. Safety part consists of complication and effectiveness part consists of number of attempt, time to complete the catheterization. Each part is again subdivided into 4 portions. According to variability each portion contains number from 1 to 4. Thus, the scale contain a total number of 3 to 12.

Finally rating of safety & effectiveness of catheterization of both group (USG& anatomical landmark) were done by one's points what he/she earned from the above scale and it was rated as follows:

	Points
1. Excellent	10-12
2. Very good	7-9
3. Good	4-6
4. Average	1-3

Higher marks mean better performance that is less or no complication, less number of skin prick, less time for cannulation. Low marks mean poor performance of a procedure that produces more severe complication, more number of attempts and more time for cannulation.

Though the scale is new but the component of the scale has been taken by searching the previous studies and most important and mostly used outcome variable has been taken. Though the effectiveness scale maintains homogeneity, but

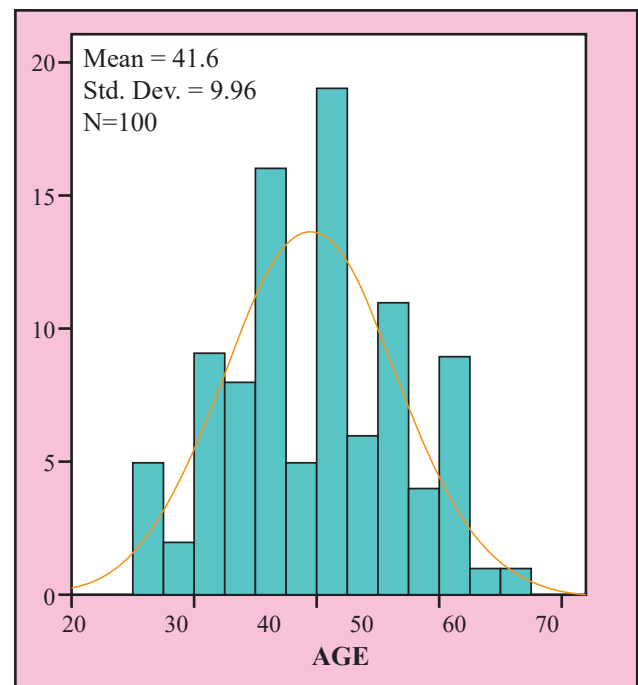
for safety scale top most three different complication has been chosen. By this scale one person can get an idea about the performance of a procedure at a glance.

Statistical analysis: All the informations were collected in data sheet. Data were edited by using data collection sheet. After editing and coding, data cleaning, validation and analysis was performed using the SPSS/PC software version 22.0 [International Business Machines (IBM) Corporation] and graph and chart by MS excel. Continuous data were expressed as mean  $\pm$  standard deviation if normally distributed and as median(IQR) if not normally distributed. Categorical variables were expressed by frequency and percentage. Chi-square test was used to see the association between groups. A "P" value <0.05 considered as significant.

**Result:**

This Prospective observational study was carried out on 100 patients referred to ICU of DMCH, Dhaka, Bangladesh, to make a trend to do the central venous catheterization under USG- guidance.

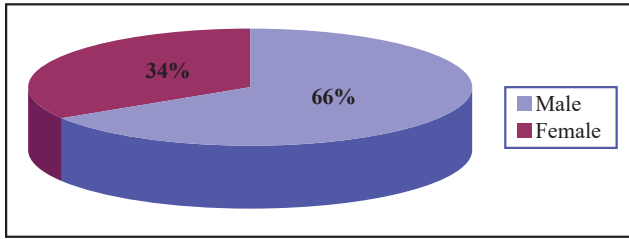
Mean age of the study patients was 41.6  $\pm$ 9.962 years (fig 2). Age distribution resembles normal distribution where the numbers of middle to elderly aged patients were high in contrast to extreme or younger age groups. About 80% patient's age was between 30 to 60 years. Least numbers of patients was present from other age groups. But this difference is not significant.



**Figure- 2: Histogram showing age distribution of the patients**

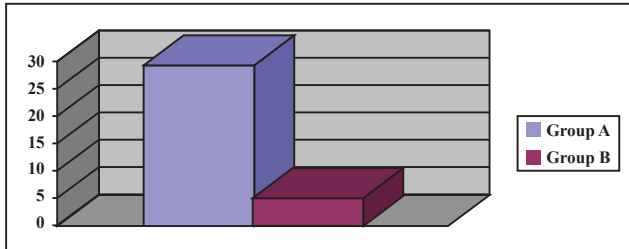
Figure 3 shows gender of the patients. Out of 100 cases 66.0% cases were male and 34.0% were female. Male and female ratio was 1.9:1.





**Figure- 3: Gender distribution of study subjects**

In this study success rate in first attempt of Internal Jugular Vein catheterization in critically ill patients revealed that, in group A patients, 29(58.0%) of procedures achieved success performance in first attempt, but it was 5(10.0%)in group B. The difference was statistically significant ( $p<0.05$ ) between two groups (Figure 4).



**Figure - 4: Success rate at first attempt of Internal Jugular Vein Catheterization in Critically ill Patients**

Present study shows that majority of the subjects, e.g., 39.0% patients required two times attempt for Internal Jugular Vein Catheterization (Group A 32.0% vs Group B 46.0%). Success rate in single time attempt was higher in group A (58.0%) patients and only single case had required >3 times attempt for catheterization. But in group B, 5(10.0%) of patients had required >3 times attempt for catheterization. The mean number of cannulation attempts was  $1.7\pm0.2$  times in group A subject and  $2.8\pm0.1$  times in group B subject. The difference was statistically non-significant ( $p<0.05$ ) between two groups (Table I).

**Table- I: Distribution of the patients according to number of attempt required for Internal Jugular Vein Catheterization in Critically ill Patients (N=100)**

Number of attempt	Frequency and Percentage		Total (%)	P value
	Group A	Group B		
	(Ultrasound) No. (%)	(Landmark) No. (%)		
Single time	29(58.0%)	5(10.0%)	34	0.001 <sup>s</sup>
Two times	16(32.0%)	23(46.0%)	39	0.075 <sup>ns</sup>
Three times	4(8.0%)	17(38.0%)	21	0.001 <sup>s</sup>
> 3 times	1(2.0%)	5(10.0%)	6	0.158 <sup>ns</sup>
<b>Mean±SD</b>	<b>1.7±0.2</b>	<b>2.8±0.1</b>		

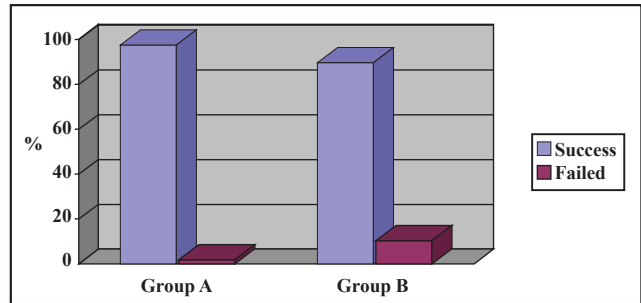
Data were expressed as frequency, percentage and mean, standard deviation Chi-square test was used to see the association between groups

%=Percentage of the study population

s= significant

ns=non-significant

Figure 5 shows overall success rate was higher in group A patients 49 (98.0%) compared with group B 45 (90.0%). Difference between two group was statistically non-significant.



**Figure- 5: Successful catheterization of Internal Jugular Vein in Critically ill Patients**

It is evident from Table II that the maximum cannulation time for 33 patients was between 3.1 and 5.0 minutes, with a predominance in Group A (25 in Group A and 8 in Group B, respectively). Mean cannulation time was lower in group A ( $4.9\pm1.3$  min) than group B ( $11.4\pm5.8$  minutes). So group- A or ultrasonographic guidance to have influence overall operating time as compared to with traditional techniques; the difference was statistically significant ( $p<0.05$ ) between groups.

**Table-II: Evaluation of operating time for Internal Jugular Vein Catheterization in Critically ill Patients**

Time (min)	Frequency and Percentage		Total (%)	P value
	Group A	Group B		
	(Ultrasound) No. (%)	(Landmark) No. (%)		
0-3 min	14(28.0%)	5(10.0%)	19	
3.1-5.0 min	25(50.0%)	8(16.0%)	33	
5.1-7.0 min	8(16.0%)	20(40.0%)	28	
>7.1 min	3(6.0%)	17(34.0%)	20	
<b>Mean±SD</b>	<b>4.9±1.3</b>	<b>11.4±5.8</b>		<b>0.001<sup>s</sup></b>

Data were expressed as mean and SD

Chi-square test was used to see the association between groups

%= Percentage of the study population

SD=Standard deviation

Table III shows different complications during internal jugular vein catheterization. Complications were comparable between two arms, but haematoma was significant in group B. Carotid artery injury occurred in single patient of group A & 2 patients of group B. Pneumothorax occurred in single patient of group A & 2 patients of group B.

**Table-III: Complications during Internal Jugular Vein Catheterization in Critically ill Patients**

Complications	Frequency and Percentage				P value
	Group A		Group B		
	No.	(%)	No.	(%)	
	No	%	No	%	
Carotid artery injury					
Yes	1	2.0	2	4.0	0.427 <sup>ns</sup>
No	49	98.0	48	96.0	
Hematoma					
Yes	0	0	4	8.0	0.021 <sup>s</sup>
No	50	100.0	46	92.0	
Pneumothorax					
Yes	1	2.0	2	4.0	0.427 <sup>ns</sup>
No	49	98.0	48	96.0	

Data were expressed as frequency and percentage  
 Chi-square test was used to see the association between groups  
 %=Percentage of the study population

In this study complication rate was higher in group B patients 8 (16.0%) compared with group A 2 (4.0%). Overall difference was significant (p<0.05) (Figure 6).

**Figure- 6: Complications rate between groups**

Present study shows that, Ultrasound guided technique is more effective (mean score was 10.3) than traditional anatomic landmark technique (mean score was 8.2). The difference was statistically significant (p<0.05) (table IV).

**Table-IV: Assessment & evaluation of Four points' safety and effectiveness scale between groups**

Scale with Variables	Frequency and Percentage				
	Group A		Group B		
	No.	(%)	No.	(%)	
	Points	No	%	No	%
Number of attempts for successful catheterization					
1	4	29	58.0	5	10.0
2	3	16	32.0	23	46.0
3	2	4	8.0	17	34.0
4	1	1	2.0	5	8.0
Time to complete catheterization (min)					
0-3	4	14	28.0	5	10.0
3.1-5.0	3	25	50.0	8	16.0
5.1-7.0	2	8	16.0	20	40.0
>7.1	1	3	6.0	17	34.0

Safety scale					
No Complication	4	48	96.0	42	84.0
Hematoma	3	0	0	4	8.0
Carotid artery injury	2	1	2.0	2	4.0
Pneumothorax	1	1	2.0	2	4.0
Mean score		10.3	8.2		

**DISCUSSION:**

Purpose of the present study was to observe the outcome in terms of number of attempt, success at first attempt, successful catheterization, complications and catheterization time of Internal Jugular Vein by anatomical landmark versus USG guided technique. For final comparison four points' safety and effectiveness rating scale was used. According to that rating scale, USG guided cannulation stood in excellent group and anatomical landmark group stood in very good group and the study reveals that-USG guided technique for Internal Jugular Vein catheterization is superior to anatomical landmark technique in most of the aspect.

In this study, age of patients ranged from 18 to 67 years. It was observed that majority of the patients belonged to age 41-50 years. The mean age was found 41.4±9.7 years in Group-A and 42.1±8.5 years in Group-B. Age distribution resembles normal distribution where the numbers of middle to elderly aged patients were high in contrast to extreme or younger age groups. There was no significant difference between two groups. All these findings consistent with result of other study. The mean age was 38.78 ± 8.01 in a study conducted by Karimi-Sari et al (2014)<sup>14</sup>.

Male and female ratio for the present study was 1.9:1. Demographic profile between groups was statistically non-significant (p>0.05). In a developing country like Bangladesh, problems or diseases of females are not taken seriously in every aspect. For this, the percentage of treatment taken or hospital admission for better management is relatively low for female then male. Present study is a reflection of this circumstance. Similar result was found in a study where 120 patients were enrolled, 77 (64.2%) patients were males<sup>15</sup>.

In this study success rate in first attempt of Internal Jugular Vein catheterization revealed that, in group A patients, 29(58.0%) of procedure achieved successful performance in first attempt, but in group B it was 5(10.0%). The difference was statistically significant (p<0.05) between two groups. The result shows superiority and safety of ultrasound over anatomical landmark. In the matter of comparison of first attempt, several studies showed 100% success rate under ultrasound guidance such that study done by Henjarappa et al (2014) with significant p value<sup>16</sup>. Here the experience of the operator was not mentioned. On the other hand some studies showed similar result with present study, such as 15% success rate was achieved in anatomical landmark procedure in a study by Mallory et al (1990)<sup>17</sup>. Although the success rates at

first attempt are significantly higher in US-guided method in present study, the success rate of both method are relatively lower in relation to other studies. It's because of operator inexperience and lack of skillness regarding internal jugular vein catheterization by both US and anatomical landmark procedure. Though the procedure was done by the same inexperienced operator, as ultrasound allows visualization of the targeted vessels, qualify detection of anatomical variation like vein and artery transposition and overlap, can detect the diameter and depth of vessel-was the causes of superiority of US-guidance procedure in success at first attempt.

Present study shows that majority of the subjects, e.g., 39% patients required two times attempt for Internal Jugular Vein Catheterization (Group A 32% vs Group B 46%,  $p = 0.075$ ). The mean number of cannulation attempts was  $1.7 \pm 0.2$  times in group A subject and  $2.8 \pm 0.1$  times in group B subject. The result of the present study are consistent with other study result, such that study done by Sazdov et al where mean cannulation attempt by anatomical landmark was  $1.52 \pm 0.81$  with significant  $p$  value in relation with ultrasound procedure<sup>18</sup>. Though results are similar but the mean attempt required for blind procedure of the present study is relatively more than some other studies. Other than the inexperienced hand, for the present study one of the important cause of frequent attempt was patient selection. Among the study patients who received Internal Jugular Vein catheterization, major causes was shock and hypovolemia due to sepsis and hemorrhage. So it was easy to miss the small diameter of hypoplastic or hypovolumic vessels in blind procedure. This problem was solved a little bit by direct visualization of small vessel under ultrasound supervision. Above it, when there was problem occurred to differentiate between artery and vein as artery also compressed in very low blood pressure, then Doppler imaging was done to detect vein. Restlessness is another important cause of failure attempt as because a portion of study population was under post-partum eclampsia and eclampsia group. This issue is important as because the increase in number of attempt, unsuccessful attempt and improper catheter placement could increase the risk of bacterial infection.

In present study, the procedure was declared unsuccessful after three attempts. Overall success rate was higher in group A patients (98%) compared with group B (90%). The difference was statistically non-significant between two groups. But Jeyeraj et al found significant difference in their study<sup>19</sup>. Most of the previous studies have not specified the definition of successful cannulation and it varied from <3 attempts to <7 attempts. In such study, successful cannulation (<3 attempts) was achieved in 90.83% of patient without any statistical significant difference between the groups<sup>15</sup>.

In this study operating time was measured from skin puncture to the end of catheter placement, not including the suturing and fixation time. It is evident from the table that, maximum patients (33) cannulation time was 3.1-5.0 min with group A predominance (25 vs. 8 in group-A and group -B respectively). Mean cannulation time was lower in group A ( $4.9 \pm 1.3$  min) than group B ( $11.4 \pm 5.8$  minutes). Thus, Group

A (ultrasonographic guidance) had a significant influence on reducing the overall operating time compared to traditional techniques ( $p < 0.05$ ). Mean cannulation time is a reflection of frequency of attempt and time required to complete the cannulation. As mean number of attempt was lowered for US-guidance, it impacts the time. Another important fact behind the increased mean cannulation time for anatomical landmark procedure was that, for the present study when the first attempt was failed, before subsequent attempt both patient position and bed position was rechecked and surface marking was recalculated which killed time. But in case of failed attempt by US-technique, at first view of ultrasound probe was changed accordingly to find out the best position and diameter of vein to do the cannulation before bed and patient position were changed, which saved time. This issue is especially important in ICU where the patients' conditions are usually critical and the time saving would be vital for the patient. Though the operational definition of cannulation time was varied from study to study, most of the study showed same result, such as in a study Karimi-Sari et al showed that mean access time was significantly lower in US-guided group with  $p < 0.001$ <sup>14</sup>.

Most of the results obtained from this study are consistent with the results of other studies. A meta-analysis revealed that, use of two-dimensional ultrasound reduced the rate of total complications overall by 71%, and the number of participants with an inadvertent arterial puncture by 72% ( $p$  value < 0.00001). Overall success rates were modestly increased in all groups combined at 12%, and similar benefit was noted across all subgroups. The number of attempts needed for successful cannulation was decreased overall ( $p$  value < 0.00001). Use of two-dimensional ultrasound increased the chance of success at the first attempt by 57% and reduced the chance of hematoma formation<sup>2</sup>.

In present study complications were comparable between two arms but hematoma was significant in group B ( $p = 0.02$ ). Overall complication rate was higher in group B patients 8(16%) compared with group A 2(4%) and the difference between two group was statistically significant ( $p < 0.05$ ). Rando et al in their study showed that, incidence of complication was 24% without ultrasound which decreased to 7% with ultrasound and both procedures were done by the same inexperienced operator<sup>5</sup>. In another study, there was no complication by US guidance where as 6% complication was produced by landmark technique<sup>1</sup>. For the frequency of complication, operators' experience (operator-dependent variable) and the type of patient (patient dependent variable) has a strong influence in current study. As the anatomic position of vein in relation with surrounding structure can predict but can't guaranteed, so the puncture of carotid artery and production of pneumothorax was more in blind procedure. Number of hematoma formation followed a linear relationship with number of attempt for blind procedure in present study. So catheterization of IJV by anatomical landmark may cause harmful effect. On the contrary two-dimensional ultrasound (US) guidance technique is safer. This issue is very important because increased complication

associated with increased morbidity, increased hospital stay and increased expense for the patient.

Other less frequent complications involve nerve injury, such as lesions of the recurrent laryngeal nerve<sup>20</sup>, cervical sympathetic chain<sup>21</sup>, and brachial plexus<sup>22</sup>. Additionally, the Internal Jugular Vein approach by anatomical landmarks displays a variable incidence of failure. Many studies point out the factors associated with complications during CVL placement by anatomical landmarks, namely operator's experience, number of attempts, site of placement, patient's body mass index (BMI), or CVL placement in an emergency situation<sup>5</sup>.

In a study by Fathi et al showed that there was no significant difference in terms of success rate of treatment, number of attempt, time for cannulation or the prevalence of complications ( $p>0.05$ ) other than carotid artery puncture( $p=0.04$ ) between two groups<sup>23</sup>. There ultrasound guided group was done by a sonography specialist who had at least 5 years of relevant experience and landmark group was done by an anesthesiologist with at least 10 years of experience of relevant work. They explained the cause of such result was due to-limited resource and lack of adequate training.

Two meta-analyses have been performed with prospective studies comparing the landmarks technique versus the ultrasound-guided technique, concluding that the ultrasound-guided technique lead to fewer failures and a lower number of attempts than the traditional technique<sup>24,25</sup>. In the pediatric setting reports also favor the ultrasound technique over the traditional one<sup>26</sup>. The Agency for Healthcare Research and Quality of the USA and the UK National Institute of Clinical Excellence both recommend CVL catheterization under ultrasound as one of the safe practices to improve patient care<sup>27</sup>.

Finally overall safety and effectiveness of the present study group was measured by four points' safety and effectiveness rating scale. By adding all the points of safety and effectiveness variable, the final score was prepared and it denotes that mean score of US guided technique is 10.3, for this it stood in excellent group and mean score of anatomic landmark group is 8.2, for this it stood in very good group. That means at a glance the performance of US guided group is better than landmark group. As this is the first study that used the scale, so there is no scope to compare this scale with other studies.

This study has several strength. Most of the previous studies, ultrasound guided CV line were done by experts sonographers. However in this study, ultrasound guided catheterization was performed by a critical care resident. This approach aligns with the ICU reality, where intensivists, rather than sonographers, conduct bedside ultrasound assessments. In this study, critically ill medical and surgical patients, requiring internal jugular vein catheterization at a major referral center, were systematically evaluated, highlighting the study's external validity for application in other busy critical care centers. In this ICU, ultrasound

machines were not used previously; however, due to this study, the use of ultrasonography has begun. The study employed an entirely new scale that enables a quick overview to easily gain a clear insight into the effectiveness of the two procedures.

Like any other scientific study our study is not without limitations. It was a single-centre study, conducted on a limited number of patients. Therefore findings derived from the study cannot be generalized to the reference population. Further multi-centre studies involving a large number of patients would confer greater applicability. Moreover, the interobserver agreement for ultrasound assessments was not taken in the study.

Despite the obvious benefit of ultrasound line placement, many countries like Bangladesh do not have practice to such technology in every operating room. In those cases, it is essential to make strong rule for the use of ultrasound to guide central venous line placement. It's an important observation that non-expert operators must use ultrasound for central venous line placement. If ultrasound machine is not available, on that circumstance it is suggested that only expert operators should perform central venous line placement. There is much scope to work with rating scale and similarly some other rating scales can be developed which will help to judge another procedure that are commonly performed in ICU.

#### CONCLUSION:

Ultrasound-guided Internal Jugular Vein catheterization is safe and effective for critically ill patient- as this method provides less number of attempts, less time to do the catheterization and produce less complication which in the long run ensure patients optimum comfort, avoid unnecessary hospital stay and save money. In ICU, catheterization should be introduced by ultrasound guidance. All Critical Care Physicians should undergo point-of-care ultrasound training to harness the full potential of this innovative tool effectively.

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