

## ULTRASONOGRAPHY GUIDANCE FOR CENTRAL VENOUS CATHETER – A PROSPECTIVE STUDY FOR PATIENT'S SAFETY & QUALITY CARE

Dr. Siddharth Kumar. B. Parmar, Dr. Sameera. N. Parikh, Dr. Sharad. S. Vyas.

1. Assistant Professor, Department of Emergency Medicine, B. J. Medical college, Ahmedabad, Gujarat.
2. Professor, Department of Emergency Medicine, B. J. Medical college, Ahmedabad, Gujarat.
3. Professor & Head, Department of Emergency Medicine, B. J. Medical college, Ahmedabad, Gujarat.

### CORRESPONDING AUTHOR

Dr. Siddharth Kumar. B. Parmar,  
Tenament no. 516, Gayatri society, Sector- 27,  
Gandhinagar, Gujarat. Pin 382028,  
E-mail: [drsid25@gmail.com](mailto:drsid25@gmail.com),  
Ph: 0091 9426332701.

**ABSTRACT: BACKGROUND: Context:** A central venous line access is very importance in management of the critically ill patients even though, it may carry a risk of complications.

**AIMS:** Objective of this study is to assess and compare success rate, attempts of cannulation and complications like inadvertent arterial puncture, hematoma, and pneumothorax occurred during the Central Venous Catheter (CVC) placement using ultrasound guidance (USG) & anatomical landmark guidance (ALG). **SETTINGS AND DESIGN:** The prospective randomized study was carried out in 64 patients for right sided internal jugular vein CVC placement. Using computer generated randomization chart, all patients were divided randomly into two groups: Group USG and Group ALG. **METHODS AND MATERIAL:** Right sided internal jugular vein (IJV) was cannulated with the guidance of ultrasound and anatomical landmark, respectively in group USG and group ALG. Patients were observed & data were recorded for success rate, no. of attempts, and complications like inadvertent arterial puncture, hematoma, and pneumothorax

**STATISTICAL ANALYSIS USED:** Database was analysed using graphpad prism 5 software.

**RESULTS:** Success rate is 31 out of 32 (96.88%) in group USG while 24 out of 32 (75%) in group ALG (p =0.031). Placement of central venous catheter with 1<sup>st</sup> attempt is 28 out of 32 (87.50%) in group USG while 18 out of 32 (56.25%) in group ALG (p =0.012). Hematoma and overall complications are 0 versus 6 (18.75%) in group USG & ALG respectively. **CONCLUSIONS:** Ultrasound guided central venous catheter placement is easy, safer & prudent approach than the anatomical landmark guided central venous catheter placement. **KEY MESSAGES:** We believe that Ultrasound guidance should be encouraged for all central venous catheter placements in patients & thereby improving patient's safety and quality care.

**KEY-WORDS:** central venous line, central venous catheter placement, ultrasound, anatomical landmark guidance.

**INTRODUCTION:** A central venous line access is very importance in management of the critically ill patients even though, it may carry a risk of complications.

The role of ultrasound has been established in central venous catheter (CVC) placement since a long time in different country.

Objective of this study is to assess and compare success rate, attempts of cannulation and complications like inadvertent arterial puncture, hematoma, and pneumothorax occurred

during the CVC placement using ultrasound guidance (USG) & anatomical landmark guidance (ALG).

**MATERIAL & METHODS:** A prospective, randomized study was performed in medical & surgical Intensive care unit of a tertiary care hospital between April 2010 and October 2010. Total 64 patients of both sexes with age between 20 – 60 years were enrolled in this study. Inclusion criteria were fresh patients for CVC placement in whom adequate peripheral venous access is unobtainable and who required central venous access as a part of clinical management e.g. invasive hemodynamic monitoring, inotropic supports, dialysis & long term parenteral nutrition. Exclusion criteria were local site infection, coagulopathy.

Using computer generated randomization chart, all patients were divided randomly into two groups:

Group USG: 32 cases Ultrasound guided CVC placement

Group ALG: 32 cases an anatomical landmark guided CVC placement

Right sided internal jugular vein (IJV) was cannulated in all patients in this study. In both groups, the procedure was performed by consultant anaesthetist with more than 3 years experience in ICU & who had undergone workshop on role of ultrasonography in emergency medicine & hands-on training.

Peripheral line was ensured in all patients before the procedure. Standard monitors were applied. The patient was placed in supine position with slightly head down and neck rotation on contra-lateral side. Wedge was placed between shoulder blades. Part preparation & draping was done, taking all aseptic and antiseptic precautions.

For group USG:

A portable ultrasound “Sonosite Micromaxx” machine with 7.5 M Hz Linear array (vascular) probe was used in this group. Lead and transducer probe were cleaned with antiseptic solutions. Sterile jelly was applied on the probe. The probe was covered with sterile sheath. Now, sterile jelly was applied over the area to be scanned. Probe was placed perpendicular to the area at apex of the triangle formed by two heads of sternocleidomastoid (SCM) muscle and clavicle.

Each probe has an orientation marker placed on one side which correlates to a mark on the image screen. In the longitudinal plane, the probe is oriented with the marker towards the patients head, providing a view of the vessels along its long axis. In the transverse plane, the probe is placed with the marker facing towards to the patient’s right, which provides an image similar in appearance to a CT scan.

Vessels were visualized in transverse section in 2-D ultrasound. Internal carotid artery (ICA) was seen as a circular pulsatile structure while IJV as an oval non-pulsatile structure. On applying downward pressure with probe, IJV get compressed whereas ICA remained as such. Target vessel patency was checked every time in all patients in this study at time of compressibility test.

Once vein was identified, probe was positioned so that vein was visualized in centre of the screen. Once introducer needle first indents the anterior wall of the IJV, 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. After successful aspiration of blood, a guide wire was inserted through it by visualizing ultrasound image in longitudinal plane. Introducer needle was withdrawn and a dilator was passed once through guide wire to

dilate the tract and withdrawn, CVC was inserted over the guide wire and guide wire was withdrawn. CVC was checked for free flow of blood. CVC was sutured with skin and a dressing was applied.

For group ALG:

The patient was placed in supine position with slightly head down and neck rotation on contra-lateral side. Wedge was placed between shoulder blades. Part preparation & draping was done, taking all aseptic and antiseptic precautions

Apex of the triangle formed by two SCM was palpated for carotid pulsations. With fingers of the left hand, carotid artery was pressed slightly medially and introducer needle inserted lateral to pulsation point, directing toward the ipsilateral nipple at an angle of 20-30 with the skin. After successful aspiration of blood, a guide wire was inserted through it and Introducer needle was withdrawn. Rest of the procedure was similar to that in group USG.

A chest x ray was obtained in all patients of this study after the procedure.

The complications like arterial puncture, hematoma, & pneumothorax were recorded.

Less than 2 attempts for CVC placement by either technique was defined as success in this study while more than 2 attempts (defined as separate skin punctures) for CVC placement by either technique were considered as failure.

Carotid artery puncture was noted by forceful pulsatile expulsion of bright red blood from the needle.

In previous study<sup>1</sup>, success rate is 74.2% in first attempt in conventional group (non USG), So, taking this 74.2% ( $p=0.742$ ) and  $E=10\%$  of  $p$ , in above formula, required sample size<sup>2</sup> is around 32 for each group.

$$(n) = Z_{\alpha/2}^2 \frac{pq}{E^2}$$

Where  $n$  = sample size,  $Z_{\alpha/2}$  = level of significance i.e. 0.95,  $p$  = prevalence,  $q = 1-p$ ,  $E$  = allowable errors (10% of  $p$ )

We used graphpad prism 5 version for the statistical analysis. The means of continuous variables compared using the student's t-test and categorical variables were compared using the chisquare test and fisher's exact test. A  $p$ -value  $<0.05$  was considered statistically significant.

**OBSERVATIONS:** The present study was undertaken in 64 indoor patients for comparison between USG guided & anatomical landmark guidance guided CVC placement.

In present study, success rate for CVC placement was 31 (96.88%) for group USG and 24 (75%) for group ALT. Result is statistically significant ( $P = 0.031$ ). Successful CVC placement on 1<sup>st</sup> attempt was 28 (87.5%) for group USG and 18 (56.25%) for group ALT. Result is statistically significant ( $P = 0.0123$ ). Successful CVC placement on 2<sup>nd</sup> attempt was 3 (9.38%) for group USG and 6 (18.75%) for group ALG. Result is statistically not significant ( $p=0.4721$ ). Failure rate for CVC placement was 1 (3.13%) and 8 (25%) in group USG and group ALT respectively. Result is statistically significant ( $p=0.031$ ). Average No. of attempts was  $1.16 \pm 0.45$  for group USG and  $1.56 \pm 0.8$  for group ALT. Result is statistically significant ( $P = 0.0165$ ).

There was no complications in group USG while there was 6 (18.75%) complications in group ALG. Result is statistically significant ( $P = 0.032$ ). Arterial puncture was encountered zero in group USG and 3 (9.38%) in group ALG. Result is statistically not significant ( $P = 0.2369$ ). Hematoma encountered zero in group USG and 6 (18.75%) in group ALG. Result is statistically significant ( $P = 0.032$ ). There was no any pneumothorax in both groups.

**DISCUSSION:** CVC line has become an integral part of management in critical as well as in emergency medicine. Traditionally, all CVC insertions have been performed using the anatomical landmark guidance. Even with experienced hands, complications rates of up to 12.3% have been reported for CVC insertions using the anatomical landmark guidance.<sup>3</sup> Considering the increasing use and role of CVC in the management of critical as well as emergency medicine day by day, efforts should be made to minimize & prevent the occurrence of complications and thereby improving patient safety and quality care. So, we studied to assess and compare success rate, attempts of cannulation and complications like inadvertent arterial puncture, hematoma, and pneumothorax occurred during the Central Venous Catheter placement using ultrasound guidance (USG) & anatomical landmark guidance (ALG).

In our study, we could visualise IJV and its relationship with carotid artery, introducer and guide wire entering into IJV very well with ultrasound in group USG. So, success rate was high (96.88%) in group USG because of Workshop and hands-on training which was needed for the successful use of USG guided CVC placement.

In our study, we cannulated IJV in all patients but we needed more than 2 attempts for IJV cannulation in 8 patients which was considered as failure as per definition fixed for it. So, success rate was low (75%) in group ALG.

In our study, there was no complication in group USG. There were 3 (9.38%) arterial puncture and 6 (18.75%) hematoma in group ALG. Arterial puncture was the reason for hematoma in 3 cases. Double wall puncture of IJV might be the reason for hematoma in other 3 cases. So, overall complications remained 6 (18.75%) in group ALG as arterial puncture and hematoma seen in the same patients.

There are many studies done across the world supporting the present study.

E. Paramythiotou et al <sup>1</sup> found in his study that IJV cannulation was successful in 29 cases (82.8%) in the control group and in 30 cases (96.7%) of the ultrasound group ( $P = 0.07$ ). Carotid artery puncture occurred in two cases in the control group and in one case in the ultrasound group ( $P = 0.80$ ). IJV cannulation was successful at the first attempt in 74.2% and 86.6% of cases in the control and ultrasound group correspondingly ( $P = 0.25$ ). So, they concluded that ultrasound guidance improved the success rate and reduced complications as well as the number of attempts clinically but the difference was not significant statistically. The familiarity of the operators with the method is a contributing factor.

Sulek et al <sup>9</sup> found in their study to compare the success rate and incidence of complications of right IJV versus left IJV cannulation using landmark or ultrasound guidance. Cannulation of the left IJV was more time consuming; it required more attempts; and it was associated with a greater number of complications when compared to the right side ( $p < 0.05$ ). The use of ultrasound improved the success rate with less time consuming and ultrasound reduced complications during IJV cannulation.

Hind et al<sup>10</sup> observed in their meta-analysis of 18 trials (1646 participants). Compared with the landmark method, real time 2 D USG guidance for cannulating the IJV in adults was associated with a significantly lower failure rate both overall (relative risk 0.14, 95% confidence interval 0.06 to 0.33) and on the first attempt (0.59, 0.39 to 0.88). Limited evidence favoured 2 D USG guidance for subclavian vein and femoral vein procedures in adults (0.14, 0.04 to 0.57 and 0.29, 0.07 to 1.21, respectively). Three studies in infants confirmed a higher success rate with 2 D USG for internal jugular procedures (0.15, 0.03 to 0.64). Doppler guided cannulation of the IJV in adults was more successful than the landmark method (0.39, 0.17 to 0.92), but the landmark method was more successful for subclavian vein procedures (1.48, 1.03 to 2.14). No

significant difference was found between these techniques for cannulation of IJV in infants. An indirect comparison of relative risks suggested that 2 D USG would be more successful than Doppler guidance for subclavian vein procedures in adults (0.09, 0.02 to 0.38). So, they concluded that evidence supports the use of 2 D USG for central venous cannulation and catheterization under USG guidance is quicker and safer than the landmark method in both adults and children.

P. Temblett<sup>11</sup> studied for USG guided CVC placement in 82 cases, in which 85% CVCs were inserted into IJV and 15% inserted into the femoral veins. USG guided CVCs were inserted majority by senior house officers (88%). Most (82%) were inexperienced with the use of USG (less than 20 previous USG guided CVCs inserted), while most (81%) were experienced in non-USG placement (greater than 20 previous non-US-guided CVCs inserted). There was 4% failure rate. Sixty three per cent of CVCs were inserted on the first attempt, and 21% were inserted on the second attempt. The average duration of insertion was 18 min, with 57% taking less than 15 min. There was a 10% complication rate. They concluded that ultrasound guided CVC insertion by inexperienced junior doctors with minimal training is not only feasible, but also appears to decrease complications and failure rates as well as increasing rates of first pass insertion.

Ankit Agarwal et al<sup>12</sup> studied to compare USG guided CVC and conventional landmark guided CVC in 80 patients, in terms of ease of cannulation, time consumed in procedures and associated complications. They found that mean time to successful insertion was 145 and 176.4 sec in groups USG and control group respectively ( $p = 0.00$ ). An average of 1.2 attempts per cannulation was required for group USG, while 1.53 for control group ( $p = 0.03$ ); 10% witnessed arterial puncture and 2.5% pneumothorax in control group and none in USG group. So, they concluded that use of ultrasound is a quicker, easier and prudent approach for CVC insertion.

Troianos et al<sup>13</sup> found in his prospective study that cannulation of the right IJV was successful in all 77 patients in the ultrasound group and in 80 of 83 patients (96%) in the control group. Patients with ultrasound guidance required an average  $\pm$  SD of  $1.4 \pm 0.7$  needle advances, whereas in the control patients an average of  $2.8 \pm 3.0$  advances, were required for cannulation ( $P < 0.05$ ). Fifty-six of 77 (73%) patients in the ultrasound group were cannulated with one attempt as compared with 45 of 83 (54%) in the control patients ( $P < 0.05$ ). There were seven carotid punctures in the control group (8.43%) and one in the ultrasound group (1.39%) ( $P = 0.09$ ,  $X^2$ ;  $p = 0.04$  before Yates' correction). They concluded that use of ultrasound reduces incidence of complications and average no. of attempts for CVC placement.

Ultrasound technology is an emerging science, has brought a revolution in the field of medicine. Modern Ultrasound machine are compact, portable & handy with good resolution, real time guidance & safety to patient and operator. (No radiation)

In emergency or critical setting when patient might not be able to be shifted to other department for imaging and interventions, with availability of USG machine, USG guided interventions can save the time & increase accuracy, efficacy & safety in emergency & critical medicine. Thus USG is a valuable tool to reduce the medical errors and to improve the medical care.

“The Stanford evidence based practice centre” has recommended ultrasound guidance in central venous catheter insertion as one of the 11- point recommendations in “A critical analysis of patient’s safety practices” in 2001.<sup>4</sup>

“The agency for healthcare quality and research” (AHRQ), in its 2001 report on reducing medical errors in the United States, placed ultrasound guidance for CVC placement in the list of ways to reduce medical error.<sup>5</sup>

# ORIGINAL ARTICLE

Based on meta-analysis in 2002, “National Institute for clinical excellence” in UK has recommended that the use of 2 D ultrasound guidance should be considered in the most clinical situations where a central venous line is necessary electively or in an emergency. <sup>6,7</sup>

In some countries, central venous line under ultrasound guidance is likely to be made compulsory in the near future.<sup>8</sup>

## LIMITATIONS OF THE STUDY:

- No. of patients in the present study was less.
- Experience of operator in basic Ultrasound physiology & hands-on training was needed for the successful use of CVC placement.
- Familiarity of the operator with methods is probably a contributing factor & must be taken into account.

## CONCLUSION:

Based on the present study,

1. Ultrasound guidance increases success rate in CVC placement.
2. Ultrasound guidance also increases successful placement of CVC with 1<sup>st</sup> attempt and thereby reduces average no. of attempts for CVC placement.
3. Ultrasound guidance decreases overall complications & Hematoma during CVC placement.

Ultrasound guided CVC placement is easy, safe, accurate & prudent approach than the anatomical landmark guided CVC placement. This study evaluated a change in practice for CVC placements.

So, we believe that Ultrasound guidance should be encouraged for all CVC placements in patients & thereby improving patient’s safety and quality care.

**TABLE 1 Results of the present study**

Outcome	USG		ALG		p value *
	count	%	count	%	
Success	31	96.88	24	75	0.0310
1st attempt cannulation	28	87.50	18	56.25	0.0123
2nd attempt cannulation	3	9.38	6	18.75	0.4721
Failure	1	3.13	8	25	0.0310
Overall complications	0	0	6	18.75	0.0320
Arterial puncture	0	0	3	9.38	0.2369
Hematoma	0	0	6	18.75	0.0320
Pneumothorax	0	0	0	0	

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**Table 2 : Success & Failure Rate In Different Studies.**

Study	Success rate (%)		Failure rate (%)	
	USG	ALG	USG	ALG
Present study	96.88	75	-	-
Gopal B. Palepu et al, 2009 India <sup>14</sup>	97.6	91.6	-	-
E. Paramythiotou et al, 2004 Greece <sup>1</sup>	96.7	82.8	-	-
Sulek et al, 2000. USA <sup>9</sup>	-	-	3.3	3.3
Hind et al, 2003. UK <sup>10</sup>	-	-	1.7	22
P. Temblett, 2004. UK <sup>11</sup>	-	-	4	-

**Table 3: 1st Attempt Cannulation & Average No. Of Attempts In Different Studies**

Study	1 <sup>st</sup> attempt cannulation (%)		Average no. of attempts (%)	
	USG	ALG	USG	ALG
Present study	87.5	56.3	1.16	1.6
Gopal B. Palepu et al, 2009. India	84.4	72.7	1.2	1.5
Ankit Agarwal et al, 2009. India <sup>12</sup>	87.5	67.5	1.2	1.5
E. Paramythiotou et al, 2004. Greece	86.6	74.2	-	-
P. Temblett et al, 2004. UK	63	-	-	-
Troianos et al, 1991. USA <sup>13</sup>	-	-	1.4	2.8
Sulek et al, 2000. USA	-	-	1.5	2.1

**Table 4 : Overall Complication In Different Studies**

Study	Overall complication (%)	Arterial puncture (%)	
		USG	ALG
Present study	18.75	0	9.38
Gopal B. Palepu et al, 2009. India	7	-	-
Ankit Agarwal et al, 2009. India	-	0	10
Sulek et al, 2000. USA	10	6.7	13.3
P. Temblett et al, 2004. UK	10	-	-
Troianos et al, 1991. USA	-	1.4	8.4
E. Paramythiotou et al, 2004. Greece	-	3.2	5.7



Figure 1: showing compressibility test in transverse plane of 2D USG.



Figure 2: introducer needle entering into IJV in transverse plane of 2D ultrasound (left) and in longitudinal plane of 2 D ultrasound (right).



Figure 3: Guide wire from introducer needle entering into IJV in longitudinal plane of 2 D USG



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