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Original Research Article

To compare the efficacy of USG guided central venous catheterisation at internal jugular vein (IJV) and at the Pirogoff's confluence

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ABSTRACT

Background and Aim: To compare the efficacy of USG guided central venous catheterisation at internal jugular vein (IJV) and at the Pirogoff's confluence [IJV, subclavian vein (SCV), Brachiocephalic Vein (BCV)].

Materials and Methods: A prospective, comparative, randomized, hospital based study was conducted on 100 patients requiring central venous access. After explaining the study to the selected patients, they were randomized into two groups with the use of sealed envelope method i.e. group A (Central venous cannulation of IJV) and group B (central venous cannulation of Pirogoff's confluence of IJV, SCV, BCV). Data was collected with respect to the efficacy of USG guided cannulation on the basis of time for visualisation, access time, number of attempts, time to CVC, total time of procedure, length of catheter inserted. Any complications encountered were recorded.

Results: There was no difference between number of attempts in either of groups, mean visualization, access time and time to CVC was longer in group B with statistically significant difference. Mean length of catheter inserted was shorter in group B with statistical significant difference. Procedure time required was comparatively more in group B.

Conclusion: The results indicated that Ultrasound guided cannulation of group A is efficacious than group B in terms of time required to culminate the procedure as well as complications but cannulation of Pirogoff's confluence is a novel approach giving easier access, better visualisation and length of catheter inserted is lesser than IJV.

1. Introduction

Central venous catheterisation is an important procedure in the practice of anesthesiology and emergency medicine in both assessment and treatment of the patient, to allow delivery of medications, intravenous fluids, parenteral nutrition, transvenous cardiac pacing and hemodialysis and monitoring of hemodynamic variables-CVP.[1] It is imperative to have central venous access among patients among critical condition. Percutaneous catheterization of the subclavian vein via infraclavicular approach has been widely used. Since Aubaniac's[2] original description in 1952, subclavian vein catheterization via the infraclavicular approach has become a well-established technique. In 1965, Yoffa[3] described an alternate supraclavicular approach to the subclavian vein that has definite advantages over the infraclavicular approach; however, it is less often taught and utilized for reasons that are not clear.

A proportion of patients undergoing central venous catheterisation suffer acute severe complications namely arterial puncture or cannulation, hematoma, hemothorax, or pneumothorax.[4,5] The use of ultrasound (US) has

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been proposed to reduce the number of CVC associated complications and to enhance the safety and quality of CVC placement. The use of ultrasound (US) guidance for CVC raises, the overall success rate of cannulation by 71% compared to the landmark technique.[6]

However, a commonly encountered perplexity during US-guided cannulation is the small lumen of the vessel (especially internal jugular vein) in patients who are volume deficient or have a history of multiple cannulations at the same site. In such scenarios, both the needle puncture and the passage of guide wire become cumbersome. The incidence of the narrow lumen of internal jugular vein (IJV) is 1% on the right side and 8% on the left side.[7] A novel technique used when the IJV has a small lumen (<0.7 cm) and subclavian puncture is contraindicated is cannulating at the venous confluence of three vessels, i.e. IJV, subclavian vein (SCV) and brachiocephalic vein (BCV) known as the "Pirogoff's confluence.[8]

The present study was conducted to evaluate an alternative puncture site and describe the technique of successfully obtaining central venous access at the Pirogoff's venous confluence of IJV, SCV and BCV under USG Guidance. The aim of the study was to compare the efficacy of central venous access at internal jugular vein with it, in respect to first attempt, puncture attempt, number of total attempts for successful cannulation, successful placement, access time, time to central venous catheterisation.

2. Material and Methods

The present prospective randomised hospital-based study was conducted at the department of anaesthesiology, Mahatma Gandhi medical college, Jaipur on patients admitted in operation rooms and ICU where central venous access is indicated. A total of 100 patients were selected according to the inclusion and exclusion criteria. Patient aged 18-70 years, those admitted in ICU entailing central venous access and who gave consent. Patients with previous central venous catheterisation within 15 days, burns and infection at the site of insertion and anatomical abnormalities were excluded from the study.

2.1. Sample size

$$n = \frac{Z^2_{\frac{\alpha}{2}}\, p(\%)q(\%)}{d(\%)^2}$$

where p is the observed prevalence

q = 100- *p*

d is the margin of error

$Z_{\frac{\alpha}{2}}$ is the ordinate of standard normal distribution at $\alpha\%$ level of significance.

Calculations:

p (Prevalence of Complications during CVC insertion) = 7.93%

q = 92.07%

d = 0.06%

$Z_{2.5\%}$ = 5% level of significance

n= 77.88

Hence, the minimum sample size required in the present study is 78.

The patients selected for study were randomized using sealed envelope method into two groups:

Group A (N=50): patients in whom central venous access obtained at Internal Jugular vein (IJV) under USG guidance.

Group B (N=50): Patients in whom central venous access is obtained at the Pirogoffs venous confluence of IJV, SCV & BCV under USG guidance.

In both groups A and B standardised monitoring of blood pressure, heart rate, SpO2, ECG monitoring to evaluate any rhythm abnormailities and ETCO2 in intubated patients was done and standardised precautions were taken aseptically. The Sonosite 6-13MHz sterile cover ultrasound machine was used to classify the injection site anatomy as well as the internal jugular vein and carotid artery positions using the long axis and short axis retained probe.

Major difference in the methodology of the two groups lies in the approach of localisation of IJV and Pirogoff's venous confluence respectively.

Group A: Once the internal jugular vein is visualised under the short axis (transverse), lateral to the carotid artery as a pulsatile entity, IJV is confirmed as an easy compressible hollow structure by ultrasound.

Group B: Once the Internal jugular vein is visualised and verified as hollow compressible structure lateral to the pulsatile carotid artery under the short axis (transverse), IJV is accompanied proximally to the intersection of the inner jugular vein, subclavian vein, and brachiocephalic vein. Subclavian artery Doppler evaluation is performed when both the Subclavian vein and the Subclavian artery lie parallel to each other. The vein valves (confluence of SCV with BCV) identified as hyperechoic structures that pass inside the lumen.

USG: The US probe can be located in a transverse direction relative to the vessel, resulting in a "short-axis" (i.e. a cross-sectional representation of the vessel) view on the US frame. The 'long-axis' view (i.e. the vessel's longitudinal image) is obtained by positioning the US probe in a parallel location relative to the vessel's direction. For both US assistance and advice on CVC positioning, short-axis and long-axis views may be used. A systematic approach was adopted as mentioned in the following steps:

1. Identify anatomy of the insertion site and localization of the vein.
2. Confirm patency of the vein.
3. Use real-time US guidance for puncture of the vein.
4. Confirm needle position in the vein.
5. Confirm wire position in the vein.
6. Confirm catheter position in the vein.[8]

Pirogoffs Venous Confluence Technique: After US assessment of IJV, the probe was placed in sagittal plane at the level of cricoid cartilage to obtain short axis view of the IJV. The linear USG probe (M-Turbo, Fujifilm Sonosite, Inc., Bothell, WA, USA) was placed in the supraclavicular fossa parallel to medial end of clavicle. The probe is tilted caudally to obtain in-plane view of BCV and venous confluence of three vessels shown in the Figure 1. Doppler power is used to differentiate subclavian and other artery from vein.

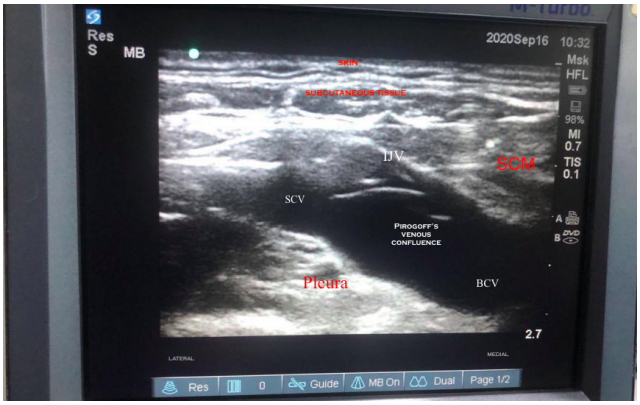

Fig. 1: Pirogoff's confluence

The three steps followed in sequence included:

1. Identification of the confluence of the vessels.
2. Doppler assessment as both the SCV and SCA lie adjacent to each other.
3. Identification of the valves in the veins (confluence of SCV with BCV) seen as hyperechoic structures moving within the vessel lumen.

Parameters noted were age, sex, weight, height, side of central venous catheterization, blood pressure, heart rate, time to visualisation the site and number of attempts of puncture of vein. The first attempt success is defined as aspiration of venous blood by finder needle in the first attempt. Successful placement is defined as successful placement of guide wire. Access time is the time between the first penetration of the skin and the aspiration of venous blood into the syringe allowing insertion of the guide wire. Time to CVC is defined as the time taken from the insertion of the finder needle till de-airing and flushing of all the three ports of the triple lumen catheter. Complications encountered during or after the procedure if any were recorded too.

2.2. Statistical analysis

The collected data were analysed with IBM. SPSS statistics software 23.0 version. To describe about the data descriptive statistics frequency analysis, percentage analysis were used for categorical variables and the mean & SD were used for continuous variables. To find the significant difference between the bivariate samples in Independent groups the unpaired sample t-test was used. To find the significance in categorical data Chi-Square test was used similarly if the expected cell frequency is less than 5 in 2×2 tables then the Fisher's Exact was used. In all the above statistical tools the probability value <.05 is considered as significant level.

3. Results

There were 38 males, 12 females in IJV group and 13 males, 37 females in Pirogoff group. In our study, mean age was 44±13 years in IJV group while the same was 47±13 years in Pirogoff group. Most of the subjects were having ASA grade III, reported among 87% of the subjects.

Mean time for visualization was longer in Pirogoff group 1min 10±0.7 seconds, as compared to IJV group with time to visualisation of 40±0.2 seconds, which is statistically significant difference as $p<0.05$ in the present study. Mean access time was longer in Pirogoff group (1.5 minutes/90±0.5 seconds) as compared to IJV group (1.1 minutes/70±0.3 seconds) with statistical significant difference (Table 1).

No significant difference was found among the groups at different intervals w.r.t mean arterial pressure and heart rate as $p>0.05$ (Table 2).

There was a slight difference between first attempt success of 86% for IJV group and 88% first attempt success in Pirogoff group which is not statistically significant with p value>0.05. Complications encountered in our study were arterial puncture in two patients in each group and displaced catheter among two patients in Pirogoff group where both these patients the catheter was misdirected in the internal jugular vein of same side found on chest x-ray (Table 3).

4. Discussion

A commonly encountered difficulty during US-guided cannulation is the small lumen of the vessel (especially internal jugular vein) in patients who are volume deficient or have a history of multiple cannulations. In such scenarios, both needle puncture and passage of guide wire become cumbersome. A novel technique used when the IJV has a small lumen (<0.7 cm) and subclavian puncture is contraindicated is cannulating at the venous confluence of three vessels i.e. IJV, SCV and BCV known as the "Pirogoff" confluence.[9] This study was conducted to assess the same.

In our study, male was the dominant subject in IJV (76%) as well as Pirogoff group (74%). Gurkan Turker et al[10] in their study found that male comprised of 64.21% of the subjects, which is similar to our study. Similar dominancy of males was shown by Dimitrios Karakitsos et al[11] in their study.

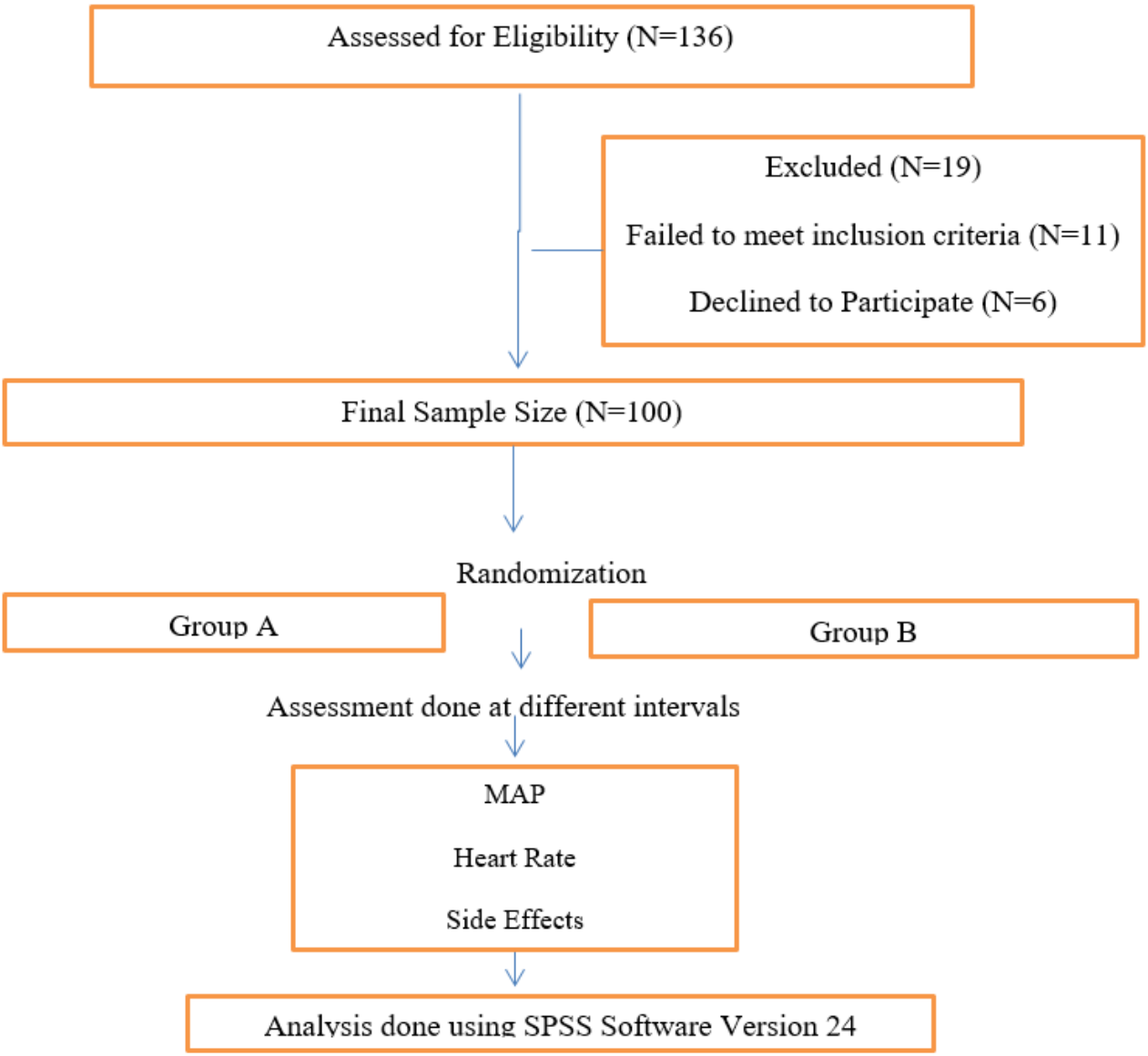

Diagram 1: Consort diagram

Table 1: Comparison of time (in mins) for visualization, access time, time to CVC and total time for procedure and length of catheter (cm) inserted among the groups

Variable	Groups	Mean	S.D	t-value	p-value
Time for Visualisation	IJV	0.7	0.2	4.275	0.009*
	Pirogoff	1.2	0.7		
Access time	IJV	1.1	0.3	5.031	0.006*
	Pirogoff	1.5	0.5		
Time to CVC	IJV	2.5	0.6	6.403	0.002*
	Pirogoff	3.7	1.1		
Total time for procedure	IJV	12.5	1.1	2.858	0.04*
	Pirogoff	13.2	1.3		
Length of catheter inserted	IJV	13.2	0.8	3.410	0.001*
	Pirogoff	12.7	0.7		

*: statistically significant

Table 2: Comparison of mean arterial pressure (mmhg) and heart rate (bpm) with Groups by unpaired t-test

Variable	Groups	Mean Arterial Pressure				Heart rate			
		Mean	S.D	t-value	p-value	Mean	S.D	t-value	p-value
Baseline	IJV	87.9	14.2	1.367	0.175	77.7	14.5	0.499	0.619
	Pirogoff	91.2	10.2			79.2	15.1		
0 mins	IJV	88	11.2	0.422	0.674	77	11.6	0.437	0.663
	Pirogoff	88.9	10.9			78.1	13.4		
5 mins	IJV	88.4	11.5	0.279	0.781	77	9.8	0.81	0.42
	Pirogoff	89	11.4			78.7	12.1		
10 mins	IJV	89.9	9.4	0.425	0.672	75.4	9.9	0.96	0.34
	Pirogoff	89.1	10.8			77.5	12.6		
15 mins	IJV	88	8	0.398	0.692	73.9	9.5	0.516	0.607
	Pirogoff	88.7	9.2			75.1	12.1		
20 mins	IJV	88.7	9	0.199	0.842	72.4	8.8	1.521	0.132
	Pirogoff	89	8			75.5	11.1		

Table 3: Comparison between number of attempts and complications among the groups

Variables			Groups		Total	Chi Square value	p-value
			IJV	Pirogoff			
Number of attempts	1	Count	43	44	87	0.088	0.77
		%	86.0%	88.0%	87.0%		
	2	Count	7	6	13		
		%	14.0%	12.0%	13.0%		
Complications	Absent	Count	48	45	93	1.382	0.44
		%	96.0%	90.0%	93.0%		
	Present	Count	2	5	7		
		%	4.0%	10.0%	7.0%		

Mean time for visualization was longer in Pirogoff group 1min 10±0.7 seconds, as compared to IJV group with time to visualisation of 40±0.2 seconds, which is statistically significant difference as p<0.05 in the present study. Mean access time was longer in Pirogoff group (1.5 minutes/90±0.5 seconds) as compared to IJV group (1.1 minutes/70±0.3 seconds) with statistical significant difference as p<0.05 in the present study. Gurkan Turker et al[10] in their study reported that access time (seconds) was 95, which is similar to our study.

In our study, second attempt culminated to favourable outcome of successful placement of guidewire and thus central venous cannulation. In our study no attempt beyond the second attempt were needed. Beccaria PF et al.[12] in their study reported that success at first attempt was 85% in IJV group, which is approximately similar to our study. They found complications among 6.3% of the subjects in IJV group. Gurkan Turker et al[10] in their study found that average number of attempts was 1.08, which is similar to our study

Mean total time for procedure was 13min 10± sec±1.3 in Pirogoff group and 12 min 30 sec±1.1 in IJV group with statistical significant difference as p<0.05 in the present study. Hence, procedure time required was comparatively more in Pirogoff group.

The optimal position of the catheter has been subject to discussion[11] but the junction of the right atrium to the superior vena cave (SVC–RA junction) was regarded as a safe location as introducing catheter in Right atarium can precipitate arrythmias. Mean length of catheter inserted was lesser in Pirogoff group 12.7±0.7 cm as compared to IJV group 13.2±0.8 cm with statistical significant difference as p<0.05 in the present study. Correct intravenous position can be verified by free in- and out-flow of blood and fluid through the catheter and further confirmation of the catheter tip position was confirmed with chest X-ray.

Complications encountered in our study were arterial puncture in two patients in each group and displaced catheter among two patients in Pirogoff group where both these patients the catheter was misdirected in the internal jugular vein of same side found on chest x-ray. For the IJV, the meta-analysis featured 35 trials found that the use of US for CVC positioning in the IJV decreases the average incidence of complications relative to traditional landmark approaches (US, 48 complications in 1212 patients (4.0%) vs. landmark, 161/1194 (13.5%); risk ratio (95% confidence interval (CI)) 0.29 (0.17–0.52)). With respect to the total difficulty rate, overall success rate, and number of attempts to achieve success, the benefits of US-guided or US-assisted CVC placement were consistent among experienced and novice operators. This meta-analysis thus

explicitly provides evidence that during CVC placement in the IJV, the US offers improvements in protection and consistency. For most outcome measures, the consistency of the proof, however, was very low and the heterogeneity among the studies was large.[6]

There are some limitations and disadvantages of US during central venous access. One might argue that the risk of catheter-related bloodstream infections might be higher if US is used for CVC placement without applying a strict aseptic approach as already described. In addition, an insufficient number of US machines in a certain unit and it is expensive to purchase and maintain US machines and to provide adequate training for all operators involved in CVC placement. US might give the inexperienced user a false sense of security and mislead him/her to neglect traditionally taught principles with regard to needle direction.

Lack of research over the Pirogoff's technique of venous cannulation limited our scope to understand the myriad of aspects of the novel approach thereby limiting us to compare and validate our results in comparison with IJV approach under US guidance.

5. Conclusion

In our research study we found success with novel approach of cannulation at the Pirogoff's confluence and can be utilized in situations where we encounter technical difficulties in cannulating the IJV; small diameter, aberrant anatomy, thrombus, short neck, obese individuals Provision of better visualization owing to its larger diameter, once mastered by the proceduralist gives an easier access and length of catheter inserted is lesser than IJV. We observed patients expressing their comfort post cannulation at Pirogoff's venous confluence due to ease of neck movement as compared to IJV. Large randomized trials are required to confirm feasibility and success rate of Pirogoff's confluence cannulations in adults.

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