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Comparison of the Characteristics and Hemodynamic Effects of Infraclavicular Subclavian Central Venous Catheterisation Done under Spontaneous Respiration versus Mechanical Ventilation

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Abstract

Context: The study was designed to compare the characteristics and hemodynamic effects subclavian central venous catheterisation done under spontaneous respiration versus mechanical ventilation.

Aims: To compare the characteristics and hemodynamic effects of infraclavicular subclavian central venous catheterisation done under spontaneous respiration versus mechanical ventilation.

Settings and Design: prospective cross-sectional study.

Methods and Material: A prospective randomised cross-sectional study was undertaken in 100 patients requiring subclavian venous catheterisation. They were randomised by computer generated random number table to receive the venous cannulation either during spontaneous or mechanical ventilation. The characteristics i.e success or failure, successful cannulation in first attempt, number of attempts, time taken ; and hemodynamic effects i.e heart rate, systolic blood pressure, diastolic blood pressure and mean arterial pressure were measured in patients with spontaneous respiration and with mechanical ventilation. Hemodynamic variables were measured every 2 minutes till successful catheterisation and till 10 minutes after successful catheterisation.

Statistical analysis used: Statistical Package for Social Sciences (SPSS) version 21.0.

Results: The demographic variables were comparable in both the groups. Failure to cannulate occurred in total of 8 patients and were comparable among the groups. Successful catheterisation in first attempt was possible in 66% patients breathing spontaneously versus 72% in mechanically ventilated patients (p=0.517). Time to successful catheterisation were also comparable between groups (145.42 ± 56.54 secvs 133.38 ± 36.78 sec, p = 0.582). Heart rate variability >20% of baseline occurred in 22% vs 4% in spontaneously breathing and mechanically ventilated patients (p = 0.015). The systolic, diastolic and MAP were comparable between the groups.

Conclusions: The characteristics of infraclavicular subclavian central venous catheterisation are similar regardless of mechanical ventilation and spontaneous respiration. The infraclavicular subclavian venous catheterisation done under spontaneous respiration may result in significant heart rate variability.

Keywords: Central venous catheterisation; Ventilation; Hemodynamics.

Keymessages: The characteristics of infraclavicular subclavian central venous catheterisation are similar regardless of mechanical ventilation and spontaneous respiration. The infraclavicular subclavian venous catheterisation done under spontaneous respiration may result in significant heart rate variability.

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Introduction

Central venous catheterization is an integral part of invasive monitoring and management. It's used by anaesthesiologists, intensivists and physicians. Central venous catheters allow measurement of central venous pressure, delivery of fluids, medication and nutritional support.[1–3] Central venous catheterisation decreased the need for open cut down procedures and associated morbidity. Studies reported prevalence of central venous catheterisation range from 32% to 80%.[4,5]

The subclavian vein is commonly used for central venous catheterization both for short- and long-term use. Advantages of using the subclavian vein for central venous access over other routes include consistent surface anatomic landmarks and vein location, its large diameter (1–2 cm), absence of valves, ability to remain patent in a relatively constant position and the ease of insertion in trauma patients with suspected cervical spine injury.[6–9] In addition, the Subclavian vein carries the lowest rate of catheter related infections and thrombosis and is associated with lesser patient discomfort, especially on long-term basis.[10–11]

Multiple percutaneous pricks tend to increase the failure and complication rate, Studies suggest that if a central vein is not accessed rapidly within the first two venepuncture's, failures and complications are likely to increase.[12,13]

There is a belief that during lung deflation the lung apex to move downward and increases the distance from the subclavian vein to pleura and lesser chance of mechanical complications. Recent studies shows that success and complication rates were similar regardless of mechanical ventilation and the distance from the subclavian vein to the pleura did not change after full expiration.[14–16]

Subjects and Methods

After the approval of hospital ethics committee and written informed consent, 100 adult patients were enrolled into a prospective, cross-sectional study. Adult patients (18–65 years) requiring central venous catheterisation of either sex with BMI 18.5 to 29.9 kg/m^2 were included. Patients with infection over skin puncture site, history of clavicle or shoulder fracture, anatomical abnormality of clavicle or chest wall, diaphragmatic dysfunction history of COPD, pneumothorax, pleural effusion and significant lung parenchymal pathology (Tuberculosis, pneumonia etc.), prior catheterization or attempted catheterization on same side, prior major surgery (Mastectomy, neck dissection, axillary dissection or thoracotomy, radiotherapy or burns of the area, deranged coagulation profile, history of bleeding disorders were excluded from the study. Randomisation was achieved by computer generated random number table. Subjects were randomized to one of the two groups of 50 patients each, Group S (Patients on spontaneous respiration) and Group M (Mechanically ventilated patients). In pre anaesthetic evaluation, the following data were recorded before insertion of central venous catheter, demographic characteristics (name, age, gender, height and weight), detailed clinical history,complete general physical and systemic examination, pre-operative ECG, pre-operative chest X-ray (PA View), complete hemogram (Hemoglobin, Total leucocyte count, differential leucocyte count, hematocrit, red blood cell count, platelet count), coagulation profile (bleeding time, clotting time, PT/INR, aPTT) and examination of site of insertion. The procedure, its benefits, complications and major risks involved were explained to the patient. Thereafter, written informed consent of the patient or relative was taken. Patient was then brought to operation theatre and standard monitors were attached. Baseline readings were recorded, an 18 gauge intravenous line was established. Anaesthesia machine was checked before proceeding further.

In spontaneous respiration group patient was laid supine, a small roll was placed between shoulder blades to expose the infraclavicular area, comfortable head ring was placed beneath patient head, patient was placed in 20 degree trendelenburg position, patient's head turned to left side, patient's eyes were covered with soft eye padding and appropriate size venturi mask was applied. Patient was sedated using fentanyl (1 microgram/kg) intravenously and midazolam (0.015 mg/kg) intravenously. Checked materials in the catheterisation trolley, sterilized the field with povidone iodine and spirit, prepared the equipments, flushed all ports, attached the three way stop cocks to the ports and landmarks for insertion was identified (1 cm inferior to the midpoint of clavicle). After sterile preparation, infiltration of local anaesthesia (5–8 ml 2% preservative free lignocaine) given at the site of needle insertion. Subclavian central venous catheterisation done by modified seldinger technique.

In mechanical ventilation group, patient was given fentanyl (1 microgram/kg) intravenously and midazolam (0.015mg/kg) intravenously. General anaesthesia was induced with propofol 2 mg/kg,

0.1 mg/kg vecuronium and maintained with 1–2% end tidal sevoflurane concentration in 50% oxygen and 50% nitrous oxide. Tracheal intubation was done 3 minutes after giving vecuronium. Patient was mechanically ventilated during the procedure by using volume control mode with a tidal volume of 8 mL/kg, respiratory rate of 12/min, inspiration: expiration ratio of 1:2 without PEEP. In the mechanical ventilation group, catheterization was performed without interruption of mechanical ventilation.

Statistical analysis

Categorical variables were presented in number and percentage (%) and continuous variables were presented as mean ± SD and median. Normality of data was tested by Kolmogorov-Smirnov test. If the normality was rejected then non parametric test was used. Quantitative variables were compared using Independent t test/Mann-Whitney Test (when the data sets were not normally distributed) between the two groups. Qualitative variables were correlated using Chi-Square test/Fisher's exact test.

A p value of < 0.05 was considered statistically significant.

Results

100 patients divided into group s and group m were studied over a period of 1 year. There was no significant difference in age, age distribution, sex and bmi between the groups with the above characteristics normally distributed in our sample (Table 1).

Table 1: Comparison of two groups based on age.

Age	Group S	Group M	p-value	Significance
Sample size	50	50	0.405	No
Mean ± SD	45.16 ± 11.67	43.02 ± 12.49		
Median	45	45		
Min-Max	22–65	23–65		
Inter quartile Range	35 – 55	32 – 50		

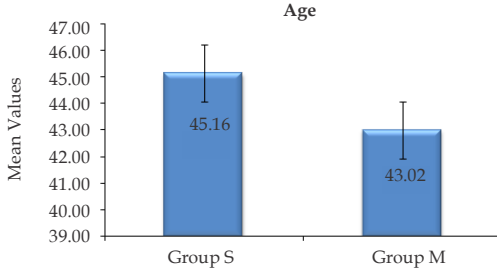

Fig. 1: Comparison of two groups based on age.

Both groups were comparable with respect to age (p value - 0.405) showing no statistical difference between two groups (Table 1/Fig. 1).

Table 2: Comparison of two groups based on age distribution.

Age distribution	Group		Total	p-value	Significance
	Group S	Group M			
21–30	16%	20%	18.00%	0.714	No
31–40	20%	28%	24.00%		
41–50	28%	28%	28.00%		
51–60	26%	18%	22.00%		
>60	10%	6%	8.00%		
Total	100.00%	100.00%	100.00%		

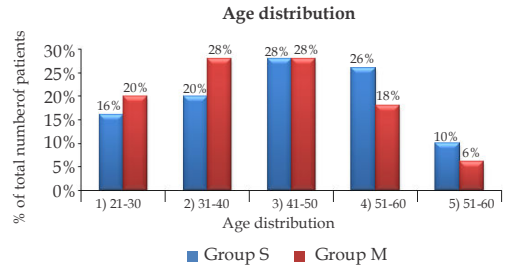

Fig. 2: Comparison of two groups based on age distribution.

Both groups were comparable with respect to distribution of age (p - value 0.714) showing no statistical difference between two groups.(Table 2/Fig. 2).

Table 3: Comparison of two groups based on sex.

Sex	Group S	Group M	Total	p-value	Significance
Male	52.00%	56.00%	54.00%		
Female	48.00%	44.00%	46.00%	0.688	No
Total	100.00%	100.00%	100.00%		

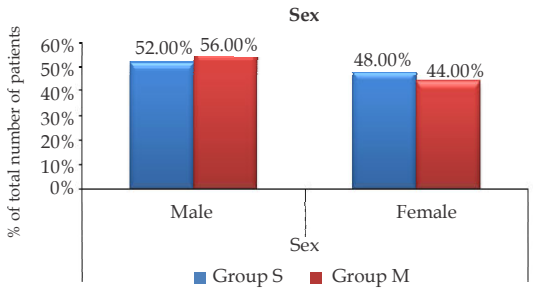

Fig. 3: Comparison of two groups based on sex.

Both groups were comparable with respect to gender (p value – 0.688) showing no statistical difference between two groups. (Table 3/Fig. 3).

Table 4: Comparison of two groups based on Body Mass Index.

BMI	Group S	Group M	p-value	Significance
Sample size	50	50		
Mean ± SD	23.03 ± 2.19	22.72 ± 1.8		
Median	23.12	22.71		
Min-Max	19.22–27.41	19.05–27.12		
Inter quartile Range	21.320 – 24.450	21.560 – 23.610		

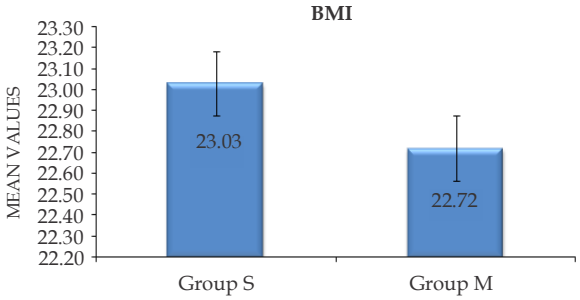

Fig. 4: Comparison of two groups based on Body Mass Index.

Both groups were comparable with respect to BMI (p value - 0.436) showing no statistical difference between two groups. (Table 4/Fig. 4).

Table 5: Comparison of two groups based on success/failure of the procedure.

Success/Failure	Group		Total	p-value	Significance
	Group S	Group M			
Successful catheterisation	45 (90.00%)	47 (94.00%)	92 (92.00%)		
Failed catheterisation	5 (10.00%)	3 (6.00%)	8 (8.00%)	0.715	No
Total	50 (100.00%)	50 (100.00%)	100 (100.00%)		

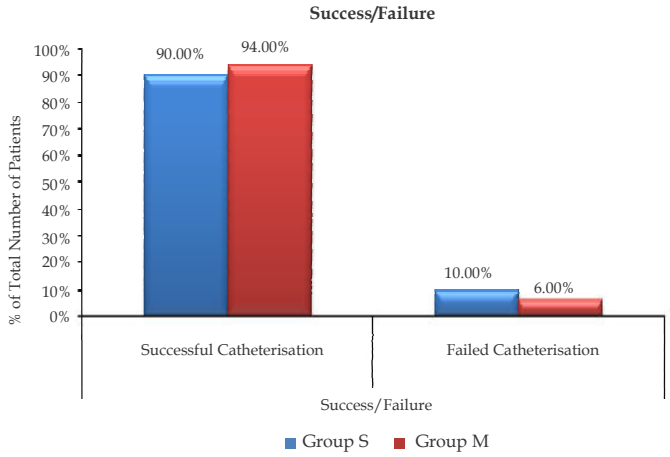

Fig. 5: Comparison of two groups based on success/failure of the procedure.

The success and failure rates were comparable in both the groups (p value – 0.715) with no statistical difference between the groups. (Table 5 / Fig. 5).

Table 6: Comparison of two groups based on success in first attempt.

Success in 1st attempt		Group		Total	p- value	Significance
		Group S	Group M			
	Yes	33 (66.00%)	36 (72.00%)	69 (69.00%)		
	No	17 (34.00%)	14 (28.00%)	31 (31.00%)	0.517	No
Total		50 (100.00%)	50 (100.00%)	100 (100.00%)		

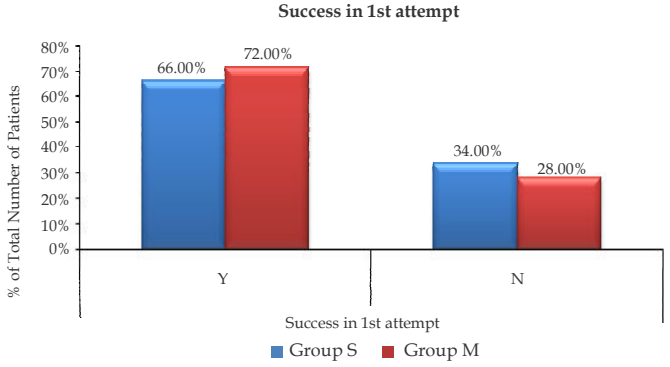

Fig. 6: Comparison of two groups based on success in first attempt.

Success rate for the procedure in first attempt was comparable between the groups (p-value -0.517) with no statistical difference. (Table 6 / Fig. 6).

Table 7: Number of attempts made for successful catheterisation.

No. of attempts	Group S	Group M	p-value	Significance
Sample size	45	47		
Mean ± SD	1.31 ± 0.56	1.23 ± 0.48		
Median	1	1	**0.521**	**No**
Min-Max	1–3	1–3		
Inter quartile Range	1 – 2	1 – 2		

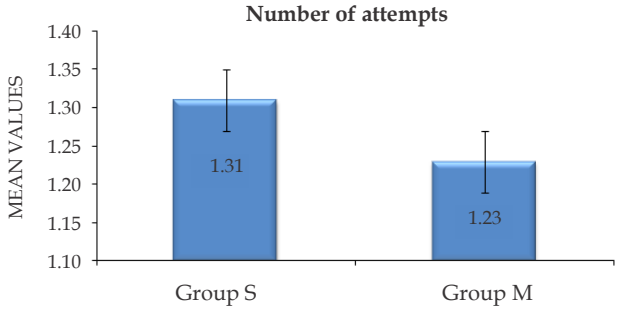

Fig. 7: Number of attempts made for successful catheterization.

Number of attempts required for the successful cannulation in both groups were comparable(p-value – 0.521) with no statistical difference (Table 7 / Fig. 7).

Table 8: Comparison of two groups based number of attempts.

No. of attempts	Group		Total	p-value	Significance
	Group S	Group M			
1	33 (66.00%)	37 (74.00%)	70 (70.00%)		
2	10 (20.00%)	9 (18.00%)	19 (19.00%)		
3	2 (4.00%)	1 (2.00%)	3 (3.00%)	**0.774**	**No**
Failure	5 (10.00%)	3 (6.00%)	8 (8.00%)		
Total	50 (100.00%)	50 (100.00%)	100 (100.00%)		

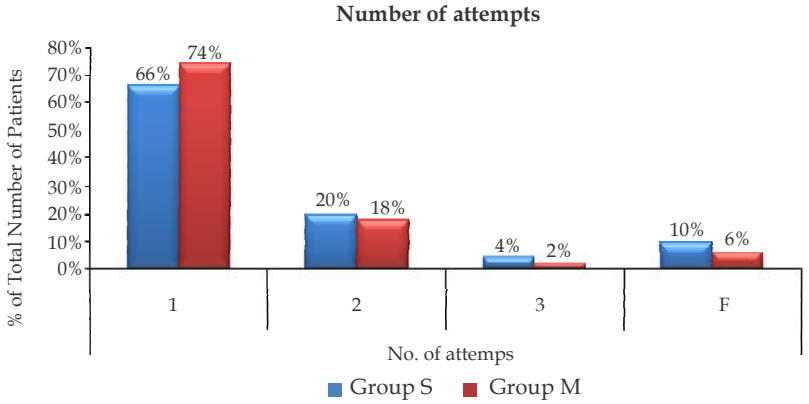

Fig. 8: Comparison of two groups based number of attempts.

Number of attempts required for the successful catheterisation in both groups were comparable (p-value = 0.774) with no statistical difference. (Table 8 / Fig. 8).

Table 9: Time taken for successful catheterisation between two groups.

Time taken (Sec)	Group S	Group M	p-value	Significance
Sample size	45	47		
Mean ± SD	145.42 ± 56.54	133.38 ± 36.78		
Median	128	120	**0.582**	**No**
Min-Max	78–324	85–238		
Inter quartile Range	103.500 – 177.250	108.250 – 145		

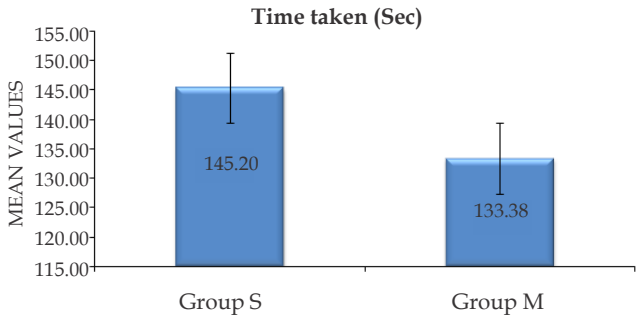

Fig. 9: Time taken for successful catheterisation between two groups.

Time taken for the procedure between the groups was comparable (p value – 0.582) showing no statistical difference (Table 9 / Fig. 9).

Table 10: Comparison of the groups based on heart rate.

Heart Rate	Group		Total	p-value	Significance
	Group S	Group M			
Variation less than 20% baseline value	39 (78.00%)	48 (96.00%)	87 (87.00%)	0.015	Yes
Variation greater than 20% baseline value	11 (22.00%)	2 (4.00%)	13 (13.00%)		
Total	50 (100.00%)	50 (100.00%)	100 (100.00%)		

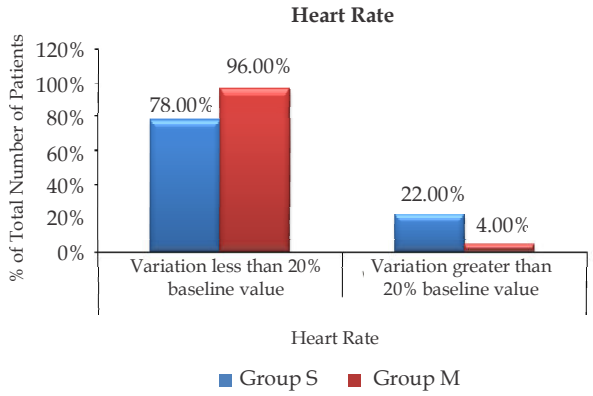

Fig. 10: Comparison of the groups based on heart rate.

Heart rate variation was found to be higher in group S than group M which is statistically significant (p-value - 0.015) (Table 10/Fig. 10).

Table 11: Comparison of groups based on systolic blood pressure.

Systolic BP	Group		Total	p-value	Significance
	Group S	Group M			
Variation less than 20% baseline value	42 (84.00%)	47 (94.00%)	89 (89.00%)	0.200	No
Variation greater than 20% baseline value	8 (16.00%)	3 (6.00%)	11 (11.00%)		
Total	50 (100.00%)	50 (100.00%)	100 (100.00%)		

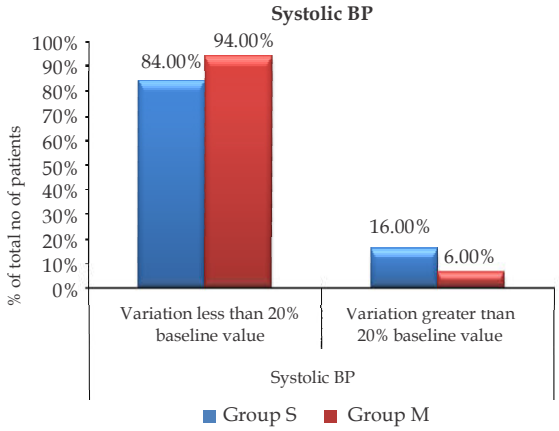

Fig. 11: Comparison of groups based on systolic blood pressure.

Systolic blood pressure values were higher in group S than group M, but difference was not statistically significant. (p – 0.200) (Table 11 / Fig. 11).

Table 12: Comparison of groups based on diastolic blood pressure.

Diastolic BP	Group		Total	p- value	Significance
	Group S	Group M			
Variation less than 20% baseline value	45 (90.00%)	48 (96.00%)	93 (93.00%)		
Variation greater than 20% baseline value	5 (10.00%)	2 (4.00%)	7 (7.00%)	**0.436**	**No**
Total	50 (100.00%)	50 (100.00%)	100 (100.00%)		

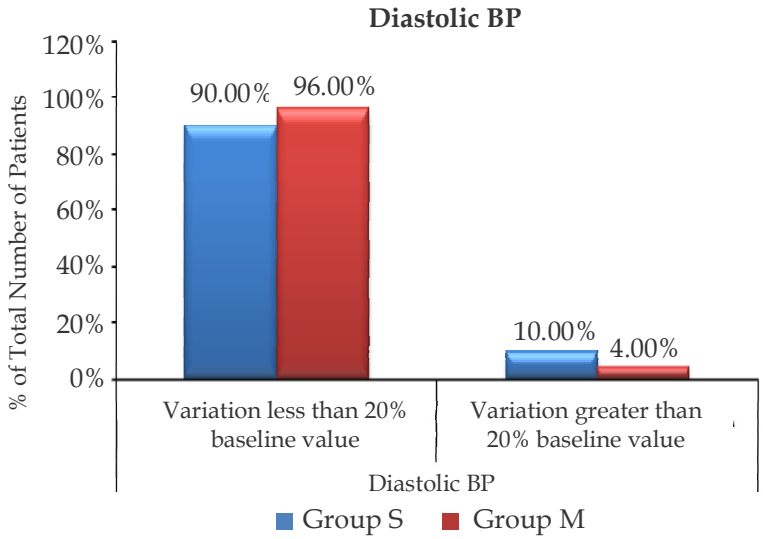

Fig. 12: Comparison of groups based on diastolic blood pressure.

Diastolic blood pressure values were found higher in group S than group M, but difference was not statistically significant. (pvalue – 0.436) (Table 12 / Fig. 12).

Table 13: Comparison of groups based on Mean Arterial Pressure.

MAP	Group		Total	p- value	Significance
	Group S	Group M			
Variation less than 20% baseline value	44 (88.00%)	48 (96.00%)	92 (92.00%)		
Variation greater than 20% baseline value	6 (12.00%)	2 (4.00%)	8 (8.00%)	**0.269**	**No**
Total	50 (100.00%)	50 (100.00%)	100 (100.00%)		

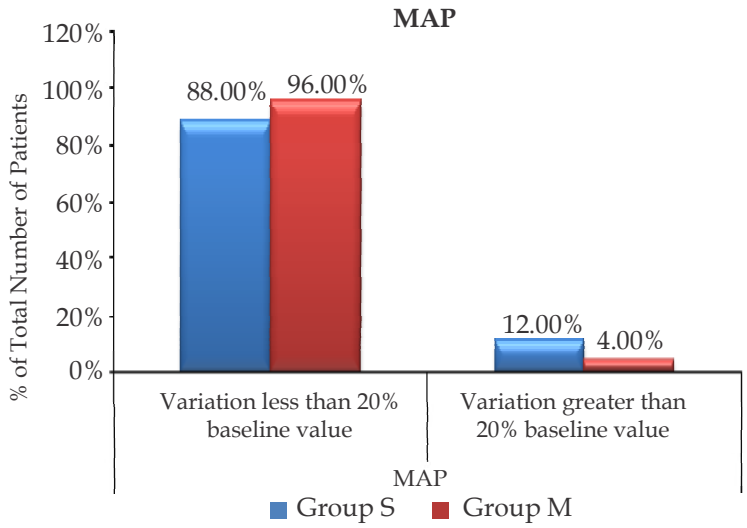

Fig. 13: Comparison of groups based on Mean Arterial Pressure.

Mean arterial pressure values were found higher in group S than group M, but difference was not statistically significant. (p value – 0.269) (Table 12/Fig. 12).

There was no significant difference in characteristics between both the groups (Table 2). Success of the infraclavicular subclavian central venous catheterisation showed that group M had a better success rate in comparison to group S, but the difference was not statistically significant. 45 out of 50 patients had successful catheterisation in group S while 47 out of 50 patients had successful catheterisation (p value 0.517). 33 patients had successful catherisation in first attempt in group S and 36 patients in group M (p value 0.715). Ten patients of group S and nine patients of group M required second attempt. In group S seven patients required three attempts, out of them five were failure and in group M four patients required third attempt, out of them three were failure. Mean number of attempts for successful cannulation in group S were 1.31 ± 0.56 and 1.23 ± 0.48 in group M (p value). Average time required to secure a successful cannulation in Group S was 145.42 ± 56.54 seconds, which was relatively higher in group M, 133.38 ± 36.78. But there was no statistically significant difference between the groups (p value 0.582).

The hemodynamic parameters showed higher variation in group S compared to group M. Heart rate showed a significantly higher variability (greater than 20% from baseline value) in group S as compared to group M. Eleven patients (22%) had heart rate greater than 20% from the baseline in group S while only two patients (4%) were having variation in group M. It was statistically significant with p value of 0.015.

The variability in systolic blood pressure, diastolic blood pressure and mean arterial pressure were found higher but it was statistically insignificant.

Discussion

We conducted a prospective cross sectional study, with 50 participants in each group, patients on spontaneous respiration (Group S) and mechanically ventilated patients (Group M). The groups were statistically matched for age, sex and BMI.

Analysis of the success and failure of the infraclavicular subclavian central venous catheterisation showed that Group M had a better success rate (f = 47, 94%) in comparison to Group S (f = 45, 90%). Among the eight failed procedures, five were from Group S. There was no statistically significant difference between two groups. Similar results were obtained in a prospective randomized study conducted by Kim et al 14 in 334 patients undergoing neurosurgical procedures under general anaesthesia with a success rate of 97.6%. In a prospective randomized study, Fragou M et al 17 observed a relatively lower success rate of 87.5% in mechanically ventilated patients by landmark method.

When the success of the procedure in the first attempt was analyzed, in all patients in the individual groups, it was comparatively better in Group M (72%) than the Group S (66%), but this was statistically not significant (p value – 0.517). Kim et al 14 observed 73.3% success rate in first attem-pt in mechanically ventilated patients and their observation was similar to our study.

Similarly second and third attempts required for successful catheterization were also more in group S in comparison to Group M. Ten patients of spontaneous respiration group and nine patients of mechanical ventilation group required second attempt. In spontaneous respiration group seven patients required three attempts, out of them five were failure and in mechanical ventilation group four patients required third attempt, out of them three were failure.

Number of attempts required to secure a patent cannulation in both groups were also statistically similar (p = 0.521). Mean number of attempts for successful cannulation in spontaneous respiration patients were 1.31 ± 0.56 and 1.23 ± 0.48 in mechanically ventilated patients. Kim et al 14 in their study demonstrated similar mean number of attempts for cannulation in mechanically ventilated patients with mean attempts of 1.4 ± 0.9. Fragou M et al 17 in their study demonstrated that mean number of attempts in locating the vein by land mark technique was significantly higher i.e, 1.9 ± 0.7.

Average time required to secure a successful cannulation in Group S was 145.42 (± 56.54) seconds, which was relatively higher than the group M (mean = 133.38, S.D. ± 36.78. But there was no statistically significant difference between the groups (p=0.582). Fragou M et al 17 reported an average insertion time of 44.8+ 54.9 seconds for subclavian venous catheterisation in landmark technique. The relatively lower insertion time reported in Fragou M et al 17 study is because they consider access time as the time between penetration of skin and aspiration of venous blood into the syringe. In our study access times were considered as the time between first skin puncture and successful placement of catheter.

When heart rate among both the groups were analysed, they showed a significantly higher variability (greater than 20% from baseline value) in spontaneous respiration group as compared to mechanical ventilation group. Eleven patients (22%) had heart rate greater than 20% from the baseline in spontaneous respiration group (group S) while only two patients (4%) were having variation in mechanical ventilation group (group M). It was statistically significant with a p value of 0.015. Higher heart rate variation was found in patients with more number of attempts.

Variation in systolic blood pressure was found higher in spontaneous respiration group (group S) as compared to the mechanical ventilation group (group M). Eight patients (16%) had higher systolic blood pressure than 20% of baseline value in spontaneous respiration group and three patients had higher systolic blood pressure values in mechanical ventilation group. But the systolic blood pressure variation was not statistically significant (p value 0.200). Variation in systolic blood pressure also increased with number of attempts.

Variation in diastolic blood pressure was found higher in spontaneous respiration group (group S) as compared to the mechanical ventilation group (group M). But the variation found to be less compared to systolic blood pressure variation. Five patients (10%) had higher diastolic blood pressure than 20% of baseline value in spontaneous respiration group and two patients (4%) had higher diastolic blood pressure values in mechanical ventilation group. But the diastolic blood pressure variation was not statistically significant (p value 0.436).

In mean arterial pressure variation also observed a similar pattern as in other hemodynamic parameters. Six patients (12%) had higher mean arterial pressure than 20% of baseline value in spontaneous respiration group and two patients (4%) had higher systolic blood pressure values in mechanical ventilation group. But the mean arterial pressure variation was also statistically not significant (p value 0.269).

Despite the paucity of reported infraclavicular subclavian central venous catheterisation under spontaneous respiration, our study reveals that it is a comparable method with success rates matching the catheterisation done in anaesthetised patients. However our sample size was only 50 patients in each group, larger sample size is desirable for validation of these findings.

Conclusion

The characteristics of infraclavicular subclavian central venous catheterisation are similar regardless of mechanical ventilation and spontaneous respiration.The infraclavicular subclavian venous catheterisation done under spontaneous respiration may result in significant heart rate variability.

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