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ORIGINAL ARTICLE

Mechanical Complications Following Central Venous Catheterisation in A Tertiary Care Teaching Institute: A Prospective Observational Study

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ABSTRACT

Background: Central venous catheters are an indispensable component of current day critical care and are employed for various indications. Central venous catheterizations (landmark-based or ultrasound-guided) are associated with mechanical complications. This study aimed to assess, analyze and compare the complication rate between two commonly employed catheterization routes: Internal jugular vein and subclavian vein.

Methodology: A prospective, observational study comparing two landmark-based central venous catheterization techniques was planned in a tertiary care teaching institute. 100 patients requiring central venous catheterizations were enrolled alternately into the IJV and Subclavian groups. Standard landmark-based insertion techniques were employed under strict asepsis. All patients were observed for mechanical complications in the first 24 hours following catheterization. Statistical analysis was done using the statistical package SPSS 20.0. Data were expressed as either mean and standard deviation or numbers and percentages. Categorical variables were analyzed using proportions and percentages. Association between categorical variables was established by Chi-square and odds ratio (OR) with 95% confidence intervals (CI).

Results: There were 22 complications observed. Incidence of complications was higher in the IJV group with 17 complications versus 5 in Subclavian group. There were 4 major complications and 18 minor complications between the two groups. Major complications comprised of hematoma formation (7/22) and arterial puncture (8/22). Incidence of complication was also analyzed with regards to independent variables.

Conclusion: Mechanical complications following central venous catheterizations was found in both groups studied. Internal jugular venous group had a higher mechanical complication rate than the subclavian group. Ultrasound guidance and greater detail in delineating the anatomy are likely to reduce the complication rates.

Keywords: Central venous catheter, Internal jugular vein, Subclavian vein, Mechanical complications, Landmark-based, Seldinger's technique

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INTRODUCTION

Central venous catheters (CVC) are an indispensable component of modern critical care.[1] Central venous catheters are commonly employed for hemodynamic/volume monitoring, administration of medications, long term total parenteral nutrition, access to renal replacement therapy, cardiopulmonary resuscitation, and for difficult peripheral catheterization.[2]

Central venous access is commonly attained via internal jugular (IJV), subclavian veins (SCV).[3] Each of the two routes commonly employed justifies their selection with numerous pros and cons. At the same time, the subclavian vein is preferred for central venous cannulation because of large diameter, ease of insertion, absence of valves, low complication rates and a high degree of patient acceptance once the catheter is in place. It also has a lower risk of catheter-related infection and thrombosis than femoral or internal jugular catheterization.[3] The Internal jugular vein is preferred due to its predictable anatomic location, readily identifiable and palpable surface landmarks, and a short and straight course to superior venacava.[3]

Despite their utility, placement of central venous catheters is often associated with mechanical, infectious and thromboembolic complications.[1] Mechanical complication are important, because their effects are usually immediate and contribute to increased length of stay, increased hospital cost, need for subsequent interventions and higher mortality rate.[1] These include bleeding (such as hematoma and haemothorax), cardiac arrhythmia, arterial puncture, arterial catheterization, nerve injury, pneumothorax, failed catheterization, and catheter tip malposition. Prior studies have demonstrated mechanical complication rates in 5% to 29% of catheter attempts.[1]

The data reported from adult Indian ICU on mechanical complication rates associated with central venous catheter (CVC) insertions is scarce.[4] Our research

aimed to estimate the incidence of different mechanical complications during central venous catheterization through the two frequently employed routes–internal jugular and subclavian route.

MATERIALS AND METHODS

This prospective, observational, single centric, parallel-group, Helsinki protocol compliant study was conducted after approval by hospital ethical committee. The study was conducted after obtaining written informed consent from the relatives of 100 patients admitted in the Intensive care unit of a tertiary care medical teaching hospital requiring central venous cannulation.

The primary objectives were to determine the incidence of mechanical complications occurring within 24 hours in patients undergoing CVC insertion via Internal jugular or subclavian approach. Secondary objectives were to identify risk factors associated with mechanical complications that occurred. Patients with infections at the puncture site, Deranged coagulation profile, Contralateral Pneumothorax, Trauma to clavicle and upper ribs, Distorted anatomy of neck of clavicle, Cervical spine trauma, post-surgical/radiotherapy, and all patients who died within the first 24 hours following CVC insertion were excluded unless the cause of mortality was CVC insertion.

Classification of Bleeding and cardiac arrhythmias shall be following Common Terminology Criteria for Adverse Events (version 5.0).[5] (Cancer Institute N Common terminology criteria for adverse events (CTCAE) common terminology criteria for adverse events (CTCAE) v5.0 2017). While Grade 1 bleedings are small bleedings, do not require interventions and are not significant clinically; these will not be included in this study. Grade 2 bleeding/hematoma formation which requires external compression for control shall be considered minor complications. Grade 3 bleeding: Resulting in haemothorax; requiring invasive intervention/ Blood transfusion and grade 4 bleeding: Resulting in haemothorax and with life-threatening consequences shall be classified as major mechanical complications. Grade 1 arrhythmia not requiring intervention and grade 2 arrhythmia requiring non-urgent medical intervention shall be classified as minor mechanical complications while Grade 3 symptomatic arrhythmia and grade 4 symptomatic arrhythmia requiring urgent interventions or with life-threatening consequences respectively shall be classified as major mechanical complications.

Arterial puncture will be considered a minor mechanical complication, whereas arterial catheterization will be major mechanical complication. Nerve injury with clinical signs resolving within 72 hours will be considered a minor complication and those with clinical signs beyond 72 hours shall be considered major complications. Pneumothorax will be classified as a major mechanical complication. Failed catheterization and catheter tip malposition requiring correction before use will be considered minor mechanical complications

Baseline data on each patient like age, sex, BMI, primary diagnosis, need for CVC insertion, Site of CVC insertion, Level of consciousness, presence of any co-morbid illnesses, and procedure type (emergency/ elective), were recorded and considered as independent variables likely to have an impact on the complication rate.

Patients have alternately been divided into groups, Group A –IJV (internal jugular) and Group B – SCV (subclavian), with 50 patients in each group.

Complete sterile-barrier precautions were followed for all central venous catheter (CVC) insertions. Strict hand washing was followed by a person inserting central venous line and assisting nurse with 2% chlorhexidine for skin disinfection. Lidocaine (2%) was used for local Anaesthesia.

All cannulations were performed either by an ICU consultant or by 3rd year registrar (with a minimum prior experience of at least 25 central venous catheters (CVC) insertions, under the supervision of a consultant. Each CVC insertion attempt was considered a new attempt and if a cannulation attempt failed and was subsequently performed by another operator, these were considered as separate insertion events. All catheters were inserted via a modified Seldinger's technique. In spontaneously breathing patients, catheters were introduced during exhalation to minimize the possibility of air embolization.

Internal Jugular Vein Cannulation

The patient was placed supine with a 15^0 head down tilt (Trendelenburg position). The operator located the IJV at the apex of the triangle formed by two heads of sternocleidomastoid and the medial third of clavicle with a 'finder needle' (22 Gauge) connected to a 2 ml syringe with heparinized saline. The needle was advanced through the skin at 30^o–45^o angle, in the direction of the ipsilateral nipple, lateral to the carotid artery pulsations with the artery being pushed medially by the palpating fingers of left hand. The entry of venous blood into the syringe attached to the needle confirmed entry into the vessel. After successful aspiration of venous blood, a guide wire was then placed through the needle into the vein, and the needle removed. A small nick was given on the skin & dilator passed over the guide wire. The catheter was then threaded over the wire and advanced into the IJV.

Subclavian Cannulation

The patient was placed supine at least 15° head down (Trendelenburg's position) to distend the neck veins and prevent air embolism. Sterile preparation of the skin was done and the area was draped. Local anesthetic was injected, the needle was introduced 1 cm inferior and 1 cm lateral to the junction of the middle and medial third of the clavicle. The needle was directed medially and slightly superiorly to stay on the inferior border of the clavicle, in the direction of the suprasternal notch where the other hand's index finger was placed. The needle was advanced slowly until its tip was in contact with the inferior border of the clavicle; while withdrawing the syringe's plunger, it was advanced on the inferior border of the clavicle until the vein was entered. When free flow of blood appeared, the guide wire was inserted via a separate port, the catheter was inserted over the guide wire. Following this guide wire was removed and the catheter was inserted.

Post Procedure

Catheter position was preliminarily confirmed by return of blood and free flow of fluid through all ports. All patients were observed for mechanical complications for 24 hours. All patients underwent a chest radiograph to assess catheter position, pneumothorax, hemothorax and mediastinal hematoma. All complications were managed as clinically indicated. A procedure was defined as emergent if the operator judged that 1-hour delay would be harmful.

Statistical analysis was done using the statistical package SPSS 20.0. Data were expressed as either mean and standard deviation or numbers and percentages. Data were entered using Microsoft Excel 2010 and statistical analysis was done using IBM SPSS v 20.0.0. Categorical variables were analyzed using proportions and percentages. The association between categorical variables was established by Chi square and odds ratio (OR) with 95% confidence intervals (CI). Continuous variables were summarized by mean and standard deviation (SD), and association tested by parametric tests. The $p < 0.05$ was considered statistically significant.

RESULTS

The CONSORT flow chart (Figure 1) depicts the participant flow in both groups. The groups displayed

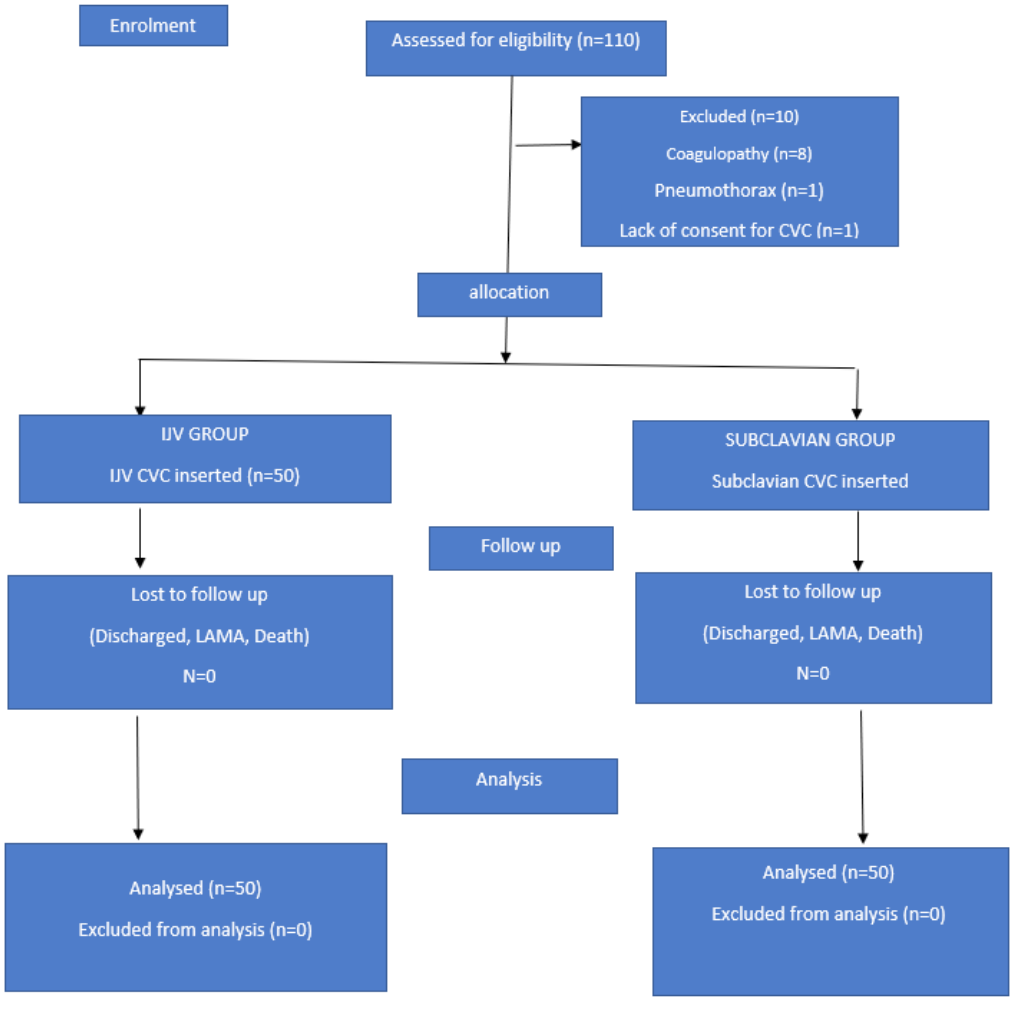

Figure 1: Consort diagram depicting flow of participants

Table 1: Demographic profile

	IJV	*Subclavian*	
Age	54.34 ± 16.964	49.66 ± 16.695	P > 0.5
Sex			
Male	38	35	P > 0.05
Female	12	15	
BMI	23.75 ± 1.99	23.40 ± 2.40	P > 0.05
Under-weight	0	3	
Normal	34	30	
Pre-obese	16	15	
Obese	0	2	

Table 2: Incidence of Major and minor complications

Complications	*IJV*	*Subclavian*
Major	03	01
Arterial puncture with cannulation	02	
Hematoma needing transfusion	01	
Pneumothorax	01	01
Minor	14	04

Table 3: complications and associated factors

	IJV		*Subclavian*	
	Complication		*Complication*	
Parameters	*Yes*	*No*	*Yes*	*No*
Number of attempts				
1	07	30	01	29
>1	10	03	04	16
Time for insertion				
0-2 minutes	04	02	02	03
3 minutes	13	31	03	42
Type of procedure				
Emergency	00	00	00	00
Planned	17	33	05	45
Sex				
Male	12	26	03	32
female	05	07	02	13
BMI				
Under-weight	00	00	01	02
Normal	11	23	01	29
Pre-obese	07	09	02	13
Obese	00	00	01	02

comparable demographic profile (Age, Sex, Mean BMI) (Table 1).

There were cumulatively 22 mechanical complications among all 100 patients with majority complications (17/22) occurring in the patients which were subjected to Internal jugular vein cannulation. While 6 complications related to hematoma formation, 7 were due to arterial puncture in these patients. These were significantly greater than those seen in the Subclavian group; where just 1 patient each developed hematoma and had inadvertent arterial puncture. (Figure 2)

There was no incidence of life threatening arrythmia, hemothorax, guidewire getting stuck or knotted nor were

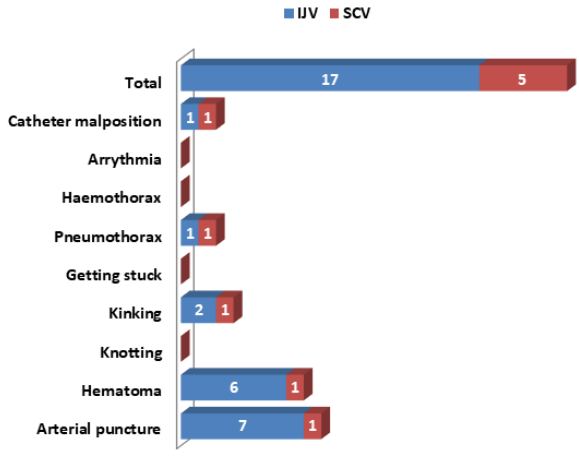

Figure 2: Incidence of mechanical complications

their any incidence of guidewire embolism. Most cases of arrythmias occurring in either group were due to excess length of guidewire inserted and were resolved merely by pulling out the extra length of guidewire and hence were not included in the data. However, there was one case each of central venous catheter malposition malposition which required repositioning of the CVC with no further complications. (Figure 2)

There was one case each of pneumothorax in either group which was treated by insertion of Intercostal drain and had no bearing on the length of stay in the hospital/ICU

In all, there were a total of 04 major complications and 18 Minor complications. Out of the major complications ¾ major complications were in the IJV group while ¼ was in the Subclavian group. Major complications in IJV group included: 2 patients suffering from arterial cannulations, 01 patient needing Blood transfusion post hemorrhage and 01 patient suffering from pneumothorax. (Table 2).

Incidence of complications were also compared with independent variables like number of attempts, time for insertion, gender predisposition and association with body mass index. (Table 3).

DISCUSSION

CVC insertion is one of the most commonly performed procedures across the world. Five million central venous catheters are projected to be inserted in The United States alone annually.[6-8] The present study was designed to compare and evaluate the incidence of mechanical complications in central venous cannulation by landmark technique between two routes (internal jugular and subclavian routes)

The complications rate for central venous catheterization when using the landmark technique versus ultrasound guided have been tilted heavily in favour of ultrasound guided group due to better visualisation and assessment over the landmark

technique which is primary a blind method.[9] However, landmark technique us still a commonly employed technique when central venous catheterizations are performed in resource limited settings. Also, the operator should be well versed with not only the USG guided method but also the landmark-based method so as to have adequate tools in his armamentarium, to tide over the situation whenever the need arises.

Mechanical complications, some of which can be potentially fatal, have been reported in up to 29% of the patients. In our study the corresponding mean value is 22%, which is slightly lower.[10] Albeit, higher incidence of mechanical complications was observed in IJV group i.e., 34% as compared to 10% in the Subclavian group. This can be attributed to the relative experience of the operator as the Subclavian approach is usually the preferred approach in our institute.

Incidence of complications in independent variables like number of attempts, gender predisposition, time for insertion and Body mass index were also studied. It was observed that increased number of attempts increased the chances of complications occurring; 10/17 and 4/5 cases where complications occurred in the IJV and Subclavian group respectively had more than one attempts while insertion of CVC. In IJV group, 4/6 cases which took less than 2 minutes for CVC insertion resulted into complications. Corresponding number in the subclavian group was 2/5. This emphasises the need for adequate time devotion while inserting a CVC, especially in planned cases. In our study all the cases that were included were planned CVC insertions and none was an emergency case.

In terms of gender predisposition, more males suffered from complications associated with CVC insertions. This can be attributed to more male patients in the study sample: 76% males in the IJV group and 70% in Subclavian group. However, analysis reveals 5/7 females in the IJV group and 2/13 females in Subclavian group encountered complications. On closer analysis it was seen that these patients also had a higher BMI than rest of the members in the group, and can be a cause for this finding of ours. Echoing the previous finding it was also seen that complication rate was higher in the pre-obese and obese group. In the IJV group 7/9 patients of pre-obese category had complications. This was attributed to presence of shorter necks and neck fat resulting into unclear anatomy and not easily identifiable landmarks.

Kaur *et al*. in 2012 conducted a prospective observational study with 480 patients undergoing central venous catheterizations, and concluded IJV route was associated with a significantly higher incidence of bleeding complications (P=0.009).[4] This finding was consistent with our study. Ruesch S *et al*. concluded from a meta-analysis found no significant differences in complication rates between internal jugular vein puncture and subclavian vein puncture except for slightly increased risk of arterial puncture with internal jugular approach.[11] These findings are mostly in agreement with our results.

A retrospective study conducted by Hiwaker P *et al*. to analyze incidence of complications following central venous catheterization in 597 patients employing Landmark-based Seldinger's technique. Authors concluded lower incidence of mechanical complication through IJV route.[12] These findings were contrary to the findings in the present study where arterial punctures and hematoma were found to be more when IJV route was used for placement of central venous catheter.

Other mechanical complications seen in our study were guidewire kinking and catheter tip malposition. **Tekin M etal.** in his research, included 1092 cases to perform CVC insertion either subclavian or internal jugular access. The incidence of catheter malposition in IJV group vs Subclavian group was tilted towards subclavian group (0.80% vs 2.02%) with no significant difference between the adults and pediatric patients.[13] The findings were consistent with the results in the present study. There was incidence of 2% of catheter misplacements in both IJV and SCV groups which were found to be statistically not significant. The incidence of kinking was 4% in IJV and 2 %in SCV group. The p value on application z test revealed a value >0.05 which was statistically not significant. Similar observation was seen by Kaur *et al.* in their study, Catheter-related complications included guidewire kinking (11 patients) and catheter tip malpositions (15 patients), the SCV and the IJV routes had similar numbers of catheter-related complications.[4]

The incidence of pneumothorax was found to be equal in both subclavian and central venous catheterization (2%) with incidence of complication increasing with the number of attempts. Our findings concurred with study conducted by aur *et al*, eleven patients developed pneumothorax during CVC insertion, and this complication occurred significantly more often in those who had "two or more" attempts at needle insertion (P=0.0058). Site of CVC insertion did not influence the occurrence of this complication in their study. The results of the present study were also consistent with the findings of meta-analysis conducted by Ruesch S *et al*.[4,11]

Jha M *et al* in a 2 years retrospective study involving 542 CVC cannulations inferred higher mechanical complications in CVC inserted through the subclavian route SV cannulations.[14] These results were contrary to our findings.

Other complications like arrhythmias, hemothorax, guidewire related complications like knotting and getting stuck did not occur in present study.

No research is without limitations, and so was ours. Firstly, the sample size of 100 in a tertiary care hospital is small. Sample size was decided upon based on the previous studies. The authors feel that the study or its modifications can be conducted with a higher sample size. Secondly, even though the catheterizations were performed by experienced operators, which resulted in possibly fewer or acceptable complication rate and profile; when the same procedures will be performed by the inexperienced the complication rates are likely to show an upward trend, thereby highlighting the need for proper training. Thirdly our research included only planned central venous catheter insertions; a separate study is a must to evaluate complications in same procedures in trauma patients and catheterizations under emergency settings.

CONCLUSION

Even though various studies (prospective and retrospective) from different centers have highlighted different rates of complications and justified one approach better than the other; authors feel the ultimate factor that decides the approach should be how well versed the operator is with the technique. Operator should be aware of all approaches and should make an informed judgement based on patient-to-patient basis. Though, in our research Internal Jugular vein approach was found to have higher incidence of mechanical complications, this might show differing results if the same study is conducted under ultrasonography guidance.

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