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Complications of central venous catheter in a tertiary care health centre: A prospective observation study

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Abstract
Central venous catheter (CVC) placement is a commonly performed procedure in hospitalized patients. However, CVC procedure is associated with various complications, which add to the morbidity, increase the hospital stay and cost. To assess the rate of complications associated with CVC placement, we analysed 325 consecutive patients over 12 month period at a tertiary care hospital. All hospitalised patients, 16 years or older, requiring CVC were included. The complications included local bleeding (6.8%), arterial puncture (4.6%), pneumothorax (0.92%), and central line associated blood stream infection (4%). Factors like multiple insertion attempts, antiplatelet use, and coagulopathy significantly correlated with higher complication rates ($p<0.05$). The subclavian site exhibited more mechanical issues compared to the internal jugular or femoral site, which was statistically non-significant. Findings underscore the importance of tailored approaches for CVC placement to mitigate risks and optimize patient outcomes. Enhanced protocols incorporating ultrasound and standardized techniques are crucial for improving procedural safety.

Keywords: Central venous catheter, pneumothorax, CLABSI, coagulopathy

Introduction
Central venous catheter (CVC) is an indwelling device that is inserted into a large central vein (most commonly the internal jugular, subclavian, or femoral) and advanced until the lumen resides within the inferior vena cava or superior vena cava. These devices and techniques employed to place them are synonymous with the term “central line” or central venous access [1]. The concept of CVC was first introduced by Dr Werner Forssman in 1929, who self-inserted a ureteric catheter through his cubital vein to reach the right side of the heart [2]. Since that time technique of central line insertion has developed further and the Seldinger technique, described in 1953 revolutionized the field of bedside procedure, especially central venous cannulation [3].

Central venous cannulation has become useful in critically ill patients mainly for the purpose of rapid fluid resuscitation, difficult intravenous access, invasive hemodynamic monitoring by measuring central venous pressure, administration of drugs like inotropes, irritant medication, and total parenteral nutrition [4].

The use of ultrasound is strongly recommended to improve patient safety and prevent complication during CVC insertion. There is still gap in existing guidelines and clinical practices while using ultrasound for placing CVC including inexperienced user, lack of sterile technique, which can be associated with immediate or delayed complications [5]. Immediate complications occur at the time of catheter insertion and include arterial puncture, bleeding with hematoma, tension pneumothorax, arrhythmia. Infectious complication associated with central line is called central line associated bloodstream infection (CLABSI).

Delayed complications include infections and device dysfunction (which include fibrin sheath formation, thrombosis, central venous stenosis). These complications can lead to increase in hospital stay, increase in hospital cost, need for subsequent intervention and impaired the quality of life of patient which result in increased morbidity and mortality [6].

Central venous catheter should be removed if there are associated complications like improper placement, occlusion of catheter, discontinuation of intravenous fluids or medication, infection, hematoma and thrombophlebitis. It should also be removed when it is no more required [7]. The factors which contribute to complications of central venous catheter insertion include high BMI (Body Mass Index), catheter lumen, site of CVC placement, coagulopathy, previous catheterization, previous surgery or radiotherapy, number of venepunctures, advanced age or any other co-morbidity, the time required for catheter placement and use of blind

approach to cannulate the vessel [8].

There is a wide variability in rate of complications associated with CVC placement, depending upon expertise, use of ultrasound and compliance with central line bundles. The aim of this study was to find the incidence of complications and to determine the risk factors associated with complications after central venous catheter insertion.

Materials and Methods

A prospective observational study was conducted in a 250 bed tertiary care health centre located in north India. All recorded CVC insertions in patients with age 16 years or older from January 2023 to January 2024 were considered eligible for inclusion. The study was approved by ethics review committee of our hospital. We collected data of 325 consecutive patients in whom central venous catheterization was done during this period. The choice of CVC site was based on patient characteristics and operator preference. All of the operators were proficient in use of ultrasound for inserting CVC at three sites including internal jugular, subclavian or femoral. Ultrasound guidance was used in 88% of the procedures. All CVC insertions followed a standard central line care bundle that includes hand hygiene, maximal barrier precautions, skin antisepsis, and optimal site selection. The Seldinger technique was used for the insertion of the CVC. The indication for the insertion and removal of central line was noted. Standard continuous central line care was provided by dedicated nurses in critical and non-critical areas.

The variables recorded during CVC insertion included: patient age, gender, use of anti- platelets or coagulopathy, vascular insertion site, number of percutaneous punctures and the patient care unit where the procedure took place. Complications were classified as mechanical, which included bleeding, arterial puncture, pneumothorax, haemothorax and infectious complications. Central lines were regularly assessed A diagnosis of central line associated blood stream infection (CLABSI) was made as per CDC definition, when patient has laboratory confirmed new blood stream infection that is not secondary to an infection at another body site.

Results and Observation

A total of 325 consecutive CVC insertions were assessed over a period of 12 months. Patient characteristics are presented in Table 1. Patients aged 51-60 years comprised the largest group (26.5%), followed by those aged 61-70 years (22.2%). Females accounted for 41.5% of cases, and males for 58.5%. Out of 325 patients, 218 CVC insertion were done in ICU (67.1%), 54 in OT (16.6%), 15 in ward (4.6%) and 38 in emergency (11.1%). The most common insertion site was the internal jugular vein (77.8%), followed by subclavian (14.2%) and femoral (8.0%) (Table 2). 92.9% of patients who underwent CVC insertion had normal coagulation profile. 23.7% patients were on anti-platelets medication at the time of CVC insertion. 80.9% CVC insertions were performed in first attempt, 14.2% required two attempts, 4.3% required three attempts and 0.6% four attempts. Indications of CVC insertion included poor peripheral IV access (43.1%) and drug administration (32.9%).

Mechanical complications of CVC insertion are presented in Table 3. 85.2% of CVC insertions (277/325) were uncomplicated, mechanical complications occurred in 14.8% cases. The complications noted were arterial puncture (4.6%), pneumothorax (0.92%), bleeding (6.8%), haemothorax (0.3%) and hemopneumothorax (0.3%). Figure 1 shows mechanical complications as per vascular site of insertion. Subclavian cannulation has higher rate of complications (26.1%) compared to internal jugular (16.6%) or femoral (15.4%), however the difference was not statistically significant ($p = 0.243$). 13 (4%) patients developed CLABSI. Figure 2 shows the rate of CLABSI as per site of CVC insertion, which was 2.8% for internal jugular, 6.5% for subclavian, 11.5% for femoral cannulation and was not statistically significant ($p = 0.060$). Multivariate logistic regression analysis showed that number of attempts (>2), anti-platelet drugs, coagulopathy, hypertension and coronary artery disease were significant predictors of complications. (Table 4)

Table 1: Demographic Profile

Age group	No. of cases	Percentage
< 20	5	1.5%
21-30	16	4.9%
31-40	41	12.6%
41-50	57	17.5%
51-60	86	26.5%
61-70	72	22.2%
> 70	48	14.8%
Gender		
Female	135	41.5%
Male	190	58.5%
Coagulopathy		
No	302	92.9%
Yes	23	7.1%
Place where central line inserted		
Emergency IP Ward	38	11.7%
General OT	54	16.6%
ICU	218	67.1%
Ward	15	4.6%
No. of Attempt		
1	263	80.9%
2	46	14.2%
3	14	4.3%
4	2	0.6%
Indication for insertion of central line		
Drug administration	107	32.9%
Poor peripheral IV access	140	43.1%
TPN	24	7.4%
Vasopressor support	54	16.6%

Table 2: Site of insertion

Site	No. of cases	Percentage
Left femoral vein	5	1.5%
Left internal jugular	67	20.6%
Left Subclavian	8	2.5%
Right Femoral	21	6.5%
Right Internal Jugular	186	57.2%
Right Subclavian	38	11.7%
Total	325	

Table 3: Mechanical Complications

Immediate complications	No. of cases	Percentage
None	277	85.2%
Arterial puncture	15	4.6%
Hemopneumothorax	1	0.3%
Hemothorax	1	0.3%
Bleeding	22	6.8%
Pneumothorax	9	2.8%

Table 4: Multivariable logistic regression analysis of mechanical complications.

	p-value	Odd ratio	95% C.I. for odd ratio	
			Lower	Upper
Age	0.383	0.992	0.974	1.010
Gender-Female	0.364	0.762	0.423	1.371
Emergency Ward	0.235	3.733	0.425	32.812
GENERAL OT	0.141	4.900	0.589	40.744
ICU	0.349	2.678	0.341	21.024
Femoral vein	0.299	0.515	0.147	1.802
Internal jugular	0.128	0.564	0.270	1.178
Number of skin punctures (>2)	0.001	3.363	1.668	6.781
Patient on any antiplatelets medication.	0.015	2.139	1.161	3.940
History of previous central venous catheterization	0.857	1.156	0.239	5.592
History of previous operation or radiotherapy	0.396	0.408	0.052	3.226
Coagulopathy	0.0001	4.973	2.073	11.934
Comorbidity - Diabetes	0.053	1.892	0.992	3.609
Hypertension	0.025	0.493	0.266	0.914
Acute kidney injury	0.824	1.159	0.316	4.246
Cerebrovascular accident	0.145	1.689	0.835	3.416
Coronary artery disease	0.0001	3.688	1.817	7.485
Poor peripheral IV access	0.188	0.645	0.335	1.240
TPN	0.155	0.332	0.073	1.517
Vasopressor support	0.916	1.043	0.474	2.300

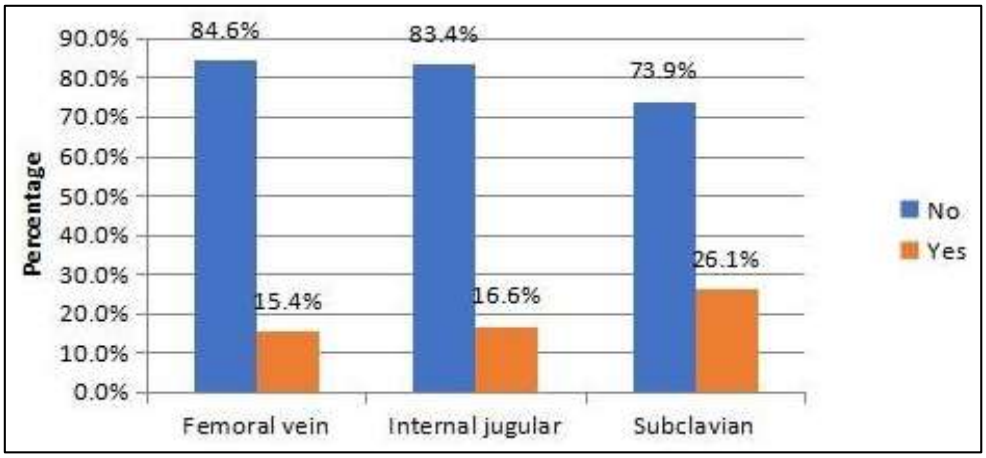

Fig 1: Correlation of Site insertion of CVC and mechanical complications (p=0.243)

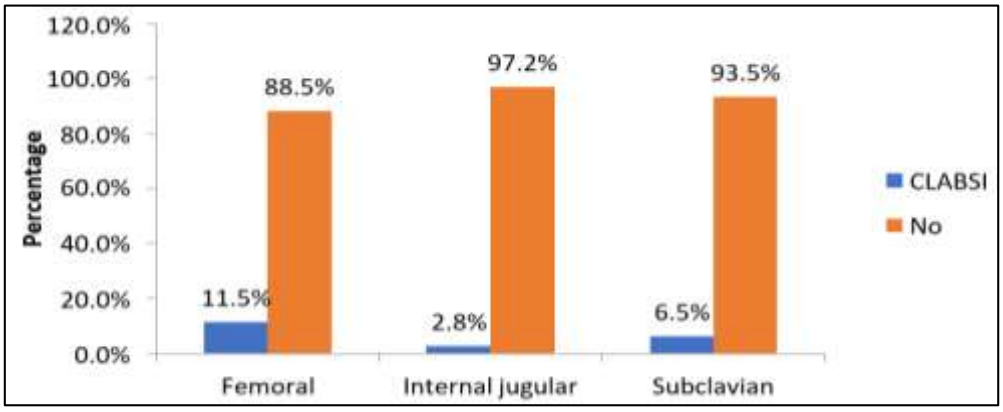

Fig 2: Site of insertion of CVC insertion and CLABSI (p = 0.060)

Discussion

This study reviews the mechanical and infectious complications in a tertiary care hospital over a one year period. The study population included both critical and non-critical areas. We reviewed 325 CVC insertions and the rate of mechanical complications was 14.8%. In a similar study by Eisen *et al*., the rate of mechanical complications excluding failures was 14%, which is comparable to our study [9].

In our study, the majority of central lines were inserted in ICU 218 (67.1%) and the preferred site of insertion was right internal jugular vein (186 cases, 57.2%). The right internal jugular vein (IJV) is preferred for central venous catheter (CVC) insertion in clinical practice due to several advantages. Its direct and relatively straight path to the superior vena cava

(SVC) facilitates accurate catheter placement, reducing the risk of complications from misplacement. Its anatomical position, located anteriorly and away from the pleura, also decreases the likelihood of pneumothorax compared to the subclavian vein approach, enhancing patient safety and comfort during the procedure. Additionally, the IJV is easily accessible and can be effectively visualized using ultrasound guidance, further improving the precision and safety of CVC insertion.

The number of attempts made during CVC insertion significantly increases the occurrence of complications, as were observed in our study. The complication rate in our study was 13.7% with single percutaneous attempt. However, as the number of attempts increased, the complication rates increased. The complication rate was 34.8% with two attempts, and with three attempts, the rate further increased to 35.7%. One of the largest studies found that attempts requiring more than 2 punctures had a 43% failure rate and a mechanical complication rate of 24% [10].

The most common complication noted in our study was oozing or bleeding (6.8%) at the insertion site. However, the bleeding was usually self-limiting and was effectively managed by applying firm pressure with a sterile dressing over the insertion site. In a study conducted by Vats HS *et al*., the incidence of local hematoma was 4.7%, which was almost similar to our study. Rockholt MM *et al*. reported in their study that out of 589 CVC insertions in 387 patients, 11% of insertions resulted in moderate to severe mechanical complications, primarily grade 2– 4 bleeding.

In our study, out of 325 CVC insertions, 77 patients were on antiplatelet medication and of them 21(27.3%) developed complications, mainly local bleeding (p = 0.017). The antiplatelet therapy may increase the risk of complications such as bleeding or hematoma formation, likely due to impaired haemostasis and increased susceptibility to vascular injury during catheterization. Among co-morbidities, hypertension and coronary artery disease were related to increased complication rates. The possible reason could be the frequent use of anti-platelets drugs in such patients.

The complication rate was 15.6% (47/302) in patients without coagulopathy compared to 47.8% (11/23) in those with coagulopathy (INR greater than 1.5), highlighting a markedly higher complication rate in the coagulopathic cases (p = 0.001). A review of one randomized control trial and 21 observational studies concluded that incidence of major bleeding is low after CVC insertion, even in coagulopathic patients. No study demonstrated the beneficial effect of prophylactic platelet or fresh frozen plasma transfusion to prevent bleeding complications following CVC insertion [11].

In our study, the overall incidence of CLABSI was 13/325 cases (4%). The rate of CLABSI for internal jugular CVC was 2.8% (7/253), for subclavian: 6.5% (3/46) and femoral: 11.5% (3/26), which was statistically non-significant (p=0.060). Our results are comparable with previous study which found similar rate of catheter infection in all three sites. The authors also concluded that in the setting of catheter insertion by trained operator, optimal site selection, use of sterile insertion technique and standard continued central line care, the risk of CLABSI remains same in different sites of insertion [12].

The study has several limitations. It was a single centre observational study and results cannot be generalised. The variables that were associated with complications should be further evaluated in a multi-centre study. The choice of insertion site was at the discretion of clinical physician and the results of coagulation profile were available before insertion, which probably introduced a bias in selecting internal jugular or femoral approach over subclavian approach in such patients. The study used data from clinical practice and some of the complications may not have been reported or missed. The majority of central lines (67.1%) were inserted in ICU, the generalisability of results may be limited in other areas.

Conclusion

The study highlights various factors influencing complications and outcomes following central venous catheter (CVC) insertion. The most common complication was minor bleeding, which could be controlled with local pressure. Factors like multiple insertion attempts, antiplatelet use, and coagulopathy significantly correlated with higher complication rates with the use of ultrasound as a standard of care for inserting CVC, the incidence of major complications including pneumothorax has decreased. There was not significant difference between site of insertion and mechanical or infectious complications. The insertion of CVC at carefully selected site by trained operator, use of sterile techniques and real time ultrasound can improve patient safety and reduce complications for all three insertion sites.

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