

Comparison of mechanical complications of central venous catheter according to the insertion site in an intensive care unit of Bangladesh

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Abstract

Background: Central venous catheter (CVC) insertion is very common in intensive care unit (ICU). CVC is usually inserted in subclavian, internal jugular and femoral veins. However, CVC insertion may lead to significant mechanical complications. Our aim was to detect the occurrence of CVC related mechanical complications according to different insertion site.

Methods: This prospective observational study was carried out during the period of May 2016 to July 2019 in Department of Critical Care Medicine, BIRDEM General Hospital, Dhaka, enrolling 349 adult patients requiring new CVC insertion in ICU.

Results: Among 349 study subjects, 167 CVC were inserted through subclavian vein, 88 through internal jugular and 94 through femoral vein. There was no significant difference among three groups (subclavian / internal jugular / femoral) in terms of age, gender distribution, presence of co-morbid illness. Total mechanical complications in study population was 43 (12.3 %) including pneumothorax (14, 4.0%), arterial puncture (10, 2.9%), hemorrhage (11, 3.2%), catheter tip malposition (6, 1.7%), hemothorax (1, 0.3%) and lost guidewire (1, 0.3%). Pneumothorax was more with internal jugular (9.1%) than subclavian (3.6 %) route, which was statistically significant ($p=0.007$). Although hemorrhage and arterial puncture events were higher with femoral site than subclavian or internal jugular, which were not significant. Catheter tip malposition occurred in 4 (2.4%) patients with subclavian insertion and 2 (2.3%) patients with internal jugular site, no such event in femoral site. Hemothorax and lost guidewire occurred in only 1 patient with subclavian and internal jugular site respectively. Site-wise total mechanical complications were higher in internal jugular (17.0%) followed by subclavian (10.8%) site and femoral site (10.6%).

Conclusion: In this study, though not statistically significant, CVC related mechanical complications occurred more in subclavian site than in internal jugular or femoral insertion site.

Key words: Central venous catheter, mechanical complications, intensive care unit, insertion site.

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Introduction

Central venous catheter (CVC), also known as central line, or central venous access catheter, is a catheter placed into a large vein in the neck (internal jugular vein), chest (subclavian vein) or groin (femoral vein). It is used to administer medications or fluids, obtain blood for tests and measure central venous pressure. Central venous catheterizations are now common among critically ill patients.

Catheterization is associated with infectious, thrombotic, and mechanical complications.¹ These complications can widely be categorized into intravascular [includes catheter related blood stream infection (CRBSI), catheter tip colonization, catheter related deep vein thrombosis (DVT)] and mechanical (includes haemorrhage, haemothorax, pneumothorax, cardiac perforation, lost guidewire, catheter tip malposition etc).

Though the CVC related infection and venous thrombosis have been studied in various research, mechanical complications of CVC was not well studied. These complications usually have been studied as secondary outcome in many studies.^{3,6} Like intravascular complications, mechanical complications also pose significant mortality and morbidity.

The rate of mechanical complications ranged from 0-12%, according to the experience of the operator and the definition of complications;² and the complications include arterial puncture, pneumothorax, mediastinal haematoma, haemothorax and injury to adjacent nerves. The introduction of more flexible catheters and of the J guide wire insertion method has decreased the rate of severe mechanical complications.² These mechanical complications also vary according to different insertion sites. Various studies demonstrate contradictory results. However, in an individual patient, criteria for choosing one insertion site over the other often remain unclear. This choice could depend on the complication rate with each approach and individual skill. An improved understanding of CVC related mechanical complications might help clinicians to choose one approach over the other in specific clinical settings.

The aim of this present study was to detect the insertion site wise occurrence of different mechanical complications.

Methods

This prospective observational study was done during the period of May 2016 to July 2019 in Department of Critical Care Medicine, Bangladesh Institute of Research and Rehabilitation in Diabetes, Endocrine and Metabolic Disorders (BIRDEM) General Hospital, Dhaka. A total of 349 adult patients (age ≥ 18 years) requiring new CVC insertion for fluid management, medications, inotrope support and monitoring were enrolled in the study. Antibiotic coated CVC, tunnelled catheters, implantable devices, radiologically inserted catheters, dialysis catheters were excluded. CVC insertion was performed only after getting informed written consent from patient or his/her relative, when the platelet count was more than 50000/cumm and the international normalized ratio was less than 1.5, as per ICU protocol. All catheterizations were performed either by an ICU consultant, registrar or a medical officer (with a minimum prior experience of at least 25 CVC

insertions under the supervision of a consultant). Insertion site selection was individualized by the treating physician. Events such as haemorrhage (immediate and late), arterial puncture, lost guidewire were noted. Chest radiograph was performed on all patients to verify the position of the tip of the CVC and to detect complications like pneumothorax or haemothorax in case of subclavian and internal jugular approach. All the patients were followed up daily after CVC insertion. Removal of CVC was done when appropriate [development of catheter related blood stream infection (CRBSI), or deep venous thrombosis (DVT) or no longer required]. All the information about the patient were collected by a structured data sheet and analysed by statistical package for the social sciences (SPSS) version 22.

Results

During the study period, 167 CVC were inserted through subclavian vein, 88 CVC through internal jugular vein and 94 CVC through femoral vein. There was no significant difference among three groups (subclavian / internal jugular / femoral) in terms of age, gender distribution, presence of co-morbid illness (Table I). Though most patients had more than one diagnosis during their admission, the primary cause/diagnosis was recorded. Table II showed the primary diagnosis of the study subjects at admission. The highest on-admission diagnosis was pneumonia (22.6%), followed by AKI (20.9%), stroke (9.7%) and acute pulmonary edema (4.9%). Total mechanical complications in study population was 43 (12.3 %) and included pneumothorax (14, 4.0%), arterial puncture (10, 2.9%), hemorrhage (11, 3.2%), catheter tip malposition (6, 1.7%), hemothorax (1, 0.3%) and lost guidewire (1, 0.3%). Pneumothorax was more in internal jugular (9.1%) than subclavian (3.6 %) route, which was statistically significant ($p=0.007$). Although hemorrhage and arterial puncture events were higher with femoral site than subclavian or internal jugular, which were not significant. Catheter tip malposition occurred in 4 (2.4%) patients with subclavian insertion and 2 (2.3%) patients with internal jugular site, no such event found in femoral site. Hemothorax occurred in only 1 patient with subclavian site and lost guidewire in only 1 patient in internal jugular site. Site-wise total mechanical complications were higher in internal jugular (17.0%) followed by subclavian (10.8%) site and femoral site (10.6%).

Table I Age, gender and co-morbidities of the study subjects (n=349)

	Site			Total (n=349)	p value
	Subclavian (n=167)	Internal jugular (n=88)	Femoral (n=94)		
Age (years)	60.63 ± 16.06	63.00 ± 14.38	61.89±12.91	61.57±14.84	0.468 ^{##}
Gender					
Male	99 (59.3)	46 (52.3)	55 (58.5)	200 (57.3)	0.540 [#]
Female	68 (40.7)	42 (47.7)	39 (41.5)	149 (42.7)	
Co-morbidities					
DM	121 (96.8)	65 (97.0)	80 (97.6)	266 (97.1)	0.950 [#]
HTN	98 (94.2)	50 (84.7)	60 (90.9)	208 (90.8)	0.131 [#]
IHD	16 (40.0)	12 (40.0)	8 (26.7)	36 (36.0)	0.444 [#]
Others	13 (40.6)	13 (50.0)	14 (46.7)	40 (45.5)	0.765 [#]

^{##}ANOVA test was done to measure the level of significance

[#]Chi-square test was done to measure the level of significance

Table II Primary diagnosis during ICU admission of the study subjects (n=349)

Primary diagnosis	Frequency	Percentage
Pneumonia	79	22.6
Acute Kidney Injury	73	20.9
Stroke	34	9.7
Acute Pulmonary Edema/LVF	17	4.9
Myocardial Infarction	16	4.6
Diabetic Ketoacidosis	13	3.7
Severe hyponatremia	12	3.4
Urosepsis	11	3.2
Meningitis	9	2.6
Hypoglycemia	8	2.3
Hyperglycemic Hyperosmolar State	7	2.0
Others	79	22.6
Total	349	100.0

Table III Mechanical complications of the study subjects (n=349)

Complications	Site			Total (n=349)	p- value
	Subclavian (n=167)	Internal jugular (n=88)	Femoral (n=94)		
Pneumothorax	6 (3.6)	8 (9.1)		14 (4.0)	0.007
Arterial puncture	3 (1.8)	3 (3.4)	4 (4.3)	10 (2.9)	0.371
Hemorrhage	4 (2.4)	2 (2.3)	5 (5.3)	11 (3.2)	0.489
Hemothorax	1 (0.6)			1 (0.3)	0.579
Lost guidewire			1 (1.1)	1 (0.3)	0.257
Catheter tip malposition	4 (2.4)	2 (2.3)		6 (1.7)	0.324
Total	18 (10.8)	15 (17.0)	10 (10.6)	43 (12.3)	

Chi-square test was done to measure the level of significance

Discussion

The overall incidence of mechanical complications in this study was 12.3% which was higher in comparison to study done by Akmal et al (0.98%)² and Parienti et al (1.4%).³ This higher rate of mechanical complications of the present study could be due to less experience of the operator, inappropriate choice of CVC insertion site and the definition of complications. The incidence of mechanical complications after three or more insertion attempts is six times the rate after one attempt. Hence, if a physician is unable to insert a catheter after three attempts, he or she should seek help rather than continue to attempt the procedure.² We did not strictly observe the number of attempts required for successful CVC insertion.

The mechanical complication rate ranged from 0-12%, according to the experience of the operator;² and 0.7-2.1% according to the insertion site.³ The mechanical complications occurred in this study include pneumothorax (4.0%), haemorrhage (3.2%), arterial puncture (2.9%) and catheter tip malposition (1.7%), hemothorax (0.3%) and lost guidewire (0.3%).

It is reported in some literatures that pneumothorax, one of the most feared complications of CVC insertions, occurs in up to 0.1% to 3.1% patients undergoing the procedure, with increasing risk with larger needle size and number of passes made, use of the subclavian route and in emergency situations.⁴ Kaur et al⁵ found that this complication occurred equally with the internal jugular and subclavian routes; however, 2 or more attempts were associated with a significantly higher risk of pneumothorax ($p=0.0052$). In the meta-analysis by Ruesch et al⁶, there was no evidence of any difference in the incidence of haemothorax and pneumothorax with the two approaches (subclavian and internal jugular). This equality may reflect the lack of randomization in the original trials, leading to selection bias. Patients at increased risk of pulmonary complications (e.g. patients with chronic obstructive pulmonary disease or acute respiratory distress syndrome) have not been included in these studies.⁶ In this study, the incidence of pneumothorax happened significantly more with internal jugular (9.1%) than subclavian (3.6%) route.

Kaur et al⁵ found that CVCs inserted via the internal jugular route had a significantly higher proportion of failed cannulations, possibly contributing to the greater

number of mechanical complications via this route in comparison to subclavian route.⁵ Bleeding complications were the greatest among all mechanical complications encountered, especially when the internal jugular route was used and when more than two attempts required for successful cannulation.⁵ In this study, the result was contradictory where haemorrhage occurred more in femoral site (5.3%), followed by subclavian site (2.4%) and internal jugular site (2.3%). Arterial puncture also occurred more in femoral site (4.3%), followed by internal jugular site (3.4%) and subclavian site (1.8%). For both events, there was no statistically significant difference among the CVC insertion site. Insertion site selection and urgency of cannulation might be the factors for such result. Extremely moribund patients and urgent CVC insertion might have a preference of femoral site over other site causing more occurrence of haemorrhage.

The data on catheter malposition may have more impact on clinical decision making. Malposition have been reported in 14% of CVCs even when they were inserted by experienced clinicians.⁷ Catheter tip malposition are reported to occur with both internal jugular and subclavian insertions. Also, malposition of a subclavian catheter may include entry into the opposite subclavian vein or the neck veins, whereas many jugular catheters may simply be pulled back if the tip lies in the right atrium. Catheter malposition may result in vascular perforations and dangerous arrhythmias. The positioning of catheter tip within the cardiac silhouette is associated with an increased risk of cardiac tamponade.⁸ Catheter tip malposition was found in 2.4% patients with subclavian approach and 2.3% patients with internal jugular approach in our study ($p=0.324$).

In many instances, guide wires have been reported to be entrapped, knotted, fractured, embolized and even lost inside patients. We observed one occurrence of lost guidewire related event in femoral site. No such event in other two insertion sites. It might be due to small sample size of this study.

Conclusion

CVC insertion procedure is commonly associated with numerous mild to severe mechanical complications. Mechanical complications were higher in internal jugular than other two sites. Attaining more experience in insertion procedure and appropriate choice of

insertion site in appropriate clinical settings may significantly reduce the number of incidence of CVC related mechanical complications.

Conflict of interest: Nothing to declare.

References

1. McGee DC, Gould MK. Preventing complications of central venous catheterization. *N Engl J Med* 2003; 348:1123-33.
2. Akmal AH, Hasan M, Marium A. The incidence of complications of central venous catheters at an intensive care unit. *Annals of Thoracic Medicine* 2007; 2(2): 61-63.
3. Parienti JJ, Mongardon N, Megarbane B, Mira JP, Kalfon P, Gros A, et al. Intravascular complications of central venous catheterization by insertion site. *N Engl J Med* 2015; 373:1220-29.
4. Mansfield PF, Hohn DC, Fornage BD, Gregurich MA, Ota DM. Complications and failures of subclavian vein catheterization. *N Engl J Med* 1994; 331: 1735-38.
5. Kaur R, Mathai AS, Abraham J. Mechanical and infectious complications of central venous catheterizations in a tertiary level intensive care unit in northern India. *Indian Journal of Anaesthesia* 2012; 56(4): 376-81.
6. Ruesch S, Walder B, Tramer MR. Complications of central venous catheters: Internal jugular versus subclavian access - A systematic review. *Critical Care Medicine* 2002; 30(2): 454-60.
7. Gladwin MT, Slonim A, Landucci DL. Cannulation of the internal jugular vein: Is post procedural chest radiography always necessary? *Crit Care Med* 1999; 27:1819-23.
8. Collter PE, Blocker SH, Graff DM. Cardiac tamponade from central venous catheters. *Am J Surg*.1998; 176: 212-14.