

## Mechanical Complications of Central Venous Catheters in Pediatric Intensive Care Unit (PICU)

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### ABSTRACT

**Background:** Central venous catheter (CVC) cannulations are associated with complications like arterial puncture, hematoma, pneumothorax and arrhythmias. These complications may be particularly dangerous in paediatric patients.

**Aim of the work:** This was a prospective 6 month study to assess the incidence of mechanical complications to central venous catheters at the pediatric intensive care unit (PICU) of Ain-Shams University Hospital.

**Patients and Methods:** present study was a prospective observational study conducted on 109 patients with a 152 CVCs inserted to them who were admitted to the Pediatric Intensive Care Unit of Ain Shams University Hospital from July to December 2017. They were observed for development of mechanical complications including arterial puncture, failed insertion, bleeding, false passage, pneumothorax, arrhythmia.

**Results:** Among the total studied of 152 CVC cannulations, mechanical complications occurred in 6.6 % of cases. The complications included failed insertion (1.3%), arterial puncture (0.7%), false passage (0.7%), bleeding with hematoma (1.3 %), arrhythmia (1.3 %) and pneumothorax (1.3 %).

**Conclusion:** mechanical complications have a low incidence in our study due to the use of ultrasound guidance during CVC insertion.

**Keywords:** Central venous catheter, Complications, Pediatric intensive care unit.

### INTRODUCTION

Central venous catheters (CVC) are considered as an essential element of patients care in the intensive care unit (ICU)<sup>(1)</sup>. Main indications of CVCs are difficult intravenous peripheral venous access, invasive hemodynamic monitoring through measuring central venous pressure (CVP), administration of irritant drugs, total parenteral nutrition (TPN) intake, long term access for frequent or prolonged use as for chemotherapy and blood sampling<sup>(2,3)</sup>. The incidence of mechanical complications has a wide range, from 5% to 34%<sup>(4)</sup>. The most common mechanical complications are arterial puncture, failed insertion, bleeding with hematoma, Pneumothorax, Arrhythmia<sup>(5,6)</sup>. Common risk factors of mechanical complications are increased number of punctures<sup>(7)</sup>, use of internal jugular vein<sup>(8)</sup>, large catheter size<sup>(9)</sup>. On the contrary the use of ultrasound guidance is associated with fewer mechanical complications<sup>(10)</sup>. So, this prospective study was done to find out the incidence of mechanical complications in PICU.

### PATIENTS AND METHODS

**Study:** This study was a prospective observational study carried out over six months, to detect complications of CVCs inserted to 109 patients including 152 CVCs during the period from July to December 2017 in Ain-Shams University Hospital.

CVC cannulations from three different routes i.e. internal jugular, subclavian and femoral vein in critically ill patients were analyzed.

**Patients:** This study was carried out on 109 patients (including 152 CVCs) admitted in PICU.

**Inclusion criteria:** Patients admitted to PICU and centrally cannulated during their admission as a part of their management.

**Exclusion criteria:** Patients with infective endocarditis.

**We recorded baseline data for each patient and SOFA score was calculated. All CVCs were inserted under guide of ultrasound.**

### Full clinical assessment including

Reason, number, duration and site of CVCs, full clinical examination including vital signs, full cardiac, respiratory, abdominal and neurological examination.

### Calculation of SOFA score (Sequential Organ Failure Assessment Score):

Each organ is graded 0 (normal) to 4 (most abnormal) providing a daily total score of 0 - 24 points as shown in the following table.

**Table (1): SOFA score according to European Society of Intensive Care Medicine:**

SOFA score	0	1	2	3	4
Respiration					
PaO <sub>2</sub> /FIO <sub>2</sub> (mm Hg)	>400	<400	<300	<200	<100
SaO <sub>2</sub> /FIO <sub>2</sub>		221-301	142-224	67-141	<67
Coagulation					
Platelets 103/mm <sup>3</sup>	>150	<150	<100	<50	<50
Liver					
Bilirubin (mg/dL)	<1.2	1.2-1.9	2.0-5.9	6.0-11.9	>12.0
Cardiovascular					
Hypotension	No hypotension	MAP <70	Dopamine ≤5 or dobutamine (any)	Dopamine >5 or norepinephrine ≤0.1	Dopamine >15 or norepinephrine >0.1
CNS					
Glasgow coma score	15	13-14	10-12	6-9	<6
Renal					
Creatinine (mg/dL) or urine output (mL/d)	<1.2	1.2-1.9	2.0-3.4	3.5-4.9 or <500	>5.0 or <200

**SOFA score according to European Society of Intensive Care Medicine** <sup>(11)</sup> *In our study it was* done initially at admission then serial measures at 48 and 96 hrs following CVC insertion.

- Detection and recognition of complications of CVC including :

1. **Failed insertion.**
2. **False passage.**
3. **Bleeding and hematoma.**
4. **Pneumothorax:**

Suspected if acute respiratory distress, hypoxia, diminished air entry at the same site of CVC insertion, hypotension if tamponading and confirmed by urgent chest X- ray.

5. **Arterial puncture**

Suspected if bright red blood rapidly filling the introduced syringe during CVC insertion.

6. **Arrhythmia:**

Marked tachycardia immediately after guidewire introduction detected by HR > 220 b/m in infants or > 180/min in children and confirmed by electrocardiography (ECG).

### Ethical approval

Verbal consents were obtained from parents of all patients.

**The study was approved by Aswan University, Faculty of Medicine.**

The steps of the study the aim of the study, the potential benefit and Hazards were discussed with the patient's parents.

confidentiality of all data was assured.

### Statistical Analysis

Statistical analysis was performed using statistical program for social science "SPSS V21.0, SOFA score: sequential organ failure assessment score

SPSS Inc., Chicago, IL, USA". Continuous data presented as mean  $\pm$  SD or median, while categorical variables as percentages. Categorical and continuous variables were analyzed using chi-square test and Mann Whitney test respectively. P value < 0.05 considered significant and P value < 0.01 considered highly significant.

## RESULTS

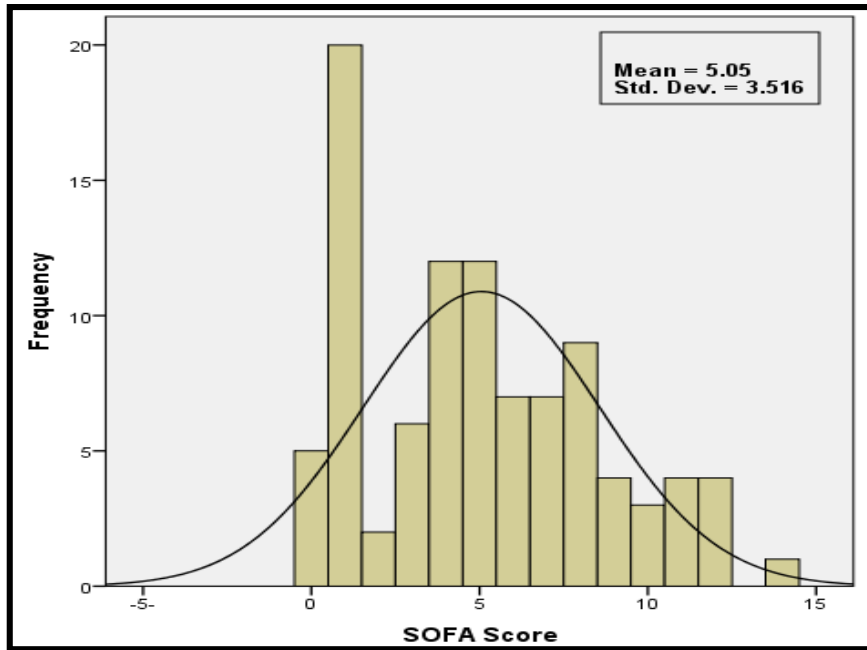
### Descriptive data of the patients assigned to our study

**Table (2): Sociodemographic criteria of the studied cases**

Variable	Category	Results (n=109)
Age in months	Mean $\pm$ SD	30.34 $\pm$ 24.5
	Median (range)	9 (1 - 192)
Sex	Male	65 (61%)
	Female	44(39%)

**Table (3): Clinical score of studied patients according to SOFA score at admission and mortality (n=109):**

Category		Results (n=109)
SOFA score at admission	Mean $\pm$ SD	5.05 $\pm$ 3.5
	Median (range)	5 (0 - 14)
Mortality	Survivors	62 (57%)
	Non-survivors	47 (43%)

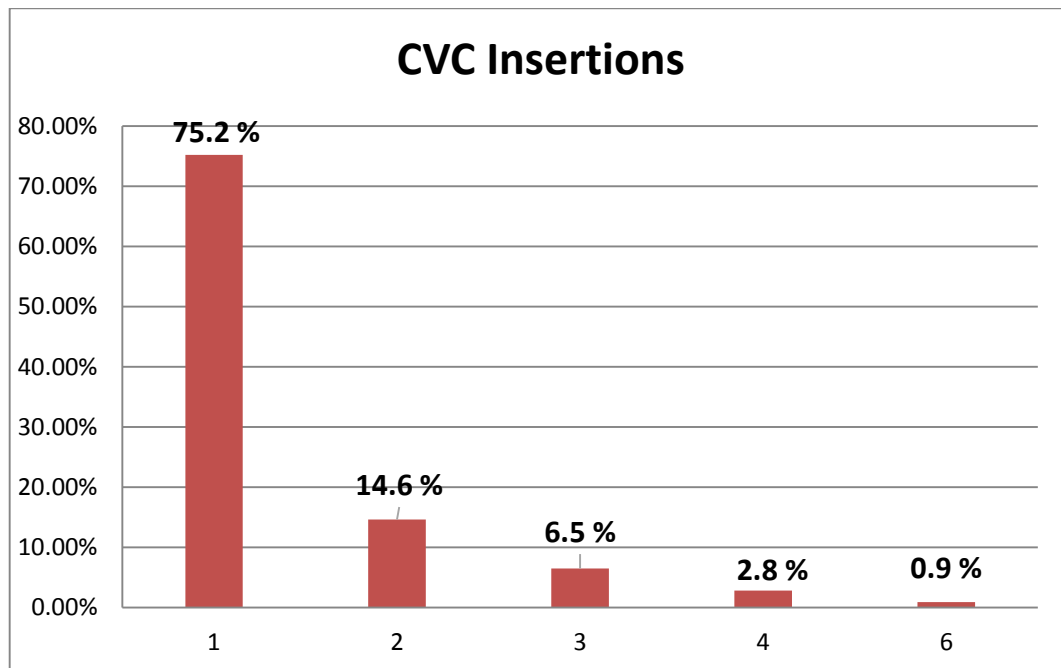


**Fig. (1):** Bar chart showing distribution of the sample according to SOFA Score on

#### Descriptive analysis of the studied CVCs

**Table (4):** Frequency of the studied CVC insertions:

Variable	Category	Number (%)
Number of insertions	1	82 (75.2%)
	2	16 (14.6%)
	3	7 (6.5%)
	4	3 (2.8%)
	6	1 (0.9%)
	Single	82(74.3%)
	Multiple	27 (24.8%)



**Fig. (2):** Bar chart showing frequency of CVC Insertions among the studied sample.

**Table (5):** Sites of insertion of the studied CVCs:

Variable	Category	Results (n=152)	%
Site of insertion	Rt. Internal Jugular Vein	107	70.4 %
	Lt. Internal Jugular Vein	36	23.7 %
	Rt. Femoral	4	2.6 %
	Lt. Femoral	4	2.6 %
	Rt. Subclavian	1	0.7 %

**Table (6):** Reasons for CVC insertion:

Variable	Category	Result (n=152)	%
Reason for CVC insertion	CVP monitoring	49	32%
	Difficult IV access	59	38.6%
	Irritant Drugs	19	12.4%
	TPN	17	11.1%
	Multiple IV Infusion	8	5.9%

CVC: Central Venous Catheters; CVP: Central venous pressure, TPN: total parenteral nutrition, IV: intravenous

**Table (7):** CVC days, total PICU admission days:

Variable	Category	Results (n=152)
Sonar guided	All cases	100%
CVC days	Mean	15.42 ± 13.1
	Median	11 (3 - 83)
PICU days	Mean	19.04 ± 15.5
	Median	12 (3 - 113)
Total CVC days	1557 days	

CVC: Central Venous Catheters; PICU: pediatric intensive care unit

A total number of 152 CVC were inserted using Seldinger technique and all of them were under guide of sonar. The incidence of mechanical complications reached (6.6 %); including bleeding with hematoma formation (1.3%), failed insertion (1.3 %), pneumothorax (1.3 %) and arrhythmia (1.3%), false passage (0.7%) and arterial puncture (0.7).

**Table (8):** Complications of CVC insertion in our study

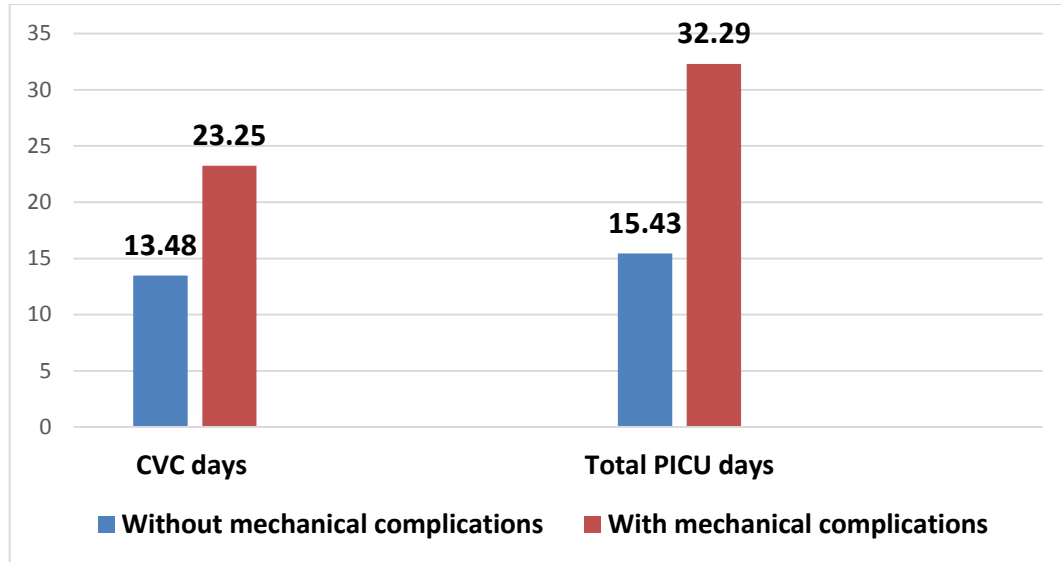
Variable	Number	%
Arterial puncture	1	0.7%
False passage	1	0.7%
Arrhythmia	2	1.3%
Pneumothorax	2	1.3%
Failed insertion	2	1.3%
Bleeding and hematoma	2	1.3%

**Table (9):** Comparison between two subgroups of patients (with and without mechanical complications) as regards CVC duration and total PICU admission days:

Variable		Without mechanical complications	With mechanical complications	P-value
CVC days	Mean ± SD	13.48 ± 12.3	23.25 ± 17.2	0.001
	Median	10 (3 - 57)	18 (3 - 83)	
Total PICU days	Mean ± SD	15.43 ± 13.1	32.29 ± 22.9	0.001
	Median	10 (3 - 80)	26.5 (3 - 113)	

CVC: Central Venous Catheters; PICU: pediatric intensive care unit

A significant statistical relationship was found between CVC days and total PICU admission days with mechanical complications.



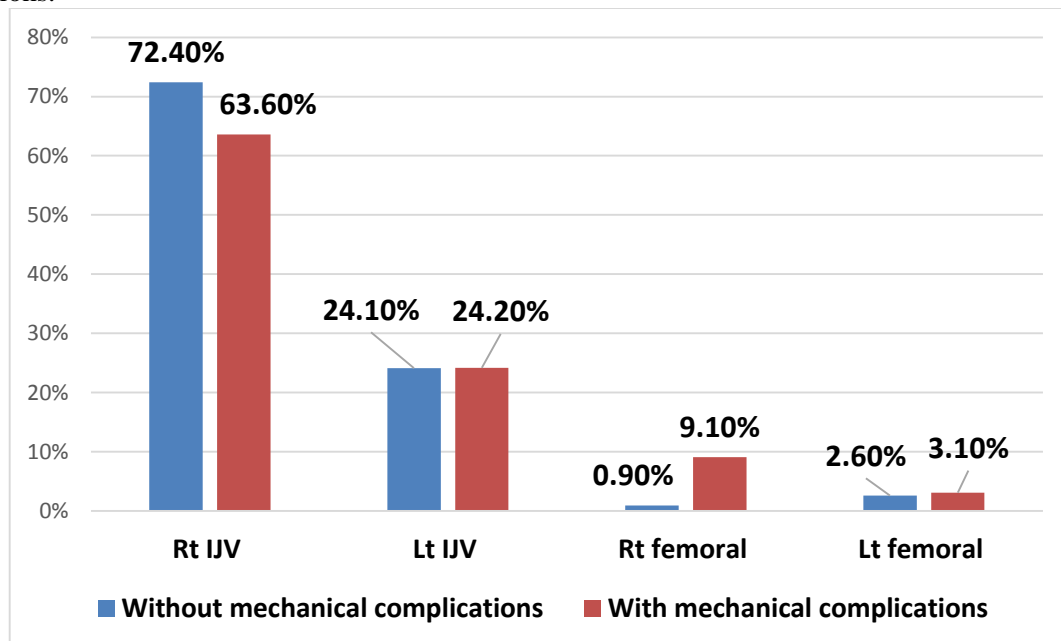
**Fig. (3):** Bar Chart comparing between two subgroups of patients (with and without mechanical complications) as regards CVC duration and total PICU admission days.

**Table (10):** Comparison between two subgroups of patients (with and without mechanical complications) as regards CVC site:

CVC site	Without mechanical complications	With mechanical complications	P-value
Rt IJV	84 (72.4%)	21 (63.6%)	0.05
Lt IJV	28 (24.1%)	8 (24.2%)	
Rt femoral	1 (0.9%)	3 (9.1%)	
Lt femoral	3 (2.6%)	1 (3.1%)	
Rt subclavian	1 (0.9 %)	0(0 %)	

CVC: Central Venous Catheters; IJV: internal jugular vein

No statistically significant relationship was found in our study between site of CVC insertion and mechanical complications.



**Fig. (4):** Bar chart comparing between two subgroups of patients (with and without mechanical complications) as regards CVC site

**Table (11):** Relation between serial SOFA scores during PICU admission with mortality

Variables		Outcome (n=109)		P-value
		Non-survivors (n=43)	Survivors (n=66)	
Serial SOFA score during PICU admission	Mean $\pm$ SD	6.62 $\pm$ 3.1	3.95 $\pm$ 3.4	< 0.001
	Median (range)	6.5 (0 - 14)	4 (0 - 12)	

PICU: pediatric intensive care unit; SOFA score: sequential organ failure assessment score

**SOFA score was considered as a predictor of mortality in our study (P-value = < 0.001).**

## DISCUSSION

A total of 109 patients were enrolled in the present study over a period of 6 months including 152 central venous catheters (CVCs) inserted to them. Patients were enrolled if they required a CVC for 48 hours or longer. The mean age of the patients was  $30.34 \pm 24.5$  months and 61% of them were males while 39% were females. All central venous catheters (CVC) were inserted in PICU. The central vein most commonly used for cannulation was right internal jugular vein up to 107 CVCs (70.4 %), which is comparable with the study of *Karapinar & Cura* who had used femoral vein 45% patients <sup>(12)</sup>. Out of the 109 patients (152 CVCs) the most common indication of CVC was difficult intravenous access (38.6%), followed by CVP monitoring (32%), then administration of irritant drugs (12.4%), administration of TPN (11.1%) and the least common indication was multiple IV infusions (5.9 %).

Incidence of mechanical complications was (6.6 %) which agreed with other studies done that reported an incidence of complications ranging from 5 to 19 % <sup>(1,2,13,14)</sup>.

The mechanical complications included bleeding with hematoma formation (1.3%), failed insertion (1.3 %), pneumothorax (1.3 %) and arrhythmia (1.3%), false passage (0.7%) and arterial puncture (0.7). Compared to results of a study done by *Karapinar & Cura* <sup>(12)</sup> in which arterial puncture (8.9%), malposition (7.3%) , slippage (3.8%), extravasation (3.8%), bleeding (3.3 %) and a study by *Mestrovic et al.* <sup>(15)</sup> in which malposition occurred in 19 %, slippage in 13 %, infection related to CVC in 14 % of cases.

Analysis of data from our patients shows a significant statistical relationship between CVC days and total PICU admission days with mechanical complications (P-value =.001), but there is no statistical relationship between site of CVC and mechanical complications (P-value =.05) consistent with results by *David et al.* <sup>(13)</sup> found that internal

jugular and subclavian venous catheterization carry similar risks of mechanical complications.

**Arterial puncture occurred** at one patient (0.7%), which is considered a lower rate compared to other studies as that report incidences of arterial puncture from 0.9% to 10.6% <sup>(16,17)</sup>, but most of them are around 4% <sup>(4,18)</sup>.

In our study Dynamic Ultrasound used to guide needle placement into the vein and confirm the presence of guide wire in the vein. Recent consensus is that where the technology is affordable it should be used routinely for CVCs. <sup>(19)</sup>.

Cardiac arrhythmias due to guide wire touching the myocardium was uncommon only 2 CVCs (1.3%) and the type of arrhythmia was SVT. The arrhythmia settled on withdrawing the guide wire in one case, but the other case needed medical treatment. The lower incidence in our study could be due to insertion of central lines with ECG monitoring and guide of ultrasonography. Similar results in other studies done by *Almeida et al.* <sup>(20)</sup> in which supra ventricular tachycardia occurred 12 hours following catheter insertion and treated by Synchronized cardioversion. In a study by *Flannery et al.* <sup>(21)</sup> the arrhythmia was sustained ventricular tachycardia with cardiac arrest.

Pneumothorax was detected in 2 patients (1.3%) by chest X-ray after right internal jugular vein cannulation. Both were treated with chest tube under water seal. These results are like other studies with an incidence range of pneumothorax that vary from 1 % to 6.6 % <sup>(9)</sup>.

Other immediate complication during the procedure of insertion was malposition and false passage. In one patient the CVC passes through the right internal jugular vein then to axillary vein. The malposition of CVCs required repositioning before catheter use, but was never associated with any further complications. CVC insertion failed in two patients despite the ultrasonographic guidance, in one patient 5 trials were done in the right internal jugular vein.

SOFA score was done in serial measures; higher SOFA scores were associated with a high risk of mortality in our study.

## CONCLUSION

Mechanical complication rates of CVC insertion in our study was low compared to other studies, which is due to the use of ultrasound guidance in all cases. Increased duration of CVC and prolonged PICU stay were associated with a high risk of mechanical complications.

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