



## Hospital acquired central venous catheter associated bloodstream infection in infants and children

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### ABSTRACT

**Background:** Critically ill children frequently require central lines [central venous catheter (CVC) and artery line). CVCs are used for various reasons such as inotropes, total parenteral nutrition, renal replacement therapies, plasma exchange, blood sampling and invasive monitoring. Despite the many benefits of CVCs, they carry significant risks such as central line associated blood stream infection (CLABSI) and thrombosis. CLABSI is one of the worst types of HAIs, with a mortality rate of 12%-25%. **Aim:** The aim of this study was to determine the incidence of CLABSI, the causative organism, patient's risk factors and their impact on hospital stay length, morbidity and mortality. This will help the healthcare providers for better control of infection in children with conditions necessitating central line catheterization. **Methods:** We enrolled children aged from 1 day to 18 years who were admitted to Mansoura University Children's Hospital, with central lines inserted at hospital, during the period from March 2021 to March 2023. Central and peripheral blood cultures were done for each patient, after 48 hours of central line insertion and repeated whenever infection was suspected. **Results:** A total of 68 children, with CLs inserted in MUCH, their median age 3 years, 57.4% of them were males, 42.6% were females, were evaluated. From those 46 patients developed CLABSI. The study revealed the most common pathogen responsible for development of CLABSI in MUCH is staphylococcus aureus followed by klebsiella and candida. **Conclusion:** Based on the findings of the current study, it can be concluded that CLABSI is common among pediatric especially during infancy. Staphylococcus aureus followed by klebsiella are common pathogens causing CLABSI in MUCH. Jugular site of CVC insertion associated with lower incidence of CLABSI compared to femoral. CLABSI associated with high morbidity and mortality among patients especially those admitted in ICU and NICU.

**Keywords:** nosocomial infection, central venous catheter, central line associated bloodstream infection, pediatric, intensive care unit, blood culture.

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### INTRODUCTION

Hospital-acquired or healthcare associated infections (HAI) are causes of morbidity and mortality in hospitalized patients also they are associated with prolonged hospital stay (1).

Some of the HAIs are bloodstream infections (BSI) [frequently central line-associated bloodstream infection (CLABSI)], nosocomial pneumonia [frequently ventilator associated pneumonia (VAP)], urinary tract infections [frequently catheter-associated urinary tract infection (CAUTI)], and surgical site infections.

Critically ill children frequently require central lines [central venous catheter (CVC) and artery line) (2). CVCs are used for various reasons such as inotropes, total parenteral nutrition, renal replacement therapies, plasma exchange, blood sampling and invasive monitoring (3).

Despite the many benefits of CVCs, they carry significant risks such as CLABSI and thrombosis.

CLABSI is one of the worst types of HAIs, with a mortality rate of 12%-25% (4).

### MATERIALS AND METHODS

We conducted a preliminary prospective, observational study, in Mansoura University Children's Hospital (MUCH), from March 2021 to March 2022.

Infants and children (aged between 1 day and 18 years), with central lines inserted in MUCH were included in this study.

CDC definition of Central line-associated BSI (CLABSI): A laboratory confirmed bloodstream infection where an eligible BSI organism is identified and an eligible central line is present on the LCBI (5).

Eligible Central Line: A CL that has been in place for more than two consecutive calendar days, following the first access of the central line, in an inpatient location, during the current admission.

Such lines are eligible for CLABSI events and remain eligible for CLABSI events until the day after removal from the body or patient discharge, whichever comes first (6).

**Eligible BSI Organism:** Any organism that is eligible for use to meet LCBI (laboratory confirmed blood stream infection) or MBI-LCBI (mucosal barrier injury) criteria. In other words, an organism that is not an excluded pathogen for use in meeting LCBI or MBI-LCBI criteria (6).

**Exclusion criteria:** CVC inserted outside hospital and the initial assessment before CVC insertion denoted presence of blood stream infection according to the results of blood culture, these cases had been excluded

**Laboratory evaluation: Blood culture:** Two blood cultures withdrawn simultaneously; one from the CVC and the other is peripheral percutaneous blood culture, **CBC and CRP**

If results show negative growth, blood cultures have been repeated when there are signs suspecting CLABSI.

CLABSI was suspected if there were the following signs (7).

Fever > 38 or hypothermia < 36, tachycardia, hypotension, poor perfusion, altered mental status or CVC malfunction and confirmed by isolation of the same microorganism from the catheter and concomitant peripheral blood cultures, which are not related to an infection at another site.

**Method of blood culture:** Automated blood culture has been used (bact/alert): Aerobic blood culture bottles have been inoculated with 3 ml blood and usually incubated for 5 days and aliquots of the content sub-cultured overnight on blood agar.

**Ethical considerations:** The study was approved by Institutional Research Board of Faculty of Medicine, Mansoura University. Written informed consent was taken from legal guardians of all

patients before enrollment in the study. All measures were taken to keep data confidentiality of patients. All study participants were free to leave the study at any time without penalty.

**Statistical analysis:** Data were analyzed using the Statistical Package of Social Science (SPSS) program for Windows (Standard version 24). The normality of data was first tested with one-sample Kolmogorov-Smirnov test. Qualitative data were described using number and percent. Continuous variables were presented as mean  $\pm$  SD (standard deviation) for normally distributed data and median (min-max) for non-normal data. The following tests were used; **Chi square test:** Compare qualitative variables. **Monte carlo test:** Compare qualitative variables when expected count less than 5. **Independent t test:** Compare two quantitative variables (parametric).

**Kaplan- Meier test:** used for survival analysis and statistical significance of differences among curves was determined by Log-Rank test.

**Logistic regression:** Significant variables on univariate analysis entered into Logistic regression model using the forward wald statistical technique to predict the most significant determinants and to control for possible interactions and confounding effects. For all above mentioned statistical tests done, the threshold of significance is fixed at 5% level. The results was considered significant when  $p \leq 0.05$ . The smaller the p-value obtained, the more significant are the results.

## RESULTS

This study included 68 patients admitted in Mansoura University Children's Hospital with central lines inserted in hospital, their median age was 3 years ,39 males (57.4%) and 29 (42.6%) were females. The study included 39 (57.4%) patients admitted in ICU and NICU 29(42.6%) patients were admitted in general wards. Table (1)

**Table (1): Demographic data among the studied group:**

Demographic data	The studied group (n=68)
<b>Age (years)</b> <b>Median (Min-Max)</b>	<b>3.0 (0.003-16)</b>
<b>Age categories</b>	
≤ 1y	31 (45.6%)
1-6 y	14 (20.6%)
6-12 y	17 (25.0%)
>12 y	6 (8.8%)
<b>Gender</b>	
Male	39 (57.4%)
Female	29 (42.6%)
<b>Place of admission</b>	
General wards	29 (42.6%)
ICU and NICU	39 (57.4%)

As regard the nature of disease in studied patients in this study, among 68 patients 19 (27.9%) had

neurological diseases, 14(20.6%) were renal patients, 11(16.2%) had respiratory diseases,

7(20.3%) had cardiac diseases, 6(8.85%) patients had immunological diseases, 4(5.9%) patients had gastrointestinal diseases, 3(4.4%) patients had endocrinal diseases, 2 patients (2.9%) with

hematological diseases, one patient had hepatologic disease and one patient with inborn error of metabolism. Table (2)

**Table (2): presenting diseases among the studied group:**

Diseased system	The studied group (n=68)	
	no	%
Neurological disorders	19	27.9
Renal disorders	14	20.6
Respiratory disorders	11	16.2
Cardiac disorders	7	10.3
Immunological disorders	6	8.8
GIT disorders	4	5.9
Endocrinal disorders	3	4.4
Hematological disorders	2	2.9
Hepatological disorders	1	1.5
Metabolic disorders	1	1.5

As regard to the site of CVC insertion internal jugular vein was the most common site 43 patients (63%) followed by femoral veins 12 patients (17%), umbilical veins 7 patients (10%), PICC 5 patients (7.5%) and the least was subclavian vein

one patient (1.5%). This study included 55 patients with non-tunneled (80%), 7 patients with UVC (10%), 5 patients with PICC (7.5%) and one patient with tunneled CVC (1.5%). CVCs durations range from 3 to 40 days with median 18 days. Table (3)

**Table (3): Site and type of CVCs among the studied patients:**

Site and type of CVC	The studied group (n=68)	
	no	%
<b>Site of CVC insertion</b>		
Jugular	43	63.2
Femoral	12	17.6
Subclavian	1	1.5
Umbilical vein	7	10.3
PICC	5	7.4
<b>Type of CVC</b>		
CVC non-tunneled	55	80.9
PICC	5	7.4
UVC	7	10.3
Tunneled	1	1.5
<b>CVC days</b>		
Median (Min-Max)	18 (3-40)	

CLABSI positive cases among studied were 46 patients (67%) while 22 patients (32%) were negative Table (4).

**Table (4): CLABSI among the studied group:**

CLABSI	The studied group (n=68)	
	no	%
<b>CLABSI</b>		
Positive	46	67.6
Negative	22	32.4

As regard the causative microorganism among the CLABSI positive patients, staph aureus was the commonest pathogen 16 patients (34%) followed by klebsiella 12 patients (26%) then candida in 11 patients (23%). Table (5).

**Table (5): Organisms at blood culture among CLABSI positive cases:**

Organism at blood culture	The studied group (n=46)	
	no	%
<b>Bacterial growth</b>	<b>35</b>	<b>76</b>
<b>Staph aureus</b>	<b>16</b>	<b>34.7</b>
<b>Klebseilla</b>	<b>12</b>	<b>26</b>
<b>E.coli</b>	<b>2</b>	<b>4.3</b>
<b>Gram positive diplococci</b>	<b>2</b>	<b>4.3</b>
<b>Pseudomonas</b>	<b>1</b>	<b>2</b>
<b>Proteus</b>	<b>1</b>	<b>2</b>
<b>Serratia</b>	<b>1</b>	<b>2</b>
<b>Fungal growth (candida)</b>	<b>11</b>	<b>23.9</b>

As regard risk factors among CLABSI positive patients; duration of the central line was significant risk factor. Table (6)

**Table (6): Association between CLABSI and CVC site**

	CLABSI		Total cases	Test significance	of	P value
	Positive	Negative				
<b>Site of CVC</b>	27 (62.7%)	16 (37.3%)	43	MC		0.367
<b>Jugular</b>	10 (83.3%)	2 (16.7%)	12			
<b>Femoral</b>	0 (0%)	1 (100%)	1			
<b>Subclavian</b>	5(71%)	2(29%)	7			
<b>Umbilical</b>	4(80%)	1(20%)	5			
<b>PICC</b>						
MC: Monte carlo test						

Femoral site of insertion was associated with higher CLABSI incidence but without significant difference. Table (7)

**Table (7): Association between CLABSI and duration of CVC insertion:**

	CLABSI		Total cases	Test significance	of	P value
	Positive (n=46)	Negative (n=22)				
<b>CVC days</b>			68	$\chi^2=3.63$		0.057
<b>≤18 d</b>	20 (57.1%)	15 (42.9%)	35			
<b>&gt;18 d</b>	26 (78.7%)	7 (21.3%)	33			
$\chi^2$ : Chi square test						

Mortality rate was higher among CLABSI positive cases; 20 patients died, 18 were CLABSI positive (90%) and this was statistically significant. Table (8)

**CLABSI score:** Number of clabsi cases percv days \*1000  $46 \setminus 1259 *1000=36$  per 1000 central line days

**Table (8): Association between CLABSI and outcome:**

	CLABSI		Test significance	of	P value
	Positive (n=46)	Negative (n=22)			
<b>Mortality</b>			$\chi^2=6.47$		0.011*
<b>Survived</b>	28 (60.9%)	20 (90.9%)			
<b>Died</b>	18 (39.1%)	2 (9.1%)			

## DISCUSSION

Critically ill children frequently require central lines [central venous catheter (CVC) and artery line) (2). CVCs are used for various reasons such as inotropes, total parenteral nutrition, renal replacement therapies, plasma exchange, blood sampling and invasive monitoring (3).

Despite the many benefits of CVCs, they carry significant risks such as CLABSI and thrombosis. CLABSI is one of the worst types of HAIs, with a mortality rate of 12%-25% (4).

We conducted a prospective observational study over one year to evaluate the incidence of CLABSI among patients in different wards at MUCH and to determine the risk factors.

This study included 68 patients admitted at Mansoura University Children's Hospital and needed central lines insertion, 39 patients were males (57.4%) and 29 patients were females (42.6%). As regard site of CVC insertion; 43 patients (63%) central lines were inserted in internal jugular veins, 12 patients (17%) central lines were inserted in femoral veins, one patient (1%) had subclavian line, 7 patients (10%) had UVCs and 5 patients with PICC lines (7%).

Among 68 studied patients 46 cases developed CLABSI, the most common organism grew at the blood culture was staph aureus in 16 patients (17.6%) followed by klebsiella in 12 patients (17.6%), candida in 11 patients (16.2%), E.coli in 2 patients (2.9%), gram positive diplococci in 2 patients (2.9%), pseudomonas in one patient (1.5%), proteus in one patient (1.5%), serratia in one patient also (1.5%) and these results matching the study done by Miliaraki et al., that revealed that Most of the bacterial pathogens isolated in CLABSI episodes were Gram positive, including different strains of staphylococci, while Gram-negative bacteria were involved in 30% of episodes. Invasive mycosis was isolated in 7.5% of episodes and this could be due to contamination of central line from the skin (8).

This study revealed that 46 cases were CLABSI positive; 27 patients with jugular CVCs (58%), 10 patients with femoral CVCs (21%), 5 patients with UVCs (10%) and 4 patients with PICCs (8%). The femoral site of insertion was associated with higher incidence of CLABSI; (83.3% of femoral cases, 80% of PICCs, 71% of UVCs and 62.7% of jugular CVCs developed CLABSI) and this is in concordance with the study done by Hafeez et al., which reveal that femoral CVC has higher incidence of CLABSI compared to the internal jugular access (58.3% vs. 41.7%) and this could be attributed to colonization of the central line with organisms from genitourinary and gastrointestinal tracts (9).

As regard CVC duration as a risk factor for development of CLABSI; this study revealed that 68 patients with CVCs with duration ranged from 3 days to 40 days with median 18 days. CLABSI was significantly higher in CVCs lasting more than 18 days 26 patients (78%) of them while 20 patients (57%) were positive CLABSI from patients with CVC duration less than 18 days and this is in concordance with that done by Dahan et al., which revealed that CLABSI was more in central lines lasting more than 7 days (10).

As regard survival 20 patients died and 48 were discharged alive, 18 patients i.e., (90%) of the dead patients were CLABSI positive (i.e. mortality was more among CLABSI positive cases) and this is in concordance with the study done by Hu et al., (11) which revealed more mortality

among CLABSI positive cases (14% of CLABSI positive cases died).

Calculated CLABSI score was 36 per 1000 central line days. This score is in concordance with the study done by Worth et al., (12) which revealed that the rate of CLABSIs in limited-resource countries ranged from 1.6 to 44.6 cases per 1000 CL days and higher than CDC NHSN hospitals in the United States, which report a mean CLABSI rate is of 1.5 cases per 1000 CL days which may be attributed to better hygiene and less crowding in developed countries.

There are some limitations for this study. A single center study, with a relatively small sample size, hence additional extended large-scale studies are required to substantiate the findings of the current study.

## CONCLUSION

Based on the findings of the current study, it can be concluded that CLABSI is common among pediatric especially during infancy. Staphylococcus aureus followed by klebsiella are common pathogens causing CLABSI in MUCH. Jugular site of CVC insertion associated with lower incidence of CLABSI compared to femoral. CLABSI associated with high morbidity and mortality among patients specially those admitted in ICU and NICU.

## LIST OF ABBREVIATIONS

CBC: Complete blood count

CLABSI: Central line associated bloodstream infection.

CRP: C reactive protein.

CVC: Central venous catheter.

HAI: Health care associated infection.

MUCH: Mansoura University Children's Hospital

NICU: Neonatal intensive care unit.

PICC: Peripherally inserted central line.

PICU: Pediatric intensive care unit

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