

Central Venous Catheter related Complications in Pediatric Intensive Care Unit (PICU)

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Abstract

The objective of this study was to evaluate the use of central venous catheters (CVCs) in the Pediatric intensive care unit (PICU) of Sohag University Hospital. We reviewed the records of all children that had CVCs and were hospitalized between 1st of January 2016 to the end of December 2016. Patients were evaluated with respect to their age, gender, catheter type, indication for CVC insertion, site and side of the body of CVC insertion. The duration of catheter use and eventual complications were also taken into consideration. A total of 115 CVCs were inserted in 100 children. Patient age ranged from 1 month to 16 years. The average catheter insertion time was 12 days. We noted 80 (80%) CVC-related complications. Complications related to CVCs insertion were infection(40%),occlusion(10%),local edema(8%),hematoma(5%), pneumothorax(4%),catheter displacement(4%),hemothorax(4%),thrombosis(3%),air embolism(2%) were complications associated with length of CVCs use. We conclude that central venous catheterization is a safe and efficient procedure with many complications in pediatric patients.

Key words: central venous catheter, indications, complications, children.

INTRODUCTION

Central venous catheters (CVCs) have now become indispensable in intensive care units. Insertion of CVC is amongst the most frequently performed invasive procedures⁽¹⁾. In severely ill and long-stay patients, inserted CVCs enable relatively safe and painless application of parenteral nutrition, long-term antibiotics, chemotherapy, intravenous fluids and blood components and is also used for repetitive blood sampling. Furthermore, CVCs are used for invasive hemodynamic monitoring, hemodialysis, and plasmapheresis and in case of shortage of a peripheral access. CVCs intended for children are made of a variety of materials, including silicone, polyurethane, polyvinyl chloride and polyethylene⁽²⁾. Access to a vessel can be gained via percutaneous puncture or with use of open surgical techniques. Seldinger percutaneous technique is the most frequently used. CVCs are inserted via the Subclavian vein, internal and external jugular veins or umbilical vein in newborns. The tip of the catheter can be placed into the

right atrium, superior or high inferior vena cava.⁽³⁾

Aim of the work

The aim of this study is to give an overview about frequency of application, complications of central venous catheters (CVCs) in pediatric intensive care unit (PICU) at Sohag university hospital.

Patients and Methods

This study was a prospective observational study conducted for one year in Pediatric Intensive Care Unit (PICU) of Sohag University Hospital, a tertiary health center which provide specialized care to critically ill infants and children with about 400 admissions yearly. All studied will be subjected to the following:

Full clinical history with special interest to:

- Time of onset of disease.
- Presenting symptoms as respiratory distress, cyanosis or disturbed conscious level, etc.

Clinical examination: include the following:

- General examination (general look, cyanosis, convulsions, or dehydration).
- Vital signs (pulse, respiratory rate, blood

pressure,temperature).

•Chest examination,cardiac examination,abdominal ,neurological and others.

The procedures were performed in aseptic conditions with continuous monitoring of patients electrocardiogram, heart rate and oxygen saturation. An appropriate catheter was chosen on the basis of the size of the patient. Polyurethane catheters were most commonly used, three-lumen catheters were used predominantly .

We do Sedation of the patient with midazolam . Patients were adequately positioned for the procedure. The site of catheter insertion was cleaned with chlorhexidin in 70% isopropyl alcohol. Standard sterile technique including the use of sterile gloves, gown, mask and cap was used in all cases. Catheters were inserted percutaneously following the Seldinger technique. The preferred site was internal jugular vein (IJV). After the catheter was inserted, blood flow was checked and the lumen was flushed with normal saline. Catheters were sutured and covered with dressing. The catheters were maintained by heparin flushes of 10 units/ml. After CVC insertion, chest X-ray was obtained to confirm the tip was positioned above the pericardium, and to identify any complications . Two to three hours following catheter insertion, a patients electrocardiogram, heart rate and oxygen saturation were monitored. Catheter blood flow and insertion site were checked and maintained daily.

Laboratory investigations, including:complete blood picture (WBCs,RBCs,platlet,toxic granulation,reticulocyte ,etc), c- reactive protein, blood culture , arterial blood gases, prothrombin and partial thromboplastin time, INR,liver functions, and kidney functions.

Imaging:chest x-ray looking for site of CVC. All patients were followed-up daily, and the central venous insertion site was examined for purulence or soiling. If an exit

All CVCs were placed by a specialized team of pediatric intensivists and nurses skilled in intensive care procedures and were carried out at the bedside

site infection was suspected, exit site swabs were sent for microbiological analysis. If catheter tip colonization/infection or catheter-related bloodstream infection (CRBSI) were suspected, the CVC was removed and the tip of the catheter along with two sets of blood was sent for culture analysis. Follow up of the patients after discharge for 6months at out patient clinic was done;all discharged patient improved with time with no sequelae.

2. Study size and sampling

2.1 Study population

Our study was conducted on 100 critically ill children admitted to PICU .

2.2 Patient selection

Inclusion criteria: About 100 critically ill patients aged from one month to 16 years admitted to medical PICU at sohag university hospital needing insertion of CVC for various reasons during the study period.

Exclusion criteria:

Patients with complications not related to CV catheters as infections at 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. N.B Presence of any of exclusion criteria will exclude the babies from the study.

3. Ethical consideration

Approval of Sohag faculty of medicine research ethics committee was obtained and informed consent from the parents was obtained.

4.Statistical analysis:

A. descriptive statistics which included:

Demographic characteristics, indications for admission to PICU, clinical features of studied critically ill patients in PICU, duration of admission and outcome of studied critically ill patients in PICU, prevalence, frequency and indications of CVCs insertion and complications of studied

critically ill patients in PICU.

B. Overall incidence: Incidence of complications CVCs insertion in critically ill children.

Data was analyzed using STATA intercooled version 12.1. Quantitative data was represented as mean, standard deviation, median and range. Data was analyzed using student t-test to compare means of two groups. When the data was not normally

D. Significance level: P value was considered significant if it was less than (0.05).

E. Programs used and versions distributed Mann-Whitney test was used. Qualitative data was presented as number and percentage and compared using either Chi square test or fisher exact test. Graphs were produced by using Excel or STATA program

STUDY RESULTS

This prospective case control study carried out at Sohag University Hospital during the period from 1st of January 2016 to the end of December 2016 at the pediatric intensive care unit (PICU). Average catheter placement time 12 days . A total of 100 patients aged from 1 month to 16 years with the mean age 22 month, 48 males and 52 females enrolled in this study. A total of 115 CVCs inserted in 100 patient (1 catheter in 83 patient, 2 catheters in 15 patients, 3 catheters in 2 patient), 98% of CVCs had been introduced blindly, 2% with ultrasonographic guided(US) , 96% of CVCs introduced in internal jugular vein (IJV), 4% in femoral vein. patients aged from 1 month to 12 month (57%) and this is the most age group admitted in PICU , (30%) of patients aged from 1 to 4years , (9%) of patients aged from 4 to 8 years , (4%) of patients aged from 12 to 16years. patients admitted to PICU by neurological disease(64%), (16%) by respiratory disease, (14%) by GIT disease, (4%) by cardiovascular disease , (2%) by renal disease. There are(63%) of patients had been received I.V therapy longer than 14 days, (22%) due to lack of peripheral I.V access,(9%) due to parenteral nutrition , (6%) due to hemodialysis. There are complications developed from CVC placement where (40%)of cases admitted to PICU had positive infection which is the main complication occurred , followed by occlusion (10%) , local edema (8%), hematoma(5%), pneumothorax (4%), catheter displacement (4%), hemathorax(4%), thrombosis (3%) ,air embolism(2%). There is a relation between indication of admission to PICU and occurrence of complications where 53% of complications occurred in patients with neurological problems, 9% of complications occurred in patients with GIT problems, 8% occurred in patients with respiratory problems, 4% occurred in patients with cardiac indication of admission, 1% occurred in renal patients while 25% of patients had no complications, P value 0.036 which is significant. 96 patients had been introduced CVC in IJV, so most of the complications occur with it, 4 cases only had been introduced CVCs in femoral vein as no experience on this type, three of them have DVT (Thrombosis). (27%) of patients admitted to PICU are positive CRBI, (8%) are positive exit site infection, while (5%) are positive for tip catheter colonization.

Figure (1) Age group

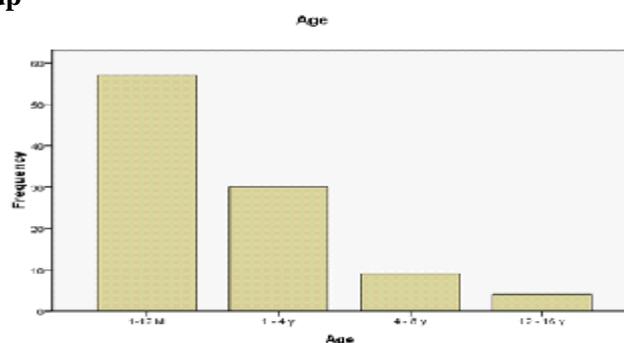


Table (1): Indication of admission to PICU

	Number of patients	Percent
Cardiac	4	4.0
Respiratory	16	16.0
Neurological	64	64.0
GIT	14	14.0
Renal	2	2.0
Total	100	100.00

Table (2): Indication of CVC placement

	Number of patients	Percent
Lack of peripheral i.v Access	22	22.0
Parenteral nutrition	9	9.0
i.v therapy longer than 14 day	63	63.0
Hemodialysis	6	6.0
Total	100	100.0

Table (3): Complications of CVCs

	Frequency	Percent
Pneumothorax	4	4
Infection	40	40.0
Thrombosis	3	3.0
Displacement	4	4.0
Air embolism	2	2.0
Hemothorax	4	4.0
Hematoma	5	5.0
Occlusion	10	10.0
Local edema	8	8.0
Total	80	80.0
No complications	20	20.0
Total	100	100.0

Table (4): Indication of admission Complication relationship

indication of admission	Complications		Total
	YES	NO	
Cardiac	4	0	4
Respiratory	8	8	16
Neurological			
GIT	53	11	64
Renal	9	5	14
Total	75	25	100

Table (5): Infection

	Frequency	Percent
CRBSI	27	27.0
Catheter tip infection	5	5.0
Exit site infection	8	8.0
Total	40	40.0

Discussion

Complications associated with CVCs had a major impact on the hospital course of patients admitted to the PICU due to the morbidity, mortality, and increased healthcare costs associated with them, our complication rate is within the limits of published data (Kaur et al., 2012).⁽⁴⁾ The present study had been performed at the pediatric intensive care unit (PICU) of Sohag university hospital through the period from 1st of January 2016 to the end of December 2016 .it included 100 patients at the age category from 1 month to 16 years , with median age 22 month.

In our study 52 female and 48 male with female predominance. The aim of this work was to study the frequency of application, complications of central venous catheters (CVCs) in children at Sohag university hospital along one year.

In this study, there was female predominance among total cases which had been inserted CVCs. These results in contradictory,as (Ayse et al., 2011) in Turkey,49 patients(44.5%) female and 61(55.5%) male with male predominance. A total of 115 CVCs inserted in 100 patient (1 catheter in 83 patient, 2 catheters in 15 patients, 3 catheters in 2 patient). This findings were in agreement with recent study, as (Ayse et al., 2011) in Turkey, a total of 128 catheters were inserted in 110 patients with median age 21 month.⁽⁵⁾

In our study infants (1 month to 12 months) were the biggest age group that needed CVC insertion (57%), and this was different from a study done by (Julije et al., 2006) ;where newborns were the biggest age group included. Our study the mostly indicated reasons for

CVCs insertion were Intravenous therapy more than 14 days (63%), lack of peripheral venous access(22%), parenteral nutrition (9%), lastly hemodialysis (6%).

These results in agreement, as a study done by (Julije et al., 2006) , as the commonest indication for CVC insertion Intravenous therapy more than 14 days (28.4%) but insertion due to parenteral nutrition was the 2nd common cause(21.6%) ,then invasive hemodynamic monitoring the 3rd common cause(18.5%), then prematurity,then blood exchange and lastly dialysis;because this study extended to the newborns which were excluded in our study.⁽⁶⁾

In our study, the internal jugular vein (IJV) was the preferred place for insertion of CVC (96%), while (4%) in femoral vein where the intervention is considered to be risky, Femoral catheters were inserted by the responsible specialist of the Pediatric Intensive Care Unit, and training only limited on jugular catheterization. These results are contradictory with a study done by, (Julije et al., 2006) ⁽⁶⁾ ,where left subclavian vein (101% catheters, 28.7%) was the most common site for CVC insertion,then umbilical vessels,then right femoral vein,then left femoral vein, followed by right subclavian vein, followed by right internal jugular vein, lastly left internal jugular vein.

In other study as, (Ayse et al., 2011) ⁽⁵⁾ ; Femoral catheter was inserted in (68.8%) of patients, subclavian catheter was inserted in (28.9%) of patients and jugular catheter was inserted in (2.3%) of patients.

In our study the most indicated cause for admission to PICU was neurologic disease (64%) of patients (53%) of them developed

complications , (16%) of patients with respiratory diseases (8%) of them developed complications ,(14%) of patients with GIT diseases (9%)developed complications,(4%) of cases with cardiac diseases ;all developed complications,lastly (2%) with renal problems (1%) which developed complications .This was different from study done by (Ayse et al., 2011)⁽⁵⁾ ; in which sepsis (30%) was the most common diagnosis at admission to PICU, followed by lung disease (27.3%),then trauma the 3rd common (11%), then neurologic disease (8.2%),cardiovascular disease (4.5%), Gastro intestinal disease (2.7%). In our study, 65 of the catheters (56.5%) were removed because the requirement was eliminated, 17 catheters (14.7%) were removed because complications developed.These results correlate with astudy done by (Ayse et al., 2011)⁽⁵⁾ ; 73 of the catheters (57%) were removed because the requirement was eliminated, 13 catheters (10.1%) were removed because complications developed.

Sepsis and thrombosis among these complications require removal of the catheter (Sheridan ,et.al., 2006).⁽⁷⁾

Hospital-acquired infection is a serious problem in the intensive care unit (ICU), the susceptibility of patients in the ICU, combined with the risk factors associated with the invasive treatments and monitoring that they may be receiving, and the ICU environment itself, contribute to the increased risk of infection in this patient group (Curtis, 2009).⁽⁸⁾

The incidence of infectious complications in our study (40%); Catheter-related bloodstream infection(CRBSI) was found with arate 27%. This rate ranges between 3.7% and 40% in the literature because of use of different definition criteria (Venkataraman et al., 1997)⁽⁹⁾ ,exit site infection (8%),catheter tip colonization (5%). The most serious, among all notified complications, was CRBI, no catheter

became infected during the first 48 hours after insertion.These results consistent with astudy done by (Ashita et al., 2016)⁽¹⁰⁾ ;in which exit site infection was (7%), catheter tip colonization was (3%), but CRBSI was (2%) which is lower than our result and this due to complete sterile-barrier precautions were followed for all CVC insertions. In our study other complications included occlusion (10%) the 2nd complication, local edma (8%), pneumothorax,hemothorax and catheter dislodgment (4%) each of them, thrombosis (3%).These results in agreement to some extent to astudy done by (Julije et al., 2006)⁽⁶⁾ ; malposition was the common 19 patient (5, 4%), followed by occlusion 15 patients (4, 3%) Occlusion of the CVCs was one of the most frequent complications (Thiagarajan et al., 1997)⁽¹¹⁾ , but within the expected range of (0% - 7%) ,then CRBI 14 patient (4,0%), dislodgment 13 patients (3, 7%), Pneumothorax 3 patients (0, 9%).

In our study the largest percentage of CVC had been introduced blindly (98%) as the doctors well trained on this and the facility of ultrasonography had been introduced 4 months after the start of the research.These results were different from a study done by (Jijeh et al., 2014)⁽¹²⁾ ;Ultrasound is even more advantageous when cannulating central veins in pediatric patients due to their smaller size. They showed a success rate of 100% in patients who received central line placement with ultrasound guidance, while the landmark group showed only 77% success rate. An added benefit of the ultrasound group was that there were no punctures to the carotid artery when cannulating the IJV, while the group without ultrasound had carotid artery puncture in 25% of attempts. For these reasons, use of ultrasound is strongly indicated for central venous catheterization of pediatric patients (Jijeh et al.,2014)⁽¹²⁾ . A study performed with critically ill children showed that catheterization via direct puncture was associated with the highest CVC-associated bloodstream infection rate. The deep

puncture technique can result in serious complications, so this technology must be performed by experienced professionals results showed that the most frequent insertion complications were: catheter related blood stream infection, catheter occlusion, occurrence of hematoma, pneumothorax, hemothorax, catheter displacement, and thrombosis in femoral central lines.

The incidence of infection in IJV group can be attributed to its proximity to the oral cavity where the presence of oral secretions can result in infection at this site. They also concluded that infection in the jugular access remains under investigation. It is probably due to two factors: Proximity to the oral cavity, and higher density of the local bacterial flora due to the high local temperature and difficulty of keeping occlusive bandages. The limitation of all studies is that they were carried out in the ICU setting, with sicker patients with fever, some of them on ventilatory support with an endotracheal tube or tracheostomy and difficulty to clear oral secretions. The high incidence of CRBIs in our patients is probably due to bad managing of CVCs. It was found that the duration of the catheter use was critical for the occurrence of infections.

When catheters are in place for extended periods, the catheter probably plays a major role in providing access for microorganism to the blood-stream by migrating endoluminally (**Salzman et al.,1995**).⁽¹⁴⁾

All other complications that occurred in our study presented minor problems with no influence on morbidity. Pneumothorax can be a serious complications, other serious complications occurred include hemothorax, thrombosis and embolism. We noticed that almost all patients in our study with femoral CVC (3 Patients) have thrombosis(DVT) which are symptomatic, therefore ultrasonographic follow up should be done regularly with those patients (**Kim, 2001**)⁽¹⁵⁾. All of our catheter related thrombosis cases were observed after the

(**Paiva et al., 2006**).⁽¹³⁾

In our study of children hospitalized in a PICU,

first week. No other risk factor was found in our patients in whom thrombosis developed. Doppler ultrasonography was performed only in symptomatic patients. The rate of thrombosis related to femoral catheter is reported to be higher compared to the rate of thrombosis related to internal jugular catheterization (**Sheridan et al., 2006**).⁽⁷⁾

These results consistent with a study done by (**Ayse et al., 2011**)⁽⁵⁾, all of the six cases of thrombosis occurred in patients in whom femoral catheter was inserted. As the dwelling time of femoral catheter increases, the risk of thrombosis increases. Therefore, it should be specifically emphasized that femoral vein should be preferred for short-term catheterizations (**Karapnar et al.,2007**)⁽¹⁶⁾. Some authors reported that ultrasonographic examination performed two time a week to monitor thrombosis in femoral catheterization lasting more than 5 days would be an efficient method for prevention of development of complication (**Shefler et al.,199**)⁽¹⁷⁾. pneumothorax and hemothorax occurred in low rate 4% ,but needed intervention significantly.

Therefore, we can conclude that percutaneous central venous catheterization can be recommended as a safe and efficient procedure with minimal complications in pediatric patients. However, the emphasis should be on strict adherence to existing guidelines when CVCs are inserted, and during subsequent care for CVCs (**Koletzko et al., 2005**)⁽¹⁸⁾. Risk factors for the development of catheter-related infections included an immune compromised state, duration of the catheter in situ, femoral venous cannulation, and triple lumen catheters. Choice of venous cannulation to minimize the risk of catheter-related infection in ascending order for risk of infection is the jugular vein, and the femoral vein. There was no role for empirical antibiotic therapy to prevent intravascular

catheter-related local or systemic infections. Although handling CVCs is a routine activity in pediatric ICUs, it requires specific attention and rigorous compliance to preventive measures designed to avoid pathogenesis and assure quality care and patient safety. Based on discussions regarding information related to the reasons for removing the CVCs, it is possible to conclude that there is a need for several interventions, modifications, and standardization of health care practices that are aimed at reducing mechanical and infectious complication rates in neonatal and pediatric ICUs. This goal represents a great challenge for all health professionals involved in hospital care practices. The choice of catheter type in relation to the number of lumens must consider the need and the condition of the child, the quantity of drugs prescribed, and the indications for TPN (Mesiano et al.,2007)⁽¹⁹⁾. Several studies affirm that the greater the number of lumens, the higher the risk of infectious complications associated with the CVC due to the frequent manipulations of the connections and infusion lines. This risk factor for infectious complications was also observed in this study; only the triple-lumen catheter was removed due to the occurrence of CVC-associated clinical sepsis (Ogrady et.al., 2002)⁽²⁰⁾. When selecting the insertion site, professionals must evaluate the patients age, diagnosis, condition of the blood vessels, previous venous accesses, and therapy type and time with an endotracheal tube or tracheostomy and difficulty to clear oral secretions (Arajo et.al.,2007)⁽²¹⁾. Therefore we can conclude that percutaneous central venous catheterization can be recommended as a safe and efficient procedure with minimal complications in pediatric patients. However, the emphasis should be on strict adherence to existing guidelines when CVCs are inserted, and during subsequent care for CVCs(Koletzko et.al.,2005)⁽¹⁸⁾.

Conclusion:

In our study the most common complication

of CVCs was infection(40%) this high incidence attributed to proximity of jugular access to the oral cavity and the high density of the local bacterial flora due to the high local temperature and difficulty of keeping occlusive bandages and bad managing of CVCs. Complications occurred more with age group from 1 month to 12 months (61.2%), then with age group from 1 year to 4 years (23.8%). All the observations were statistically analyzed, and following results were drawn:

The total incidence of infectious complications was 40%, and the The internal jugular route was associated with higher incidence of infectious complications. The incidence of infection was found to be statistically significant.

This critical analysis of central venous catheterization processes included a thorough review of standard care practices to improve the care provided to pediatric patients who were hospitalized in ICUs of the Sohag university hospital. The study results showed that many CVCs were removed due to mechanical and infectious complications. The technological advancements that support the survival of critically ill children have paradoxically created conditions that predispose hospital infection, which increase morbidity and mortality. The high rates of CVC-related bloodstream infection rates underscore the need to implement stronger institutional policies aimed at preventing and controlling hospital infections to improve health care quality and the safety of children inpatients. The CVC is a fundamental technology that supports the survival of newborns and children in critical condition in ICUs. However, these devices also carry the risk of complications, demanding both constant surveillance and specific care from the professionals involved to reduce the high rates of morbidity and mortality caused by treatment interruption and the frequent infections associated with CVC use.

Appropriate CVC use is a highly complex process that demands specific knowledge

and continuous training of health teams regarding its insertion, handling and removal, and preventive measures to address complications resulting from inadequate practice.

The results of this study will allow the medical and nursing staff to reflect critically on the practice of intravenous therapy with the goal of reducing hospital costs, incorporating new technologies, and considering the cost-benefit relationship to guarantee patient safety and achieve excellence in care delivery.

Recommendations:

1.CVC use needs continuous training by health teams regarding its insertion, handling and removal, and preventive measures.

2.We should compare the cost-benefit relationship in the use of central intravascular devices.

3.Many CVCs should be removed due to mechanical and infectious complications.

4.The high incidence of CVC related bloodstream infections need a strong institutional policies aimed at preventing and controlling hospital infections .

5.We should emphasize on improving health care quality and the safety of children inpatients specifically critically ill patients admitted to PICU.

6.We should put in our mind the risk-benefit ratio in use of CVCs.

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