

Central venous catheterization in pediatric and neonatal intensive care units*

O PROCESSO DO CATETERISMO VENOSO CENTRAL EM UNIDADE DE TERAPIA INTENSIVA NEONATAL E PEDIÁTRICA

EL PROCESO DEL CATETERISMO VENOSO CENTRAL EN UNIDAD DE CUIDADOS INTENSIVOS NEONATAL Y PEDIÁTRICA

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ABSTRACT

This descriptive, prospective cohort study aimed to analyze the process of central venous catheterization in neonatal intensive care and pediatric units; describe the variables related to study characterization, including admission unit, age, and sex; and to investigate related variables, such as catheter type, reason for insertion, number of lumens, insertion site, type of professional who performed the procedure, medication therapy infused, reason for withdrawal, length of time catheter was in situ, and mechanical and infectious complications. Data collection was performed with 82 charts in the intensive care units (ICUs) of the Instituto Fernandes Figueira. In the majority of cases, the indications for catheter insertion were prolonged drug infusion and total parenteral nutrition. Removal was predominantly required due to mechanical and infectious complications. This study assessed the process of central venous catheterization with the aim of improving care provided to the neonatal and pediatric patients.

DESCRIPTORS

Catheterization, central venous
Intensive Care Units
Infant, newborn
Child
Neonatal nursing
Pediatric nursing

RESUMO

Estudo descritivo, longitudinal e abordagem quantitativa, que objetivou analisar e discutir o processo do cateterismo venoso central nas Unidades de Terapia Intensiva neonatal e pediátrica; descrever as variáveis relacionadas à caracterização da população do estudo (unidade de internação, faixa etária e sexo) e descrever as variáveis relacionadas ao processo do cateterismo venoso central (tipo de cateter, motivo de indicação, número de lumens, sítio de inserção, profissional que realizou o procedimento, terapêutica medicamentosa infundida via cateter, motivo de retirada, tempo de permanência e as complicações mecânicas e infecciosas). A coleta de dados foi realizada em unidade de terapia intensiva neonatal e pediátrica, em 82 prontuários. As indicações dos cateteres foram, em sua maioria, para infusão medicamentosa prolongada e Nutrição Parenteral Total. A remoção foi indicada predominantemente por complicações mecânicas e infecciosas. Esse estudo viabilizou rever a prática assistencial para estabelecer o aprimoramento da assistência prestada à clientela neonatal e pediátrica.

DESCRIPTORIOS

Cateterismo venoso central
Unidades de Terapia Intensiva
Recém-nascido
Criança
Enfermagem neonatal
Enfermagem pediátrica

RESUMEN

Estudio descriptivo, longitudinal y con enfoque cuantitativo, que tuvo por objetivo analizar y discutir el proceso del cateterismo venoso central en las Unidades de Cuidados Intensivos neonatal y pediátrica; describir las variables relacionadas a la caracterización de la población del estudio (unidad de hospitalización, grupo etáreo y sexo) y describir las variables relacionadas al proceso del cateterismo venoso central (tipo de catéter, motivo de indicación, número de lúmenes, sitio de inserción, profesional que realizó el procedimiento, terapéutica medicamentosa infundida vía catéter, motivo de retirada, tiempo de permanencia y las complicaciones mecánicas e infecciosas). La recolección de los datos se realizó en la unidad de cuidados intensivos neonatal y pediátrica, en 82 historias clínicas. Las indicaciones de los catéteres fueron, en su mayoría, para infusión medicamentosa prolongada y Nutrición Parenteral Total. Se indicó la retirada, principalmente, por complicaciones mecánicas e infecciosas. Este estudio permitió revisar la práctica asistencial para establecer la mejora de la atención prestada a la clientela neonatal y pediátrica.

DESCRIPTORIOS

Cateterismo venoso central
Unidades de Cuidados Intensivos
Recién nacido
Niño
Enfermería neonatal
Enfermería pediátrica

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INTRODUCTION

In light of new technological advances, there has been a shift in the profile of hospitalized children that requires nursing professionals in neonatal and pediatric areas to deliver more complex care and invasive procedures to support their survival.

Among the technological advances observed in this health area, central venous catheterization stands out. This treatment demands a high level of technical knowledge from nurses regarding its handling and maintenance to avoid complications and provide quality care, and it can ultimately contribute to decreasing the length of stay and hospital costs.

Central venous catheterization is the introduction of a catheter in the vascular system with access to the central circulatory system. Central venous catheters (CVC) are indicated for fluid infusion, repletion of water and electrolytes, blood transfusions and draws, with its extremity located in the superior or inferior vena cava. CVCs are classified as short term, which are umbilical venous catheters (UVCs), CVCs inserted via femoral, internal jugular and subclavian vein approaches, and those inserted through venous dissection (VD); or long-term catheters, such as peripherally inserted CVCs (PICC), semi-inserted catheters (Broviac and Hickman), and completely inserted catheters⁽¹⁾.

In neonatal intensive care units (NICUs), UVCs are recommended for newborns during the first days of life, as the insertion is relatively simple and carries a low risk of related complications⁽²⁾.

PICCs are commonly used in critically ill newborns and children who require safe and long-term venous access (>6 days)⁽³⁾.

CVC insertion by direct vein puncture (CVCP) offers long-term venous access and is often indicated for children as a way to monitor central venous pressure, chemotherapy, parental nutrition, long-term antibiotic therapy, exchange transfusion, plasmapheresis, hemodialysis, and blood draws. The most common puncture sites to insert these catheters are the subclavian, internal jugular, and femoral veins⁽⁴⁾.

Some CVCs are surgically inserted, such as by VD, and therefore pose a greater risk of infection compared to other types of catheters⁽⁵⁾. Semi-inserted and totally inserted catheters reach central vessels (subclavian, jugular, femoral) and are surgically inserted. These devices have some type of mechanism to avoid extraluminal bacterial colonization⁽⁶⁾.

In this study, central venous catheterization is considered to be a process, rather than a procedure centered only in the moment of device insertion. This view is much

broader, as professionals who deal with the process stages must perform a clinical evaluation at the moment the child is admitted into the intensive care unit (ICU), regarding the correct indication of the device and considering individual clinical characteristics; this is in addition to the systematized assessments throughout catheter dwell time aimed at avoiding or minimizing complications resulting from inappropriate practices of the health care staff.

Scientific and technological advances in health care requires professionals in this area to constantly update their knowledge, particularly in regards to the proper and safe use of technology⁽⁷⁾. Moreover, when professionals who deal with the central venous catheterization process have the necessary knowledge regarding insertion, maintenance, and prevention of complications related to the use of intravascular devices, they become responsible for the success of this process by becoming aware of the predictable and attributable consequences of their own actions or omissions in caring for fragile and vulnerable children.

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Assuring patient safety is fundamental to quality nursing and health care. On one hand health, care interventions aim at improving the care provided, while on the other hand, the combination of processes, technologies, and human resources related to the health care offered may become risk factors for errors and adverse effects⁽⁸⁾.

Because neonatal and pediatric ICUs admit children with serious clinical conditions who need intensive care and prolonged intravenous therapy, there was an interest in determining, through scientific research, which CVCs are used in neonatal and pediatric patients, as well as detailing the related factors that interfere in the maintenance of these catheters. Such knowledge is important, as these devices are frequently present in our professional practice and contribute to the survival of these children, as well as the emergence of CVC-associated complications that affect the quality of the care provided.

The objective of the present study was to analyze and discuss the process of central venous catheterization in pediatric and neonatal ICUs, describe the variables related to the characterization of the study population (hospital unit, age range, and gender), and describe the variables related to the process of central venous catheterization such as catheter type, reason for insertion, number of lumens, insertion site, type of professional who performed the procedure, drug therapy infused through the catheter, reason for removal, dwell time, and mechanical and infectious complications.

METHOD

This was a descriptive, prospective cohort study, with longitudinal outlining and quantitative approach. The study

design was developed at the Fernandes Figueira National Institute for Women's, Children's and Adolescents' Health (IFF) of the Oswaldo Cruz Foundation (FIOCRUZ), a technical-scientific unit aimed at the development of research, teaching, care, technological development, and increased quality in the maternal-child area, in addition to being a center for scientific-technological qualification.

Data collection was prospectively performed on 82 medical records of newborns and children requiring central venous catheterization who were hospitalized in the surgical neonatal intensive care unit (SNICU), non-surgical NICU, or pediatric intensive care unit (PICU) of the mentioned institution between February 1 and July 31, 2009. The ICU was chosen because it is an area of high complexity that requires technological resources and specialized professionals to support the survival of children in critical condition who are in need prolonged intravenous therapy, with the CVC being the most commonly used device in these units.

The study included the medical records of children who had undergone the process of central venous catheterization in the SNICU, NICU, or PICU, whose catheter had been inserted between February 1 and July 30, 2009, with the processes being monitored until July 31 of that year to obtain the conclusion variables. We excluded the medical records of children with CVCs who had been transferred to another hospital, due to the impossibility of acquiring the study variable values.

During this period, 130 instances of central venous catheterization were identified and monitored through 82 medical records. Data were collected utilizing a data collection instrument for study variable registration.

The information obtained from medical records and registered in the instrument of data collection was recorded by the author and processed through the program Epi Info 3.5.1. Descriptive data analysis was performed, and the results are presented in tables, with the categorical variables described by absolute and relative frequencies and the continuous variables described by means, medians, modes, and maximum and minimum values. The study data were categorized and statistically analyzed, conforming to the specific literature.

Considering the ethical aspects of research involving human beings with the use of medical record data, a Term of Liability of Data Use was used, guaranteeing to the institution the appropriate disclosure of the collected data and patient privacy^(9, 10). The study was approved by the Committee of Ethics in Research of the Fernandes Figueira National Institute for Women's, Children's and Adolescents' Health of the Oswaldo Cruz Foundation (IFF/FIOCRUZ), under protocol No. 0046/08.

RESULTS

The study was developed at the Fernandes Figueira National Institute for Women's, Children's and Adolescents'

Health (IFF/FIOCRUZ), through the analysis of 82 medical records of children who had undergone the process of central venous catheterization in the study period, totaling 85 hospitalizations (three children were hospitalized more than once).

Subject characteristics are listed in Table 1 and show that there was a prevalence in the insertion of CVCs in the NICU (40%), in newborns (61%), and in male children (58.5%).

Table 1 – Characterization of the children undergoing the process of central venous catheterization in the ICUs. IFF/FIOCRUZ – Rio de Janeiro, RJ – 2009.

Characterization of the subjects	N=85	(%)
Hospitalization unit		
NICU	34	(40.0)
PICU	29	(34.1)
SNICU	22	(25.9)
Age range		
Newborn	50	(61.0)
Infant	24	(29.2)
Preschooler	4	(4.9)
School-aged child	4	(4.9)
Gender		
Male	48	(58.5)
Female	34	(41.5)

The types of CVC used were PICC, CVCP, VD, and UVC. Data in Table 2 show that in the NICU there was a high prevalence of PICC use (54.2%), being the device of first choice or used following UVC.

Table 2 – Distribution of CVC types inserted by hospitalization unit. IFF/FIOCRUZ – Rio de Janeiro – 2009.

Hospitalization Unit	Types of Central Venous Catheters				Total n (%)
	UVC n (%)	PICC n (%)	CVCP n (%)	VD n (%)	
NICU	14 (29.2)	26 (54.2)	–	8 (16.8)	48 (100.0)
PICU	–	1 (2.3)	38 (88.4)	4 (9.3)	43 (100.0)
SNICU	–	32 (82.1)	–	7 (17.9)	39 (100.0)
Total	14 (10.8)	59 (45.4)	38 (29.2)	19 (14.6)	130 (100.0)

In the SNICU, there were no UVCs inserted due to the impossibility of this procedure in newborns with abdominal malformations, such as gastroschisis and umbilical hernia. The most commonly used catheter in this surgical unit was the PICC (82.1%). Conversely, the PICC catheter was rarely

used (2.3%) in the PICU in relation to other venous catheter types, with a prevalence of CVC insertion via direct puncture (88.4%). On the other hand, the catheter surgically inserted through VD was used in all units.

Regarding the professional who performed the procedure, there was a prevalence of nurses (22.3%) obtaining vascular access. As for CVCP, there was a prevalence of insertion procedures performed by medical residents undergoing training. Only 13.2% of catheters were inserted by intensive care doctors, and 5.3% by surgeons and surgical residents. VDs were mainly performed by surgeons and surgical residents (47.9%).

There were one or more reasons for the insertion of CVCs in the studied children. There was a prevalence of prolonged drug infusion (PDI), as well as infusion of total parenteral nutrition (TPN) in 40.8% of cases.

Data in Table 3 show that single-lumen CVCs were the most common types of catheters inserted (63.8%), followed by double lumens (35.4%) and triple lumens (0.8%).

Table 3 – Distribution of lumen number by CVC type. IFF/FIOCRUZ – Rio de Janeiro, RJ – 2009.

No. lumens	CVC Type				Total N (%)
	CVU N (%)	PICC N (%)	CVCP N (%)	DV N (%)	
Single	14 (100.0)	58 (98.3)	–	11 (57.9)	83 (63.8)
Double	–	1 (1.7)	37 (97.4)	8 (42.1)	46 (35.4)
Triple	–	–	1 (2.6)	–	1 (0.8)
Total	14 (100.0)	59 (100.0)	38 (100.0)	19 (100.0)	130 (100.0)

The most common insertion site for the PICC was the basilic vein (39.0%), followed by the cephalic vein (20.3%). CVCPs were typically inserted in the femoral (52.6%) and jugular veins (44.7%).

There was prevalence of infusion of venous hydration in combination with antibiotics (37.2%), and the PICC was the most commonly used catheter for this therapeutic procedure (66.1%). Significant UVC use was observed for the infusion of venous hydration and antibiotics (42.9%). However, other infusions were also observed, such as amines and sedation.

The average dwell time of the UVC was 5 days, whereas the PICC and the CVCP were used for an average of 12 days, and the DV for 10 days (Table 4).

Data in Table 5 show that CVC removal was indicated, predominantly, by mechanical and infectious complications (47.7%). Among the types of CVCs, the UVC was not usually removed because it was no longer necessary; rather, it was generally replaced by the PICC for the continuation of the intravenous therapeutics (14.3%).

Table 4 – Distribution of the dwell time (days) by CVC type. IFF/FIOCRUZ – Rio de Janeiro, RJ – 2009

CVC Type	CVC indwelling time (days)				
	Minimum	Mean	Median	Mode	Maximum
PICC	0	12	12	7	29
VD	2	10	11	4	25
CVCP	2	12	12	11	23
UVC	0	5	5	5	11

Table 5 – Distribution of the reasons for removal by CVC type. IFF/FIOCRUZ – Rio de Janeiro, RJ – 2009.

Reason for removal	CVC Type				Total n (%)
	UVC n (%)	PICC n (%)	CVCP n (%)	VD n (%)	
Mechanical and infectious complications	3 (21.4)	30 (50.8)	19 (50.0)	10 (52.7)	62 (47.7)
End of therapy	2 (14.3)	21 (35.6)	13 (34.2)	5 (26.3)	41 (31.5)
Death*	1 (7.1) ⁺	7 (11.9) ⁺	3 (7.9) ⁺	4 (21.1) ⁺	15 (11.5) ⁺
Others	8 (57.1)	1 (1.7)	3 (7.9)	–	12 (9.2)
Total	14 (100.0)	59 (100.0)	38 (100.0)	19 (100.0)	130 (100.0)

*Deaths were not considered to be due to catheter-related complications.

⁺Absolute and relative frequencies represent the deaths of children who were using a CVC and were not considered to have a catheter-related complication.

Regarding patient deaths, it is possible to observe a greater incidence in children with VD (21.1%), which reflects the greater severity of their condition.

Among the mechanical complications occurring in catheters in this study, there was a considerable rate of obstruction (36.0%). Regarding the UVC, 66.7% were removed because there was no free flow of blood, which is a necessity for the execution of exchange transfusion. The second reason was solution leakage that may have occurred either due to fracture of the catheter or due to faulty connections of the equipment, which undermines the therapeutic and positive clinical response of the child, who lacks appropriate medication infusion.

Nevertheless, Table 5 shows that PICCs (35.6%) and CVCPs (34.2%) were removed due to the conclusion of therapeutics at a higher rate than VD. The most frequent infectious complications noted in this study were CVC-associated clinical sepsis (40.0%) and fungal sepsis (33.3%).

The CVCs analyzed in this study were also removed for other reasons, such as the catheter replacement (n=9) and the presence of other catheters (n=3). UVC removal occurred most often due to the insertion of another type of CVC (88.9%), with PICC being the second choice in eight cases.

DISCUSSION

In the NICU, there was a prevalence of CVC insertions in premature newborns. These patients require prolonged intravenous therapy, including the infusion of hypertonic solutions and total parenteral nutrition, and CVCs can safely administer these agents with the aims of saving and prolonging life and assuring the growth and development of these vulnerable patients with underdeveloped organs and systems⁽¹¹⁾.

Both in the NICU and in the SNICU, there was a preference for VD over the CVC inserted via direct puncture. A study performed with critically ill newborns showed that catheterization via direct puncture was associated with the highest CVC-associated bloodstream infection rate⁽⁵⁾.

The deep puncture technique can result in serious complications, so this technology must be performed by experienced professionals. In a study of children hospitalized in a PICU, results showed that the most frequent insertion complications were: catheter misplacement, arterial puncture and pneumothorax⁽¹²⁾.

One of the factors that affect the incidence of complications is the prior experience of the healthcare professional performing the procedure. That incidence is inversely related to the frequency of complications secondary to CVC insertion⁽¹³⁾.

PICC catheters are used on a large scale in ICUs and fall under the responsibility of the nurses. Therefore, nurses are increasingly becoming qualified to carry out this duty⁽¹⁴⁾.

In neonatal and pediatric ICUs, children are admitted with serious clinical conditions and are in need of immediate and long-term interventions, such as TPN infusion, fluid and electrolyte replacement, and antibiotic therapy⁽¹⁵⁾.

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⁽¹⁶⁾. 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⁽¹⁾. 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.

When selecting the insertion site, professionals must evaluate the patient's age, diagnosis, condition of the blood vessels, previous venous accesses, and therapy type and time⁽³⁾. In this study, the most often used PICC insertion sites were the basilic or cephalic veins, which is similar to what has been reported in the literature⁽³⁾.

Regarding CVCP, most were inserted in the femoral or internal jugular veins. The choice of catheter insertion site depends on factors such as accessibility and catheter

size (caliber). Health care professionals must consider the comfort, safety, and specific factors affecting each child, for instance: pre-existing catheters, anatomy deformities and bleeding, and the risk of complications⁽¹⁾.

Adverse events related to the use of central intravascular devices are frequent among the neonatal and pediatric populations; therefore, it is essential to evaluate those events in order to indicate the aspects of care that could be improved so as to provide safer care⁽¹⁷⁾.

This study identified that catheter obstruction was the main mechanical complication. Some measures that the team professionals must adopt to prevent this complication include: not infusing blood and blood products in catheters with a caliber smaller than 3.8 fr, not administering incompatible drugs simultaneously, performing a saline flush after the infusion of blood products and drugs; and maintaining a continuous flow of intravenous infusion⁽³⁾.

Despite the technological advances in the fields of neonatal and pediatric care, health care-related infections are considered to be a global challenge due to the variability of diagnostic and therapeutic procedures. Furthermore, they are partly responsible for the significant increases of morbidity, mortality, and hospital costs, causing great concern for health service administrators⁽¹⁸⁻¹⁹⁾.

Infectious complications can occur due to intrinsic and extrinsic factors. This study shows that extrinsic factors may contribute to the reduction of infection rates, considering that UVCs do not present infectious complications, probably because of the short length of time these catheters are in situ (5 days on average).

According to the data obtained in this study, catheters inserted through deep venous puncture were associated with the highest rates of infectious complications. It is important to highlight that the complications resulting from the use of CVCs increase the length of stay in the hospital unit and, consequently, the cost of hospitalization.

Our data verify that the mean dwell time of the PICC was similar to that of the CVCP (12 days) and higher than that of the VD (10 days). However, the proportion of the number of catheters inserted in the study period and the number of infectious complications reveal a higher infection rate in catheters inserted through deep venous puncture (34.2%), followed by VD (26.3%), in comparison to the PICC (18.6%).

Although handling CVCs is a routine activity in neonatal and pediatric ICUs, it requires specific attention and rigorous compliance to preventive measures designed to avoid iatrogenesis 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.

CONCLUSION

This critical analysis of central venous catheterization processes included a thorough review of standard care practices to improve the care provided to neonatal and pediatric patients who were hospitalized in ICUs of the Fernandes Figueira National Institute for Women's, Children's and Adolescents' Health (IFF) for intravenous therapy. It also allowed a review of the indications for central intravascular devices, the cost-benefit relationship in the execution of care and the choice of technological resources, and the development of new studies aimed at improving the quality of care and guaranteeing patient safety.

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.

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