

Risk factors for bloodstream infection associated with peripherally inserted central catheters in neonates

Fatores de risco para infecção de corrente sanguínea associada ao cateter central de inserção periférica em neonatos

Priscila Costa¹

Eny Dórea Paiva²

Amélia Fumiko Kimura¹

Talita Elci de Castro³

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Corresponding author

Priscila Costa
Doutor Enéas de Carvalho Aguiar
Avenue, 419, 05403-000,
São Paulo, SP, Brazil.
priscila2.costa@usp.br

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Abstract

Objective: To identify the risk factors for bloodstream infection associated with peripherally inserted central catheters in neonates.

Methods: A prospective cohort study conducted in the neonatal intensive care unit with newborns undergoing insertion of 401 peripherally inserted central catheters. Clinical characteristics of the newborn, catheter insertion technique, intravenous therapy and catheter dwell time were tested as risk factors for removal due to catheter associated bloodstream infection, using bivariate analysis and multivariate analysis with Poisson regression.

Results: The data suggest that the lowest mean in weight and corrected gestational age, as well as the largest catheter dwell time were associated with the occurrence of bloodstream infection associated with the catheters. The corrected gestational age, clinical diagnosis of transitional metabolic disorder or apnea, and the use of two-lumen catheters have been identified as risk factors.

Conclusion: The lowest correct gestational age of the newborn, the clinical diagnosis of metabolic disorder or apnea, and the use of two-lumen catheters were identified as risk factors for bloodstream infection associated with peripherally inserted central catheters in neonates.

Resumo

Objetivo: Identificar os fatores de risco para infecção de corrente sanguínea associada ao cateter central de inserção periférica em neonatos.

Métodos: Estudo de coorte prospectivo conduzido em unidade de terapia intensiva com recém-nascidos submetidos à instalação de 401 cateteres centrais de inserção periférica. Características clínicas do neonato, técnica de inserção do cateter, terapia intravenosa e tempo de permanência do cateter foram testados como fatores de risco para remoção por infecção de corrente sanguínea associada ao cateter, por meio de análise bivariada e análise multivariada com regressão de Poisson.

Resultados: Os dados sugerem que as menores médias de peso e idade gestacional corrigida, bem como o maior tempo de permanência do cateter estiveram associados à ocorrência de infecção de corrente sanguínea associada ao cateter. A menor idade gestacional corrigida, os diagnósticos clínicos de transtorno transitório do metabolismo e apneia, e o uso do cateter de duas vias foram identificados como fatores de risco.

Conclusão: A menor idade gestacional corrigida do neonato, os diagnósticos clínicos de transtorno transitório do metabolismo e apneia, e o uso do cateter de duas vias foram identificados como fatores de risco para infecção de corrente sanguínea associada ao cateter central de inserção periférica em neonatos.

¹Escola Paulista de Enfermagem, Universidade Federal de São Paulo, São Paulo, SP, Brazil.

²Escola de Enfermagem, Universidade Federal Fluminense, Niterói, Rio de Janeiro, RJ, Brazil.

³Hospital e Maternidade São Luiz, São Paulo, SP, Brazil.

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Introduction

The peripherally inserted central catheter (PICC) is a widely used option for central venous access in newborns admitted to a neonatal intensive care unit (NICU). It is a vascular device inserted at the bedside using aseptic technique, through a peripheral vein in the arm, leg, cephalic or cervical region, by a physician or qualified nurse. These catheters have a diameter between 1.9 and 3Fr for neonates, are single or double-lumen, made of polyurethane or silicone.⁽¹⁾

The PICC is indicated for intermittent or continuous infusion of intravenous solutions, for short or long term, with vesicant and irritant characteristics, pH <5 or > 9, and solutions with osmolality higher than 600mOsm/L.⁽²⁾ However, this use is not without risk. Mechanical and infectious complications occur in 13 - 50.7% of newborns using the device, such as: obstruction, phlebitis, thrombosis, rupture, extravasation, and bloodstream infection.^(3,4)

One of the most frequent complications is a bloodstream infection associated with the catheter, generating costs and suffering for the newborn and his family, as well as a significant increase in morbidity and mortality in infants in NICUs. The incidence of this complication is highly variable, ranging from 1.2 to 24.8%, due to the different concepts and terminologies adopted by authors.^(5,6) This discrepancy highlights the need to identify risk factors for this complication, so that efforts directed at these possible causes can be implemented, in order to reduce the incidence of preventable complications.

Some risk factors for bloodstream infection associated or related to the PICC in newborns have been identified, such as: insertion through the femoral veins, insertion in infants weighing <2500 g, catheter repair and catheterization with a duration >30 days.^(7,8) However, the role of potential risk factors such as the clinical diagnoses of the neonate, type of catheter, intravenous therapy that indicated its insertion, still requires investigation in this vulnerable population.

This study aimed to identify the risk factors for bloodstream infection associated with peripherally inserted central catheter in neonates.

Methods

This was a cohort study with prospective data collection conducted from August 31, 2010 to August 30, 2012. The cohort consisted of neonates undergoing PICC insertion during hospitalization in the NICU of a private hospital in São Paulo (SP).

Participants were monitored beginning at the time of insertion until the moment of catheter removal. They were followed in the direction from “exposure” to the “outcome”, which was not present at the beginning of the study. Data were obtained by consulting patient records and interviewing hospital professionals responsible for neonatal care. Reading the hospital records allowed access to the notes, records and prescription of the medical and nursing staff, as well as the results of laboratory tests. Losses of information were minimized by interviews for clarification performed by researchers with the health professionals during data collection.

A convenience sample was used in this study. The inclusion criteria for the population were: infants born in the obstetrical unit of the same hospital, successfully undergoing PICC insertion, no other type of central venous access, no diagnosis of coagulopathy or congenital anomalies related to the loss of skin integrity, and without injury at the catheter insertion site. Exclusion criteria were: absence of patient records regarding the study variables, catheter removal due to death or transfer of the newborn, or removal due to complications such as obstruction, disruption, infiltration, leakage, accidental removal, limb edema, phlebitis, or cardiac tamponade.

Considering the management of the peripherally inserted central catheter, the institution complies with the guidelines of the institutional protocol developed by nurses of the study group on venous catheters, based on the recommendations of the Regional Nursing Council of São Paulo and the Federal Council.^(9,10)

An appropriate form, developed by the researchers, was used for data collection, according to the research problem, literature review, and

availability of information in hospital records. The variables studied were: clinical diagnosis using the International Classification of Diseases (ICD-10) 10th edition, sex, postnatal age, gestational age, weight at the time of the procedure, type of catheter used (1,9Fr silicone single lumen, or 2,0Fr polyurethane double-lumen), insertion site (insertion vein and segment), catheter indication (quantity and type of intravenous solution), duration of PICC, date and reason for removal. Polytherapy was defined when a catheter for two or more intravenous solutions was indicated. Because the identification of the reason for removal of the device is a medical assignment, the medical record was checked daily. Elective removal of the PICC was considered when infusion therapy was terminated, or compatible solutions with peripheral administration were prescribed. The definition from *Centers for Disease Control and Prevention* (CDC) was adopted for the outcome, which considers bloodstream infection associated with the catheter as the presence of bloodstream infection confirmed by laboratory tests in newborns using a PICC for at least 48 hours.⁽¹¹⁾

The collected data were double-entered into a Microsoft Excel for Windows 2003 worksheet and analyzed using Stata 11.1 software. Descriptive statistics were performed for continuous variables, using means and standard deviations. For categorical variables, distribution of absolute and relative frequencies was performed. The incidence of bloodstream infection was calculated by dividing the number of subjects who developed infection by the total number of catheters eligible for the study, expressed as a percentage. The incidence rate of infection was calculated by dividing the number of individuals who developed an infection during the studied period by the total number of individuals during that period, expressed in catheter days. The bivariate analysis was conducted to identify the variables associated with the outcome of bloodstream infection associated with the catheter. The Student t-test was used for continuous variables, and the Chi square test or Fisher's exact for categorical

variables, in addition to the calculation of relative risk, using a 95% confidence interval. The multivariate data analysis was conducted using the Poisson multiple regression analysis, to predict the response variable from a combination of explanatory variables, which should be non-negative and a count data, considering the total number of individuals with the disease or condition in a specific period of time.⁽¹²⁾ For the analysis, a significance level of 5% was adopted.

The study was registered in Brazil under the Platform Presentation of Certificate number to Ethics Assessment - *Certificado de Apresentação para Apreciação Ética* (CAAE) 0019.0.220.000-10.

Results

During the data collection period, 553 PICCs were successfully inserted in the NICU, and data for 401 PICCs inserted in 383 newborns were analyzed, as shown in figure 1. Some newborns used more than one catheter during their period of hospitalization in the NICU, but not at the same time. Among all

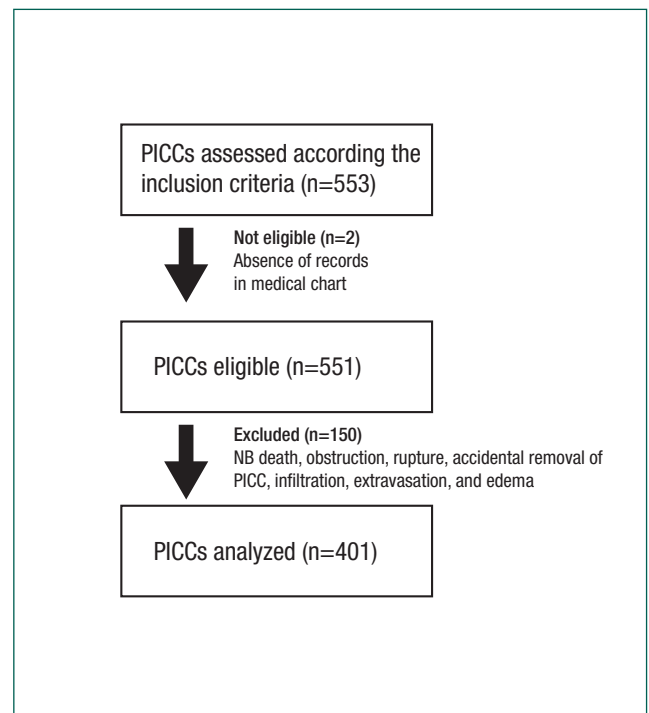


Figure 1. Flow chart of the peripherally inserted central catheters that met the study's eligibility criteria. PICC - peripherally inserted central catheter; NB- newborn

the catheters, 329 (82%) were electively removed; 72 (18%) were removed for bloodstream infection associated with the catheter.

The incidence of bloodstream infection associated with PICCs in this study was 13.1%, and the incidence of this complication rate was 11.5/1,000/catheter days.

The population characteristics showed a predominance of male newborns (54.9%), appropriate for gestational age (71.3%), with a postnatal age of 7.6 days of age (standard deviation: ±16.6 days), and mean weight of 1781.5g (standard deviation: ±0.8737 g). The most frequent clinical diagnoses were prematurity (85%), respiratory distress (71.3%), and multiple births (24.7%), because the same neonate can present more than one clinical diagnosis.

With regard to the catheter insertion procedure, the mean number of venous puncture attempts required to insert the catheter was 2.6 (1.76 ± standard deviation). Regarding the insertion site, 263

(65.6%) catheters were inserted in the right hemisphere of the body. Veins used were: 104 (25.9%) axillary, 83 (20.7%) basilic, 59 (14.7%) cephalic, 47 (11.7%) saphenous, 34 (8.5%) median cubital, 28 (7%) external jugular, 13 (3.2%) dorsal hand, 9 (2.2%) temporal, 5 (1.2%) popliteal, 5 (1.2%) posterior auricular, 1 (0.2%) dorsal *venous* arch of the foot; this information was not available for 13 (3.2%) insertions. The two-lumen PICC made of polyurethane was the most widely used, in 54.7% of the insertions. Infusion of two or more intravenous solutions (polytherapy) was indicated in a majority of the PICCs (81.5%). The most frequent types of intravenous solutions were antimicrobials (74.1%), parenteral nutrition (68.3%), and fluid therapy (35.4%). The mean duration of PICCs was 12.5 days (standard deviation: ± 8.2 days).

In the bivariate analysis (Tables 1 and 2), the numeric variables (weight on the date of catheter insertion, corrected gestational age, and duration of PICC), and categorical variables (clinical diagnosis, type of catheter, intravenous therapy that indicated the catheter insertion) were analyzed according to the relationship with the occurrence of bloodstream infection associated with the catheter.

The data suggest that the smallest mean weight and corrected gestational age, as well as longer PICC dwell time, were associated with the occurrence of the bloodstream infection associated with the catheter.

Table 1. Distribution of potential risk factors related to weight, gestational age of the newborn and the duration of the catheter for bloodstream infection associated with the peripherally inserted central catheter in neonates

Potential risk factors	With infection	Without infection	p-value
	Mean (standard deviation)		
Weight (grams)	1314.92 (±680)	1880.51(±769)	<0.01
Gestational age (days)	31.52 (±3.7)	33.8(±3.7)	<0.01
Catheter dwell time (days)	16.3 (±8.2)	11.7(±8.2)	<0.001

Table 2. Distribution of potential risk factors related to the clinical diagnosis of neonate, type of catheter and intravenous therapy for bloodstream infection associated with the peripherally inserted central catheter in neonates

Potential risk factors	With infection n(%)	Without infection n(%)	Relative risk (95% CI)	p-value
Clinical diagnosis				
Prematurity	66(91.7)	274(83.5)	1.9(0.8-4.2)	0.08
Sepsis	23(32)	55(16.8)	1.9(1.2-2.9)	0.004
Heart disease	19(26.4)	36(11.1)	2.2(1.4-3.5)	<0.001
Shock	4(5.6)	5(1.5)	2.5(1.2-5.4)	0.03
Transitional metabolic disorder	15(20.8)	15(4.6)	3.2(2.1-4.9)	<0.001
Apnea	10(13.9)	15(4.6)	2.4(1.4-4.1)	0.003
Type of catheter				
Dual lumen catheter	59(27.3)	157(72.7)	3.7(2.1-6.5)	<0.001
Intravenous therapy				
Polytherapy	63(87.5)	234(80.2)	1.6(0.8-3.04)	0.16
Parenteral nutrition	61(84.7)	213(64.7)	2.6(1.4-4.7)	<0.001
Antimicrobials	60(83.3)	237(72)	1.7(0.9-3.1)	0.04
Fluid replacement or maintenance	19(26.4)	123(37.4%)	0.6(0.4-1.1)	0.07

The clinical diagnoses that demonstrated relationship with the occurrence of bloodstream infection associated with PICCs included: sepsis (early-onset or late-onset), heart disease (patent ductus arteriosus, patent foramen ovale, atrial septal defect, and ventricular septal defect), shock (cardiogenic, hypovolemic or septic), transient metabolic disorders (hypoglycemia, hyperglycemia, disorders involving calcium, magnesium, sodium and potassium), apnea, indication of catheter for parenteral nutrition infusion or antimicrobials.

However, some variables identified as risk factors in the bivariate analysis can be considered confounding variables for the outcome, such as the diagnosis of sepsis and the catheter dwell time. All the variables with statistical significance and which were not collinear with each other were introduced in a multivariate analysis model (Table 3).

Table 3. Poisson regression model with the risk factors for bloodstream infection associated with the peripherally inserted central catheter in neonates

Risk factors	Relative risk (RR)	CI 95%	p-value
Corrected gestational age	1.12	1.061-1.186	0.002
Transient metabolic disorders	3.02	1.727-5.054	0.000
Apnea	2.38	1.105-4.564	0.016
Dual-lumen polyurethane catheter	3.70	2.0-6.954	0.000

The multivariate analysis using the Poisson regression model showed that the lowest corrected gestational age (mean of 31.5 weeks), the diagnoses of transient metabolic disorder and apnea, and the use of a dual-lumen catheter were associated with catheter removal due to bloodstream infection associated with the PICC.

Discussion

Although this study analyzed a cohort of neonates undergoing insertion of 401 PICCs, some limitations must be considered. It was a single center

study, conducted in a private hospital in the city of São Paulo. The results indicate the practices of health professionals of that institution during the data collection period, as well as the newborn profile, which can compromise the generalization of data for other populations.

Since the etiology of infection of the bloodstream is multifactorial, it is relevant to understand the insertion practices, maintenance and removal of PICCs in the institution where the data were collected. The insertion of the catheter in neonates is a mutual decision between a neonatal nurse and physician. To make a decision, factors such as type of prescribed intravenous therapy, venous network, and skin integrity at the probable catheter insertion site, complete blood count, platelet count and clinical conditions of the neonate were considered. The insertion of this device is a procedure that requires participation of two professional nurses, a physician order, and aseptic technique. At the institution where the study was conducted, the neonate's skin preparation for catheter insertion and change of dressings depends upon the weight of the newborn. In newborns weighing < 1500 grams, chlorhexidine cleansing is used, followed by a 0.9% saline solution to remove excess antiseptic. For newborns weighing >1500 grams, chlorhexidine-alcohol followed by 0.9% saline solution is used. The professionals must properly wash their hands, use a sterile apron, cap, surgical mask, and sterile gloves. Following insertion, the location of the tip of the catheter is verified by the physician by means of anteroposterior chest x-rays, and the catheter is approved or not approved for use.

For catheter fixation, a sterile adhesive suture and transparent film is used for occlusion, which allows viewing of the site where the catheter is inserted, in addition to serving as a barrier for microorganisms. The adoption of meticulous aseptic technique with maximum barrier is recommended, including use of cap, mask, sterile gloves, aprons and surgical fields, skin disinfection with chlorhexidine-alcohol concentration higher than 0.5% on insertion and dressing changes. However, no recommendation regarding the effectiveness no recommendation as to the effectiveness and safety

of the antiseptic can be made for children younger than two months of age.⁽¹³⁾

The maintenance of the catheter consists of continuously evaluating its necessity, catheter patency and integrity, presence of exudate or bleeding, occurrence of complications, and positioning of the catheter tip in the inferior vena cava or higher, confirmed by radiological imaging. Aspects related to the proper functioning of the catheter are recorded in the patient's chart, which is mandatory for all nursing professionals who handle the catheter. The dressing of the insertion site of catheter is changed in cases of detachment and excessive bleeding or dirt.

The use of gloves and disinfection of connections with a chlorhexidine-alcohol solution or 70% alcohol swab are procedures adopted for handling the PICC. Catheter patency is indicated with a flush of 0.9% saline solution before and after infusion of any intravenous medications. For newborns without a continuous intravenous solution prescription, the patency of the PICC is assessed every six hours, through a flush of 0.5 to 1 ml of 0.9% saline solution, with a 10 ml or larger syringe. The use of extenders and connectors with a closed system has been implemented in the institution since 2007.

To understand the factors involved in the occurrence of bloodstream infection associated with the PICC in neonates, it is necessary to comprehend that newborns in the NICU, especially those who are premature, have an increased risk for infection, since they are continuously exposed to invasive procedures, such as venous puncture and mechanical ventilation, and are handled excessively.⁽¹⁴⁾ In addition, other factors related to health professionals' practices influence the occurrence of bloodstream infections associated with the catheter. These factors involve the manipulation of the catheter and its connections, contamination of the intravenous solutions to be infused, and colonization of the catheter due to the migration of microorganisms on the skin around the catheter insertion site to inside the body.⁽²⁾

In relation to the incidence and the incidence rate of bloodstream infection associated with PICCs, lower results were found in a multicenter

study conducted in neonatal units, which assessed 4797 PICCs inserted in 3967 infants. The results revealed a 3.1% incidence of bloodstream infections associated with catheters, corresponding to 1.66/1,000 catheters/day.⁽¹⁵⁾

The comparison of this finding is delicate due to the diversity of concepts and terminology used in the literature for referring to infection. A term used frequently is bloodstream infection related to the catheter. However, this definition requires the removal of the catheter and processing of specific laboratory tests, such as a culture of the catheter tip, aiming to identify if the catheter is actually the source of the infection. For this reason, a simpler definition, such as bloodstream infection associated with the catheter is recommended, as the criteria adopted determine conduct in clinical practice, such as the presence of a positive peripheral blood culture in a neonate with a PICC for at least 48 hours. But as this bloodstream infection did not have a confirmed onset, the actual incidence of catheter-related infection can be overrated.⁽¹³⁾

Regarding risk factors identified in the present study, the lower gestational age group with infection, 31.5 weeks, is a finding that corroborates an epidemiological study conducted in a NICU in Minas Gerais, which demonstrated that prematurity is a risk factor for removal of PICCs for suspected infection.⁽¹⁶⁾

In this investigation, the use of a dual-lumen polyurethane catheter is a risk factor for infection. The CDC recommends the use of central vascular access with the fewest possible lumens for the proper management of the patient.⁽¹³⁾ Confirming the findings, a study that evaluated 377 PICCs in newborns showed that the use of dual-lumen catheters was a risk factor for complications that led to unplanned device removal.⁽¹⁷⁾

Other risk factors identified referred to the clinical diagnosis of the newborn. The risk of infection was two to three times higher in newborns with a diagnosis of apnea or transient disorder of metabolism. This data can be related to the severity of the clinical condition of the infant, which probably requires more frequent

exchanges of infusion therapy, due to their clinical instability, resulting in greater catheter manipulation. Prevention of infection in these newborns should focus on improving the quality of nursing care.

As this study aimed to identify the risk factors for bloodstream infection associated with the PICC in neonates, its applicability to practice includes the generation of evidence that guides the planning of preventive strategies for this complication and, consequently, increasing the survival of neonates in the NICU. Among the implications for the practice of neonatal nurse are the initial and continuing education of professionals who insert and handle catheters daily, the adoption of aseptic technique and maximum precautions, the use of ultrasound guided venipuncture for catheter insertion, the use of transparent bioocclusive dressings for protection of the catheter insertion site, disinfecting all access ports of the catheter with proper antiseptic prior to use, the use of needleless catheter connectors, as the colonization of these connectors is considered to be the cause of 50% of the post-insertion catheter-related infections which occur when there is a technical failure of disinfection, resulting in contamination and formation of a biofilm inside the connectors.^(13,18-20)

The evidence about the benefits of teams with a limited number of highly trained professionals caring for the PICCs is evidenced. Other recommendations for preventing complications in newborns include: early identification of candidates for catheter insertion, preservation of the antecubital fossa for possible insertions, detailed information on the types of catheter available in the health service, indicating the type of catheter according to the prescribed intravenous therapy and the clinical condition of neonates, and the clinical management of complications based on evidence.^(13,21)

Studies showed that the use of checklists with evidence-based practices, for identification and implementation of these strategies, standardized care, and bundles were associated with a reduction in the bloodstream infection associated with the use

of central venous catheters in neonates.⁽²¹⁻²³⁾ A study in China, comparing the incidence of infection related to PICCs in a NICU after the adoption of a checklist showed that this incidence decreased from 3.1/1,000 for 0/1,000/catheters/day, which was statistically significant. The conclusion is that the use of the checklist can be effective in preventing infection related to PICCs in very low birth weight newborns.⁽²³⁾

Other studies that evaluated factors related to catheter maintenance practices, such as the patency of the PICC and its relationship to bloodstream infections, need to be conducted. Finally, preventive strategies based on evidence are recommended, in order to minimize the occurrence of this complication.

Conclusion

The lowest corrected gestational age of the infant, the clinical diagnoses of transient disorder of metabolism and apnea, and the use of dual-lumen catheters have been identified as risk factors for bloodstream infection associated with PICCs in neonates.

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Collaborations

Costa P, Paiva ED, Kimura AF and Castro TE collaborated in the study design, analysis, data interpretation, article writing, relevant critical review of the intellectual content, and final approval of the version of the article to be published.

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