DOI: 10.1590/S0080-623420130000300004

ORIGINAL ARTICLE

Factors associated with infection from the use of peripherally inserted central catheters in a Neonatal Intensive Care unit

FATORES ASSOCIADOS À INFECÇÃO PELO USO DO CATETER CENTRAL DE INSERÇÃO PERIFÉRICA EM UNIDADE DE TERAPIA INTENSIVA NEONATAL

FACTORES ASOCIADOS A LA INFECCIÓN POR USO DE CATÉTER CENTRAL DE INSERCIÓN PERIFÉRICA EN UNIDAD DE TERAPIA INTENSIVA NEONATAL

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ABSTRACT

This was an epidemiological, longitudinal and analytical study carried out in a hospital in the Brazilian state of Minas Gerais, with the aim of analyzing the factors associated with infection due to the use of peripherally inserted central catheters in newborn infants hospitalized in the intensive care unit. Data were collected via a structured form, filled out by the professionals and checked by the researchers. We studied a total of 291 catheters inserted into 233 neonates. The factors associated with catheter removal due to suspected infection were: prematurity; birthweight ≤1500 g; polyurethane catheter; non-centralized placing of the catheter; and duration of use >30 days. After multivariate adjustment, the following factors remained independently associated: weight < 2500 g at the time of insertion, catheter repair, and duration of catheter use. We concluded that factors related to staff practices contributed to removal of the catheters, indicating a need for interventions that improve the safety and efficacy of catheter use.

DESCRIPTORS

Intensive Care Units Neonatal
Catheterization, central venous
Neonatal nursing
Infant, newborn
Nursing care

RESUMO

Estudo epidemiológico, longitudinal e analítico, desenvolvido em um hospital de Minas Gerais, com o objetivo de analisar os fatores associados à infecção pelo uso do cateter central de inserção periférica em recém-nascidos internados em unidade de terapia intensiva. A coleta dos dados foi realizada por meio de uma ficha estruturada, preenchida pelos profissionais e verificada pelos pesquisadores. Foram estudados 291 cateteres inseridos em 233 recém-nascidos. Os fatores associados à retirada por suspeita de infecção foram: prematuridade, peso ao nascer até 1.500 gramas, cateter de poliuretano, localização não centralizada do cateter e tempo de uso superior a 30 dias. Após ajuste multivariado, permaneceram independentemente associados: peso inferior a 2.500 gramas na inserção, reparo e tempo de uso do cateter. Conclui-se que fatores relacionados à prática dos profissionais contribuíram para a retirada dos cateteres, sinalizando para a necessidade de intervenções que melhorem a segurança e a eficácia em seu uso.

DESCRITORES

Unidades de Terapia Intensiva Neonatal
Cateterismo venoso central
Enfermagem neonatal
Recém-nascido
Cuidados de enfermagem.

RESUMEN

Estudio epidemiológico, longitudinal, analítico, desarrollado en hospital de Minas Gerais, objetivando analizar factores asociados a infección por uso de catéter central de inserción periférica en recién nacidos internados en unidad de terapia intensiva. Datos recolectados mediante ficha estructurada, completada por los profesionales y verificada por los investigadores. Se estudiaron 291 catéteres insertados en 233 recién nacidos. Los factores asociados a la quita por sospecha de infección fueron: prematuridad, peso al nacer hasta 1.500 gramos, catéter de poliuretano, localización no centralizada del catéter y tiempo de uso superior a 30 días. Luego de ajuste multivariado, permanecieron independientemente asociados: peso inferior a 2.500 gramos en la inserción, reparación y tiempo de uso del catéter. Se concluye en que factores relativos a la práctica de los profesionales contribuyeron al retiro de los catéteres, determinando la necesidad de intervenciones que mejoren la seguridad y eficacia de su utilización.

DESCRIPTORES

Unidades de Cuidado Intensivo Neonatal
Cateterismo venoso central
Enfermería neonatal
Recién nacido
Atención de enfermería

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Received: 07/23/2012
Approved: 12/18/2012

INTRODUCTION

Peripherally Inserted Central Catheters (PICCs) are amply used in neonatal units when children need an venous line for a prolonged amount of time[1]. Their use allows parenteral nutrition, drugs or solutions in high concentrations to be offered, along with irritants and/or vesicants[1], and further reduces the need for multiple venous punctures and changes[2].

The fine caliber of the catheters and use of an insertion technique into the peripheral veins contribute to make PICCs less invasive, and consequently offer less risk to the patients at the time of introduction, in comparison to devices surgically-inserted into large blood vessels[2,3].

However, results from scientific studies have shown a set of non-infectious and infectious complications [from PICCs] in newborns (NBs). The first correspond to obstruction of the catheter, formation of thrombi, bleeding, mechanical phlebitis, migration, fracture of the catheter, draining, cardiac perforation or perforation of the vein, among others[4]. Infections include infectious phlebitis, infection of insertion location and blood infection (sepsis)[2, 5-6].

Among the complications related to the use of the central catheter, those that are infectious stand out as an important cause of morbi-mortality in the neonatal population[7]. Their prevalence, however, varies from 0 to 40% as a result of the differences of concepts and terminologies that are used by authors to characterize them[5].

Among the complications related to the use of the central catheter, those that are infectious stand out as an important cause of morbi-mortality in the neonatal population.

The risk factors associated with blood infection caused by central venous catheters may be related to pre-existing diseases and clinical factors, such as admission into Intensive Care Units (ICU), use of mechanical ventilation and invasive hemodynamic monitoring. Other risk factors include type and material of the catheter, insertion location and following of the recommended technique for insertion and maintenance of the catheter[5]. Scientific investigations have found that some factors significantly increase susceptibility to infection: use time of the catheter, infusion of parenteral nutrition, blood transfusion[8], absence of subjacent infection at time of insertion, more than one indication for use of the device[2], and place of femoral insertion[9].

Among the repercussions from catheter-related infections, the significant increase of the cost from hospitalizations must be considered[9].

Although they can be identified in the literature, studies carried out on infections related to use of PICC have varied delineations and populations, the majority being descriptive and referring to pediatric and adult individuals[2,5-6,10]. Additionally, the PICC is included in the ample universe of central venous catheters, without considering the specificities inherent to the device and the technique of insertion and maintenance[5-8].

This theme is highly relevant and of great interest to the nursing professional, because of his/her technical and legal competencies for insertion and maintenance of the PICC[11], the use of which is growing in NB care in ICUs. Thus, recognition of the risk factors for infection related to use of the catheter can contribute to the establishment of procedures that qualify nurses' care, together with his/her team, supporting clinical practice based on scientific evidence.

In this perspective, this study had the objective to analyze the factors associated with infection from use of the PICC in NBs hospitalized in the intensive care unit.

METHOD

This paper deals with an epidemiological, longitudinal and analytical study, developed in a hospital in Belo Horizonte, in the Brazilian state of Minas Gerais. The Neonatal Intensive Care Unit of this institution has 40 hospital beds, with an average admission of 73 NBs per month in 2010. The study subjects were all of the NBs that used the PICC at some time during their hospitalization, with the insertion period being between February and December of 2010. The established exclusion criteria included: unsuccessful insertions or more than six attempts at installation of the device, since institutional protocol recommends that this number not be surpassed, based on internal quality indicators of the hospital.

Data collection was performed through a structured form to record data regarding the process of insertion, maintenance and removal of the PICC, using, as a reference, the existing form for the service, adapted from Camargo[12]. Following its restructuring, this instrument was submitted to evaluation by two professionals with experience with research and PICC insertion and maintenance. To verify its adequacy, a pilot test was performed for 15 days. After the final version of the instrument was defined, the professionals responsible for insertion and continuity of care of the device were instructed on how to fill out the forms, which were later verified by the research team. When necessary, the patient's hospital record was consulted in order to complete the information regarding the child and the device.

In order to characterize the profile of the children and process of insertion, the form presented variables regarding: sex; gestational age and birth weight; diagnosis, days of life; gestational age and weight at time of insertion of the catheter. In regard to characteristics of the catheter and its installation, data regarding type and brand of the device were collected, along with use of methods to control pain, administration of drugs, number of insertion attempts, and positioning of the end of the catheter. In

regard to maintenance and removal, occurrence of repair, attempts at desobstruction, repositioning, use time of the catheter (in days) and reason for termination of the therapy were recorded.

Recommendation for use of the PICC is determined by the health team which assists the child, and is usually made for administration of antibiotics, parenteral nutrition or substitution of the umbilical venous catheter. The insertion procedure is performed by trained nurses, under the orientation of an institutional protocol based on the directives of the Brazilian Society of Intravenous Therapy Nurses[13]. Definition of the insertion site is performed by the professional responsible for the procedure, and the first choice is usually through veins of the upper limbs. Installation occurs at the side of the bed and seeks the central location of the point of the catheter in the superior or inferior vein cavity. Confirmation of the location of the end is performed by radiography, and repositioning (traction) of the catheter occurs in cases of intracardiac positioning. Maintenance of the catheter includes changing the bandage every seven days when a transparent film is used, or whenever it is dirty, humid, bleeding or its edges are not attached properly. In some situations, especially cases of clinical instability with impossibility of installation of a new catheter, repairs are practiced with the occurrence of the rupture of the external portion of the silicon catheter, which is removed as quickly as possible. In general, however, the PICC is removed only at the end of the therapy or in the presence of side effects, in particular infection, the outcome variable of this study.

The literature on healthcare-related infections[7, 14-15], as well as the protocol adopted by the institution, signal the need to perform laboratory exams in order to confirm the diagnosis of infection related to the central venous catheter. The Center for Disease Control and Prevention (CDC) emphasizes that for diagnosis of the infection, the existence of clinical signs should be observed, along with a positive blood culture collected from the catheter or neighboring areas [16]. Yet the Brazilian Health Surveillance Agency (ANVISA) considers the possibility of laboratory or clinical diagnosis from blood infection. However, in order for it to be associated with the use of the central venous catheter, the device should be present at the time of the diagnosis or up to 48 hours after its removal, with no minimum period of insertion time[15]. Nevertheless, when dealing with infectious events, what is observed in practice is the removal of the catheter before laboratory proof, due to the presence of clinical signs suggestive of infection, such as fever, hypothermal apnea, bradycardia and phlogistic signs at the insertion location and/or along the trajectory of the PICC, such as phlebitis, hardening and hyperemia.

Considering the practice of the professionals at the study location, in this study, removal of the catheter due to infection refers to suspension of therapy as a result of the signs and symptoms described above.

The list of potential risk factors was identified through a literature review. The following variables were considered for statistical analysis: gestational age and weight at time of insertion, device material, number of insertion attempts, occurrence of repair, attempts at desobstruction and repositioning, use time of the catheter (in days) and reason for removal of the PICC.

Characterization of the population studied was performed through calculation of the absolute and relative frequencies of the interest variables according to reason for removal of the PICC. The statistical differences were evaluated through Pearson's chi-squared or Fisher's exact tests.

The modeling process was based on two phases. Initially, the variables that showed a < 0.20 p-value in the bivariate analysis were selected. Later, a multivariate analysis was performed which employed Poisson regression with robust variances. The magnitudes of the associations were estimated by calculation of the Relative Risk (RR) and its Confidence Interval of 95% (CI 95%). The variables that showed statistical significance levels less than 5% were maintained in the final model, considering the Wald test and The Partial Likelihood Ratio Test.

Evaluation of the quality of the model was performed by calculating its coefficient of determination (R2); applications of the goodness-of-fit test, the linktest and by analysis of the remainders, primarily based on the influential points. Collinearity and interaction between the variables that remained in the final model were also tested. The STATA software (version 9.0) was used for processing and analysis of the data.

The study was approved by the Research Ethics Committee of the Hospital Sofia Feldman under opinion 03/2008, attending to Resolution 196/96 of the National Health Council on human research. Further, the professionals that participated in the study signed the term of free and informed consent and their identities remained anonymous.

RESULTS

Following application of the exclusion criteria, the insertions from 291 PICC in 233 children during the period of the study were analyzed. The removal rate of the catheter due to occurrence of infection was 15.8%, corresponding to 9.7 per 1,000 catheters-day.

In regard to the profile of the NBs that used the PICC, the majority were male (53.4%). Gestational age at birth was equal or inferior to 35 weeks in 69.7% of the cases, showing a minimum value of 24 and a maximum of 41 weeks. The percentages of birth weight less or equal to 1,500 grams, between 1,501 and 2,500 grams and greater than 2,501 grams corresponded to 42.8%, 27.5% and 29.7%, respectively. The majority of the NBs (68.4%) were up to 7 days old at the moment of insertion; 16.2% were between 8 and 30 days;

7.9% between 31 and 60 days and 7.6% were older than 61 days. The diagnoses observed at the moment of insertion were sepsis (72.5%), prematurity (70.5%), low weight (69.8%) and respiratory discomfort syndrome (16.5%). Recommendation for use of the PICC was primarily for antibiotic therapy (72.9%), followed by the need to administer parenteral nutrition (31.3%) and vasoactive amines (11.0%).

Silicone catheters were used in 57% of the insertions and polyurethane in 42.6%. The puncture locations were upper limbs, lower limbs, and the cervical and cephalic regions, which had the following percentages: 83.1%, 8.6%, 4.1% and 4.1%. Pain management was a strategy used in 74.9% of the insertions. The number attempts at insertion of the device varied from one to six. The distribution of the percentages in this interval was 25.7% for one attempt; 25.7% for two, 21.1% for three; 13.4% for four; 6.3% for five and 7.8% for six attempts. The central location of the distal end of the device was observed in 80.1% of insertions. The use time of the device was up to 7 days in 22.7% of the cases; between 8 and 14 days in 34.4%; between 15 and 21 days in 21.3%; between 22 and 28 days in 7.6%, and greater or equal to 29 days in 14.1%. The maximum use time was 68 days.

Tables 1 and 2 show the factors associated with the removal of the catheter due to suspected infection: birth weight 1,500 grams or less ($p < 0.023$) (Table 1), use of polyurethane catheter ($p = 0.002$), decentralized location of the catheter ($p = 0.005$) and use time longer than 30 days ($p < 0.001$) (Table 2).

Table 1 – Characteristics of neonates classified by reason for catheter removal in Belo Horizonte, MG, 2010.

Variables	Reason for catheter removal				p-Value
	End of therapy		Infection		
	N	%	N	%	
Gender*					**0,574**
Male	108	90.8	11	9.2	
Female	92	88.5	12	11.5	
Total	200	89.7	23	10.3	
Gestational age at birth, weeks*					**0.058**
≤ 35	139	87.4	20	12.6	
≥ 36	66	95.7	3	4.3	
Total	205	89.1	23	10.9	
Birthweight, g*					0.023
≤ 1500	82	83.7	16	16.3	
1501–2500	60	95.2	3	4.8	
≥ 2501	64	94.1	4	5.9	
Total	206	90	23	10	
Days of life at insertion					**0.670**
0–7	151	91.5	14	8.5	
8– 30	30	88.2	4	11.8	
30–60	15	88.3	3	11.7	
≥ 61	14	87.5	2	12.5	
Total	210	90.1	23	9.9	
Prematurity					**0.139**
Yes	142	88.2	19	11.8	
No	68	94.4	4	5.6	
Total	210	90.1	23	9.9	
Low weight					**0.073**
Yes	145	87.8	20	12.2	
No	65	95.6	3	4.4	
Total	210	90.1	23	9.9	
Sepsis*					**0.636**
Yes	152	90.5	16	9.5	
No	53	88.3	7	11.7	
Total	205	89.1	23	10.9	
Acute early respiratory distress syndrome*					**0.580**
Yes	35	89.7	4	10.3	
No	170	89.9	19	10.1	
Total	205	89.1	23	10.9	

Continue...

...Continuation

Variables	Reason for catheter removal				p-Value
	End of therapy		Infection		
	N	%	N	%	
Recommendation for use of antibiotic therapy*					**0.153**
Yes	154	91.7	14	8.3	
No	52	85.2	9	14.8	
Total	206	90	23	10	
Parenteral nutrition*					**0.374**
Yes	62	87.3	9	12.7	
No	144	85.7	14	14.3	
Total	206	90	23	10	
Administration of vasoactive amines*					**0.462**
Yes	21	87.5	3	12.5	
No	179	89.9	20	10.1	
Total	200	89.7	23	10.3	

*Variables with lost values.

Table 2 – Characteristics of the insertion and handling of the catheter by reason for its removal. Belo Horizonte, MG, 2010.

Variáveis	Reason for removal of catheter				p-Value
	End of therapy		Infection		
	N	%	N	%	
Type of catheter*					0.002
Polyurethane	94	76.4	29	23.6	
Silicone	149	89.8	17	10.2	
Total	243	84.1	46	15.9	
Location of puncture*					0.082
Upper limb	207	85.9	34	14.1	
Lower limb	17	68	8	32	
Cervical	9	75	3	25	
Cephalic	11	91.7	1	8.3	
Total	244	84.1	46	15.9	
Pain control					0.864
No	61	83.6	12	16.4	
Yes	184	84.4	34	15.6	
Total	245	84.2	46	15.8	
Insertion attempts, n*					0.284
1	63	86.3	10	13.7	
2	62	84.9	11	15.1	
3	48	80	12	20	
4	28	73.7	10	26.3	
5	17	94.4	1	5.6	
6	20	90.9	2	9.1	
Total	238	83.8	46	16.2	
Location of catheter end*					0.005
Central	194	87.8	27	12.2	
Non-central	40	72.7	15	27.3	
Total	234	84.8	42	15.2	
Use time, days					< 0.001
0–7	58	87.9	8	12.1	
8–14	96	96	4	4.0	
15–21	52	83.9	10	16.1	
22–28	17	77.3	5	22.7	
>29	22	53.7	19	46.3	
Total	245	84.2	46	15.8	

*Variables with lost values.

After multvariate adjustment of the data, the following factors remained independently associated to removal of the catheter due to suspected infection: weight less than 2,500 grams at time of insertion (RR = 2.30; CI 95% = 1.08 – 4.89; p = 0.030); repair of catheter (RR = 1.99; CI 95% = 1.06 – 3.73; p = 0.031) and use time of the catheter in days (RR = 1.04; CI 95% = 1.02 – 1.06; p<0.000) (Table 3). Removal of the variable *puncture location* compromises the final adjustment of the model, as observed after application of the statistical likelihood ratio test. Thus, it was decided to maintain it in the final model.

Table 3 – Variables potentially associated with infection from use of the catheter, Belo Horizonte, MG, 2010.

Variables	RR (95% CI)	p-Value
Weight at insertion, g		
>2.500	1 (reference)	-
≤2.500	2.30 (1.08 – 4.89)	0.03
Repair		
Yes	1 (reference)	-
No	1.99 (1.06 – 3.73)	0.031
Puncture location		
Upper limb	1 (reference)	-
Lower limb	2.04 (0.99 – 4.22)	0.053
Cervical	1.87 (0.71 – 4.91)	0.205
Cephalic	0.69 (0.10 – 4.96)	0.712
Duration of use, days*	1.04 (1.02 – 1.06)	<0.001

*Variable inserted into the model continuously: that is, for every day of use of the PICC, the risk of infection increased by 4%.

DISCUSSION

Analysis of the data shows the infection rate from use of the PICC was 15.8% (9.7 per 1,000 catheters per day). Additionally, the variables *weight of the NB at time of insertion*, *performance of repair* and *use time of the catheter* were independently associated to this outcome. Children with low weight at time of insertion of the PICC showed increased risk (RR = 2.30) of removal of the device due to infection in comparison to those with weight over 2,500 grams. It was also shown that there is risk of infection when the catheter is repaired (RR = 1.99). In regard to use time, each day the catheter remained inserted increased the risk of infection by 4%.

Nevertheless, for analysis of the results, one should consider that the definition of adverse infectious event related to the PICC primarily showed the occurrence of clinical signs characteristic of infection as support, after elimination of the possibility of other infectious foci. Thus, to not confirm the infection diagnosis as signaled by infection protocols related to health care represents a limitation of this study.

Comparison of the infection rate identified in this investigation with that of others becomes a delicate task as there is a large variation of terminologies used to define infection from the use of the catheter and its removal. For example, one study performed in Taiwan with NBs with very low birth weight considered positive blood culture by peripheral vein, clinical signs and absence of another infection site, identifying an incidence rate of 16.3% (8.3 per 1,000 catheters per day[9]. Yet in one English NICU, removal of the PICC as a result of infection was confirmed with positive culture of blood and/or tip of the catheter, which was removed for clinical signs, reporting an incidence of 21.0% (17 per 1,000 catheters/day)[16]. One NICU in Turkey had related infection as criteria for removal of the catheter (positive culture of blood and tip of catheter and clinical signs) and associated infection (positive blood culture, presence of clinical signs and absence of other infection site), with an incidence of 6.8%[3].

Recent studies on complications related to the PICC report prematurity and low weight as conditions usually existent in infection cases related to the catheter [8-9, 17-18]. The increased risk of infection associated with low weight at time of insertion of the PICC shown in our studies is corroborated by the findings of other studies performed with at-risk NBs[17-19]. This may be explained primarily by the immaturity of the immunologic system of these NBs. Extrinsic factors such as time spent in the hospital, performance of multiple invasive procedures and inadequate hygiene techniques of the professionals also predispose the NBs to nosocomial infections[20], with blood infection associated with use of the catheter being the most frequent[15].

In selecting the insertion site of the PICC, it is recommended that the risk and benefits of the choice are considered, seeking to reduce infectious complications related to the mechanics[7]. It is recommended to avoid use of the femoral site due to higher risk of thrombus formation, and higher incidence of blood infection related to the catheter[9, 18-19]. However, few studies consider the veins of the lower limbs, those being the femoral, great saphenous, small saphenous or the dorsal venous arch of the foot, in comparison to the veins of the upper limbs. Recent studies showed higher rates of infectious complications when the insertion site of the catheter was located on the lower limbs. However, there was no statistical difference when the rates were compared to those obtained on the upper limbs, which is in consonance with the results of this investigation[8,16]. On the contrary, authors[17] concluded that catheters inserted into lower limbs had lower rates of infection from the PICC, and needed more time to develop complications in comparison to catheters inserted into other sites.

The association between length of time the device remained inserted and occurrence of infection is a finding in concordance with the studies on the theme. As the length of time that the PICC remains inserted increases, the risk of

infection does as well[9-22]. However, in these studies there is no clarity to determine the ideal moment of removal of the device in a manner that reduces the risk of infection.

Performance of repair of the PICC is not recommended by the protocols on infections related to health care. However, this practice is commonly performed in health institutions as an alternative to make possible the continuity of the intravenous therapy after damage to the external portion of the catheter. Considering the increase of handling and exposure of the device at the time of repair, the increased risk of infection is justified (RR=3.25) when compared to devices that did not undergo repair.

An evaluation of the national literature on factors related to infection from the PICC in neonates shows that studies are still incipient. Therefore, the results obtained in this study represent a significant contribution to understanding questions related to the use of the PICC, principally those on adverse events. Added to the strengths of this study are its longitudinal delineation, which guarantees temporality and relationship of cause and effect between the associations.

CONCLUSION

The PICC has been amply used in the neonatal population due to the possibilities that it offers in the care of at-risk NBs. However, it is verified that it presents adverse events that may be the result of conditions intrinsic to neonates or their care.

In this study, weight of the NB below 2,500 grams at the time of insertion of the catheter, use time in days and performance of repair of the PICC were shown to be predictors of infection from the use of the device in NBs hospitalized in an ICU.

Given that infection is the adverse event that most contributes to removal of the catheter before termination of the therapy, these findings should be considered in the clinical practice of the nurse and other members of the nursing and multiprofessional teams, especially regarding modifiable factors, such as use time and catheter repair, for greater safety and efficacy in the use of the PICC in the neonatal population, thereby guaranteeing quality care that is free of harm.

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