

ORIGINAL ARTICLE

PERIPHERALLY-INSERTED CENTRAL VENOUS CATHETER: AN EXPERIENCE IN A HIGH-COMPLEXITY HOSPITAL

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ABSTRACT

Objective: to describe the variables associated with thrombosis in patients with peripherally-inserted central venous catheters.

Method: a retrospective cohort study with data collected in 2016, in the Research Electronic Data Capture information system of a high-complexity hospital in São Paulo, Brazil.


Results: the critical patient was the one who presented more thrombosis (77.3%). The patient who had a peripherally-inserted central venous catheter taking more than 33% of the blood vessel, when punctured more than once (15.4%), evolved with thrombosis. Regarding the puncture area, there was no significant result since 96.2% of the patients had the catheter in the ideal puncture zone in the arm.


Conclusion: the incidence of patients with Peripherally-Inserted Central Venous Catheters who evolved with thrombosis was 1.2%, considered low compared to other studies, contributing to strengthen the policies of good practices for the success of the intravenous therapy with its use.


DESCRIPTORS: Thrombosis; Catheters; Nursing; Peripheral Catheterization; Nursing Care.


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CATETER VENOSO CENTRAL DE INSERÇÃO PERIFÉRICA E TROMBOSE: EXPERIÊNCIA EM HOSPITAL DE ALTA COMPLEXIDADE**RESUMO**

Objetivo: descrever as variáveis associadas à trombose nos pacientes com cateter venoso central de inserção periférica.

Método: estudo de coorte, retrospectivo, com dados coletados em 2016, no sistema de informação Research Eletronic Data Capture de um hospital de alta complexidade em São Paulo, Brasil.

Resultados: o paciente crítico foi o que mais apresentou trombose (77,3%). O paciente que tinha o cateter venoso central de inserção periférica com ocupação do vaso sanguíneo maior que 33%, quando puncionado mais de uma vez (15,4%), evoluiu com trombose. Referente à área de punção, não houve resultado significativo já que 96,2% dos pacientes estavam com o cateter na zona ideal de punção no braço.

Conclusão: a incidência de pacientes com Cateter Venoso Central de Inserção Periférica que evoluíram com trombose foi de 1,2%, considerada baixa em comparação com outros estudos, contribuindo para fortalecer as políticas de boas práticas para o sucesso da terapia intravenosa com seu uso.

DESCRIPTORES: Trombose; Cateteres; Enfermagem; Cateterismo Periférico; Cuidados de enfermagem.

CATÉTER VENOSO CENTRAL DE INSERCIÓN PERIFÉRICA Y TROMBOSIS: UNA EXPERIENCIA EN UN HOSPITAL DE ALTA COMPLEJIDAD**RESUMEN:**

Objetivo: describir las variables asociadas a la trombosis en pacientes con un catéter venoso central de inserción periférica.

Método: estudio de cohorte, retrospectivo, realizado con datos recolectados en el año 2016, en el sistema de información Research Eletronic Data Capture de un hospital de alta complejidad en San Pablo, Brasil.

Resultados: los pacientes críticos fueron los que presentaron más casos de trombosis (77,3%). Cuando se realizó más de una punción (15,4%) en pacientes en los que el catéter venoso central de inserción periférica ocupaba más del 33% del vaso sanguíneo, el cuadro clínico evolucionó con trombosis. En relación al área de punción, no se registró un resultado significativo, puesto que el 96,2% de los pacientes tenía el catéter en la zona ideal de punción en el brazo.

Conclusión: la incidencia de pacientes con un Catéter Venoso Central de Inserción Periférica que evolucionaron con trombosis fue del 1,2%, considerada baja en comparación con otros estudios, lo que contribuye a fortalecer las políticas de buenas prácticas para el buen resultado de la terapia intravenosa con su uso.

DESCRIPTORES: Trombosis; Catéteres; Enfermería; Cateterismo Periférico; Cuidados de Enfermería.

INTRODUCTION

The use of central venous catheters is essential for the treatment of patients with several pathologies treated in the hospital setting. These catheters can be tunneled, non-tunneled or fully implanted⁽¹⁾. Their insertion, performed by specialized physicians, can bring risks and complications for the patient, such as pneumothorax, arterial puncture, hemothorax, and arrhythmias. During its use, the patient can experience complications such as bloodstream infection, Deep Vein Thrombosis (DVT) and catheter displacement, as well as catheter blockage^(1,2).

In Brazil, there was an increase in the use of the Peripherally-Inserted Central Catheter (PICC) in the 1990s in hospitalized patients, as an alternative to other central venous catheters.⁽³⁾ The PICC is a long and thin flexible catheter made of biocompatible material, which can be made of silicone, polyurethane, impregnated with antibiotics and coated with antithrombogen. It is inserted through the anterior part of the arm or the antecubital fossa, and then advanced through the central circulation until its tip is located in the vena cava or in the cavoatrial junction⁽¹⁾.

Due to its peripheral insertion, the PICC presents a reduced risk of complications such as pneumothorax, hemothorax, and accidental arterial puncture^(1,3). In addition, according to the Resolution No. 258/2001 of the Federal Nursing Board (Conselho Federal de Enfermagem, COFEN), it can be inserted by nurses in the patient's own room, without the need for a surgical procedure in an operating room, which reduces costs and optimizes assistance^(4,5).

Central Venous Catheters (CVCs) present various complications⁽¹⁾, one of the most important being Deep Vein Thrombosis (DVT), with rates ranging from 55 to 72%. With regard to the PICC, studies show results of 3% to 20% of DVT symptomatically and 61.9% in its asymptomatic form⁽⁶⁾. Contradictorily, in another research study comparing the PICC with other CVCs, there is a 27% DVT association for the PICC versus 10% for other CVCs⁽⁶⁾. The highest rates of this complication affect the basilic and cephalic veins, with documented results between 3% and 58%⁽⁷⁾.

The diversity of these rates is associated with factors that interfere with the risk of thrombosis and that change depending on the population studied, the catheter insertion technique, and the heredity and clinical history; however, they follow Virchow's Triad on the risk of thrombosis, venous stasis and endothelial injury, known as hypercoagulability, which is an intrinsic factor that cannot be changed. However, we were able to interfere with venous stasis when we evaluated the vessel and selected the adequate catheter; the same happened with the endothelial lesion, when we selected the best puncture site, consequently reducing the number of puncture attempts, as shown in the study⁽⁸⁾.

The insertion method of the PICC catheter can be carried out through the ultrasound technique associated with the modified Seldinger technique, or with the direct or blind puncture technique. The first model offers several advantages compared to direct puncture, such as making the veins for catheter insertion more visible, allowing for the use of thinner needles at the time of puncture, guiding the catheter to the correct position^(4,8). The direct puncture model is not used in loco in the hospital under study, and is in disuse in Brazilian hospitals, but it is still a reality in Neonatology and Pediatrics.

A randomized study, comparing the method of direct puncture with ultrasound, associated with the modified Seldinger technique, showed a significant decrease in bleeding at the time of puncture, 0.90 ml compared to 1.79 ml for the direct puncture technique. The size of the catheter inserted in the experimental group (ultrasound associated with the modified Seldinger technique) was 39.0 cm, while that of the control group (direct puncture) was 50 cm, perhaps because the puncture site was lower than in the Seldinger technique combined with ultrasound. Regarding the incidence of venous thrombosis in the experimental group, the result found was zero, significantly lower than the rate presented

by the control group, 8.3%⁽⁴⁾.

Since 2011, certified and specialized nurses have inserted PICC catheters in the hospital selected for this study. Their presence for insertion and care of the catheter brings benefits such as success in the first puncture attempt, reduction in the rate of bloodstream infection, and reduction in the rate of adverse events with the catheter. They use the ultrasound associated with the modified Seldinger technique to perform the catheter insertions, fixing the catheter with a suture-free device, which considerably reduces the chance of bacterial colonization. After the procedure, the nurse responsible for the PICC requests a chest x-ray, as permitted by the hospital protocol, to verify the position of the catheter⁽⁹⁾.

Based on these good practices used in the insertion of the PICC, this study aims to describe the variables that are associated with thrombosis in patients with PICCs.

METHOD

This is a cohort study with retrospective data collection. It was carried out in a large private philanthropic hospital, teaching and research field, located in the city of São Paulo. Data collection was carried out in 2016, for convenience.

The study population was patients admitted to the hospital with a PICC catheter during 2015 in the following units: Intensive Care Unit (ICU), Advanced Heart Failure Unit (AHFU), cardiac Intensive Care Unit (cardiac ICU), General Critical Care Unit (GCCU), semi-intensive care unit, Bone Marrow Transplant (BMT), and Inpatient Units (IUs). The inclusion criterion was patients over 18 years of age with a PICC catheter, while outpatients and Oncology-center patients were excluded.

The nurses in the PICC group feed the data system with information through a printed anamnesis instrument, with data on how the catheter puncture progressed. This instrument has been used by the group since its creation in 2011; therefore, it was not specifically constructed for this study. This instrument comprises the variables used in this study, such as:

- Patient profile (critical, surgical); for cancer patients: Do they have active cancer?
- Prophylaxis for Deep Vein Thrombosis (DVT) (yes, no).
- DVT prophylaxis (low-molecular-weight heparin, coumadin®, unfractionated heparin, xarelto®, clexane®, liquemine®, others).
- Puncture attempts in the vein until success: one, two, three and four (maximum 4 times). Venous access chosen for puncture: basilic, cephalic, brachial, medial cubital vein, other.
- Type of catheter: Power PICC®: mono, double and triple lumen; Groshong®: mono, double and triple lumen; Double 6FR.
- Location of the tip of the catheter in which vein: superior vena cava, inferior vena cava, axillary vein, subclavian vein, anomalous vein, jugular vein.
- Puncture zone, as described in the literature, known as the ZIM zone. The nurse delimits the arm above the antecubital fold in three distinct zones; the medial epicondyle from 0 to 7 is the red zone, from 7 to 14 is the green zone (preferred for puncture) and, from 14 cm up to the axillary line is the yellow zone; as if they were traffic lights⁽¹⁰⁾.

- Location zone of the tip of the catheter in the vena cava. The current standard for the position of the PICC tip is the lower third of the superior vena cava (SVC) at the cavoatrial junction, described as zone A. Zone B is in the middle third of the superior vena cava, and zone C is in the upper third of the superior vena cava^(11,12). In this study, there was no equipment with intravascular electrocardiogram to insert the PICC⁽¹²⁾.

- Vessel filling >33%. When the percentage that the catheter fills in the lumen of the vessel is greater than 33%.

- Symptomatic thrombosis: axillary pain, limb edema, change in color, confirmation by the medical team through ultrasound scan.

- Conduct: catheter maintained: yes, no.

- If the catheter is maintained: full anticoagulation, conservative conduct.

The nurses in the PICC group monitor, maintain and evaluate the catheter when the Nursing team of the unit notices any alteration suggestive of thrombosis, such as: edema in the upper limb in which the PICC is located, change in the color of the skin, and pain reported by the patient. It is part of the daily assessment of the nurses in the units to verify the brachial circumference of the upper limb of the patient with a PICC.

If the nurses in the unit where the patient is hospitalized notices any of the abovementioned changes, they request an assessment by the PICC team, which evaluates the patient in person, measuring the brachial circumference and sharing the case with the patient's medical team; afterwards, they suggest an upper limb ultrasonography. If the medical diagnosis of thrombosis is confirmed by the ultrasound scan, the patient's physician is notified and the conduct to be taken is discussed. It is possible to opt for removal of the catheter and treatment with anticoagulants.

After checking the consistency of the data included in the Research Electronic Data Capture (REDCap) information system and exported to a Microsoft Excel spreadsheet, the categorical data were represented by absolute (n) and relative (%) frequencies and compared using Pearson's chi-square test or Fisher's exact test, when necessary. The complex matrices (2x3, 3x4...) were partitioned into simple matrices for better determination of causality. For the entire study, an α risk ≤ 0.05 of making a type I or first species error and a β risk ≤ 0.20 of making a type II or second species error were considered. The SPSS 19.0 statistical program was used.

The study was approved by the Ethics Committee and is registered in Plataforma Brasil under opinion number 1,742,158.

RESULTS

Throughout 2015, the number of patients who made use of the peripherally-inserted central venous catheter was 2,513. During this period, thrombosis was notified in 31 patients (1.2%). The age of the patients with thrombosis ranged from 19 to 100 years old. Seventeen patients (54.8%) were female, 13 (41.9%) had a cancer diagnosis, and nine (29%) had undergone surgery. Of the 13 patients diagnosed with cancer, ten (76.9%) were in an active stage of the disease.

Indications for using the PICC

According to Table 1, there was no association between the different indications for the use of the PICC related to thrombosis. Regarding the medications used in the patients with thrombosis, the use of antibiotics was the most identified, with 19 (73.1%). The use of

chemotherapy drugs is one of the indications for the insertion of the PICC; in the study, 7 (22.5%) of the patients who received this therapy developed thrombosis.

Table 1 - Number and percentage of thrombosis cases according to the type of infusion therapy. São Paulo, SP, Brazil, 2016

Infusion therapies	Thrombosis	
	N	%
Received an antibiotic	19	73.1
Received a vasoactive drug	3	11.5
Received total parenteral nutrition	1	3.8
Received chemotherapy	7	22.5

As for the number of punctures (Table 2), critically ill patients were the ones who presented more thrombosis, even with success in the first puncture in 15 (65.2%) patients.

Table 2 - Number and percentage of punctures according to the patient's profile. São Paulo, SP, Brazil, 2016

Patient's profile	1 puncture		2 > punctures	
	n	%	n	%
Critical patient	15	35.2	1	12.5
Surgical patient	6	26.1	3	37.5

The patients with thrombosis and with the PICC catheter filling more than 33% of vein had two or more punctures (4/80%). And, even when vein filling was not greater than 33%, when the patients had more than one puncture, four evolved with thrombosis (15.4%), $p=0.002$. Regarding the puncture area, there was no significance in the outcome, since 25 of the patients, 96.2% ($p=0.656$), were punctured in the ideal zone, the green area (Table 3). In this research, no patient was punctured in the red area, 0 (0%), considered at greater risk for thrombosis.

Table 3 - Puncture attempts and puncture site in the patients with thrombosis. São Paulo, SP, Brazil, 2016

Number of punctures		Vessel filling >33%	
		No n (%)	Yes n (%)
One puncture		22 (84.6)	1 (20)
Two or more punctures		4 (15.4)	4 (80)
Puncture area	Green	25 (96.2)	5 (100)
	Yellow	1 (3.8)	0
	Red	0	0

Regarding the use of thrombus prophylaxis, nine (30%) of the patients (Table 4) received prophylaxis for thrombosis; of these, seven (21.1%) used low-molecular-weight heparin.

Table 4 - Number and percentage of occurrences and type of prophylaxis for Deep Vein Thrombosis according to the puncture site. São Paulo, SP, Brazil, 2016

		Puncture site		
		Green n (%)	Yellow n (%)	Red n (%)
Prophylaxis	No	21(70)	0	0
	Yes	9(30)	1 (100)	0
Types of prophylaxis	No prophylaxis	21(72.4)	0	0
	Low-weight heparin	7 (24.1)	0	0
	Unfractionated heparin	1 (3.4)	1 (100)	0

In this study, 23 (74.1%) of the patients who evolved with thrombosis had the catheter inserted in only one attempt (Table 5).

Table 5 - Numbers and percentages of patients with one or multiple punctures, depending on vessel occlusion. São Paulo, 2016

Vessel filling >33%	Number of punctures		Pearson's chi-square
	1 n (%)	2 > n (%)	
No	22 (95.7%)	4 (50)	0.002
Yes	1 (4.3)	4 (50)	

DISCUSSION

Throughout 2015, 31 patients (1.2%) were identified with thrombosis in a PICC catheter, presenting a lower incidence than that found in a meta-analysis in 2013⁽²⁾. Regarding the indication of the PICC, a previous research study exemplified that the administration of antibiotics such as vancomycin, ceftriaxone and metronidazole is associated with an increased risk of DVT in PICC⁽¹³⁾; however, this study showed that the use of an antibiotic was unrelated to an episode of thrombosis. And one of the main indications for the use of the PICC continues to be the administration of antibiotics for a long time (drug therapy greater than seven days).

Another indication for the PICC is cancer patients undergoing chemotherapy; 22.5% of these patients in the study developed thrombosis. In the literature, cancer patients with a PICC catheter are at an increased risk of developing thrombosis due to the changes in Virchow's triad.^(2,14,15) Immobility and comorbidities caused by cancer alter blood flow and the presence of the PICC catheter in the vessel prevents normal blood flow, which can lead to venous stasis.

Another factor that contributes to the onset of thrombosis is chemotherapy administered in the catheter, which can cause damage to the vessel endothelium, and the production by the malignant cells of procoagulant factors that are released in the blood, causing hypercoagulability. For these reasons, there are several studies on PICC catheters and thrombosis in cancer patients⁽¹⁶⁾, classified as appropriate only if the proposed duration of this treatment was three months or less⁽¹⁷⁾.

Regarding the prevention of thrombosis, the clinical studies indicate heterogeneous results: some show no benefits with the use of low-molecular-weight heparin or warfarin, while others show positive results with both^(18,19). In cancer patients, the use of anticoagulants to prevent thrombosis is encouraged by some studies⁽¹⁸⁾.

The number of punctures refers to the number of attempts to puncture the vein until succeeding, with an allowed maximum of four attempts by the same professional. Even with 65.2% of success in the first puncture, observed in this study, critical patients were still the ones who presented more thrombosis. It is in these critical unit patients that we observed the use of vasoactive drugs and antibiotics, which can be associated with thrombosis and with greater immobility due to the clinical condition.

When punctured more than once (15.4%), patients with vessel filling greater than 33% had thrombosis, which may suggest an association between the greater amount of trauma to the vein caused by the puncture and the catheter filling more than 33% of the vein. Moving and bending the arm contribute to trauma at the insertion site and to endothelial injury. This also occurs at the time of venipuncture, advance of the guidewire, and introduction of the dilator. A survey showed that, with more attempts to insert the catheter, the risk of complications increases from 4% to 24%, compared to only one puncture attempt⁽²⁰⁾.

In this study, 23 (74.1%) of the patients who evolved with thrombosis had the nurse insert the catheter in only one attempt, and most of the patients had less than 33% of vessel filling. Thus, a comparison with the patients who did not evolve with thrombosis would be necessary to conclude an association which more certainly clarifies if only one factor can be determinant for evolving with thrombosis.

A limitation of this study is the incidence of thrombosis appearing only in the symptomatic cases, associated with the study's retrospective design itself, making it impossible to search for asymptomatic cases.

CONCLUSION

The number of patients with PICCs who evolved with thrombosis showed an incidence of 1.2%. Thus, it is important to highlight the differences of the puncture techniques in view of the results in terms of thrombosis, as today there is already sufficient evidence to prove the low rates of thrombosis in PICC users, even in high-risk populations like cancer and critical patients, and that the main determinant for these differences is in the Seldinger technique associated with ultrasound and in compliance with Virchow's triad.

Despite progress in understanding the factors that can increase the association between thrombosis and patients with PICCs, there are still many questions for discussion and research. It is worth mentioning that, regardless of the technology applied, principles of good practice in the insertion and maintenance are fundamental for the success of the intravenous therapy using PICCs and other central devices.

The study is relevant because it shows that the incidence of thrombosis in patients with PICCs is low. In addition, it was possible to identify factors that can increase the association of thrombosis in patients with this catheter, which can serve as a guide for the care practice in institutions that adopt the PICC line.

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