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RESEARCH ARTICLE

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FACTORS ASSOCIATED WITH PEDIATRIC PERIPHERAL VENOUS ACCESS COMPLICATIONS: AN INTEGRATIVE REVIEW

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ABSTRACT

Objective: To analyze the evidence on the main modifiable risk factors for complications related to peripheral venous access in pediatric patients. **Method:** This is an integrative review conducted in the databases: Scientific Electronic Library Online (SciELO), Scopus, National Institute of Medicine (NIH-PUBMED) and Web of Science, using the descriptors: "pediatric nursing", "peripheral catheterization", "peripheral venous catheterization", "intravenous administration" and "pediatrics" in which 15 articles were selected in Portuguese, English and Spanish, from 2009 to 2020. **Results:** From the 15 articles analyzed, 12 were cohort studies, with level of evidence III (moderate). The risk factors found focused on the type of catheter used, the children's clinical and physical conditions, the type of drug infused and the insertion site. The most frequent factor was related to the use of cefotaxime and vancomycin antibiotics and the phenytoin anticonvulsant. **Conclusion:** This review identified several risk factors for complications in pediatric peripheral venous access. The recognition of these risk factors by the nursing staff can prevent various complications of access, thus avoiding greater risks to children undergoing this procedure.

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INTRODUCTION

Venous access through Peripheral Intravenous Catheter (PIC) is an invasive therapeutic procedure where a sterile device is introduced inside the vessel, that is, it is considered a procedure that demands continuous attention, once the catheter breaks the skin barriers (Pereira et al., 2016). A large number of hospitalized children (more than 50%) require the use of a Peripheral Venous Access (PVA) for parenteral therapy, such as antibiotic therapy or intravenous fluid administration, and are inserted prophylactically before procedures and in clinically unstable patients, mainly for emergency use (Ulman et al., 2017). In most occasions the insertion of peripheral catheters in pediatric patients becomes a challenging procedure, caused by its procedural and physiological difficulties (Cooke et al., 2018). Injury associated with improper PVA insertion and maintenance is treated as a patient safety issue. The insertion of these catheters may evolve with local complications such as infection, infiltration and occlusion, or systemic ones such as thrombophlebitis, which may affect the

health and well-being of pediatric patients (Förberg et al., 2016; Ben Abdelaziz et al., 2017). However, systemic infections associated with peripheral venous access, are rare events, but can be fatal especially in children (Webster et al., 2019). The clinical sequelae resulting either from complications or from failures in the procedure can be prolonged, with delays in the administration of drug therapy and the occurrence of traumatic procedures from repeated insertion, as well as damage to peripheral vessels (Marsh et al., 2018). In addition, difficulties encountered in performing the PVA, such as difficult access to some vessels and the patient's clinical condition, delay the therapeutic method and increase health costs, such as the use of materials. These difficulties end up leading health care teams to opt for more invasive accesses, such as the central ones, thus increasing costs and the risk of complications (Paladini et al., 2018). In pediatrics, there are several risk factors that lead to these complications such as the age range of the neonates (Unbeck et al., 2015), underlying clinical conditions (de Jacinto et al., 2011), drug

origin or type of fluid administered (Shenoy and Karunakar, 2014), insertion site and access maintenance methods (Malvon *et al.*, 2014). In this context, analyzing these modifiable risk factors for complications associated with the use of PVA in pediatrics, as well as the most frequent consequences, is necessary to provide evidence to support a more informed practice, especially for the nursing staff (Ulman, *et al.*, 2019). It is considered that by identifying modifiable risk factors for complications of peripheral venous access in pediatrics, health professionals, especially nurses, can support the construction of strategies and protocols aimed at better management of this procedure, thus increasing patient safety in the pediatric age group. Thus, this study aimed to analyze the evidence of the main modifiable risk factors for complications related to peripheral venous access in pediatric patients.

MATERIALS AND METHODS

An integrative literature review study was conducted. The studies were selected from searches of the Scientific Electronic Library Online (SciELO), Scopus, National Institute of Medicine (NIH-PUBMED) and Web of Science databases from July to August 2021. We consulted the Medical Subject Headings (MeSH) and the Descriptors in Health Sciences (DeCS). The following descriptors were used: pediatric nursing, peripheral catheterization, pediatrics, intravenous administration, and peripheral venous catheterization. The search was then organized using a search filter in different combinations: 1) Scielo: "pediatric nursing" AND "peripheral venous catheterization"; 2) Scopus: "intravenous administration" AND "pediatrics" 3) NIH-Pubmed and Web of Science: "peripheral venous catheterization" OR "intravenous administration" AND "pediatrics". The selected articles met the following inclusion criteria: research available electronically in the selected databases, published in Portuguese, English or Spanish between 2009 and 2020, studies whose participants were neonatal or pediatric (0-18 years) (Hardin and Hackell, 2017) and studies that showed statistically significant associations and those that described the average length of stay of patients. The following exclusion criteria were taken: duplicates, studies with themes not relevant to the research objective, review studies, and case reports.

To ensure the joint recording of information relevant to the topic, we used the instrument proposed by Nascimento *et al.* (2021), adapted for this study with the following variables: identification data (title, authors, journal, year of publication, country of origin of the study, impact factor according to the Journal Citation Reports - JCR, qualis and database), methodological design (type/approach of the study and level of evidence) and main results (risk factors for complications, complications of PVA and site of insertion of venous access). After applying the search filters in the databases, 258 articles were initially found, so that duplicate articles were registered only once, totaling 211. After reading the titles and abstracts simultaneously, 83 publications was no relevant approach to the theme of this study, 36 review studies, and 12 case reports were excluded. Thus, 80 publications were selected to be read in their entirety. Sixty-five publications were excluded, being 57 for not statistically analyzing the risk factors for PVA and 08 for not disclosing the average length of stay of patients. Thus, the final sample consisted of 15 articles, as shown in Figure 1. The selected articles were submitted to the classification of the level of evidence, based on the Hierarchical Classification of Evidence for Evaluation of Studies instrument (Stillwell *et al.*, 2010). According to this classification, levels I and II are considered strong evidence, III and IV moderate and V to VII weak.

RESULTS

From the total of 15 articles analyzed, Table 1 shows a higher frequency of publication in 2014 (n: 03) and higher production from Brazil (n: 05), followed by Australia and Switzerland with two publications each. As for the databases, the Web of Science had the largest number of articles analyzed (n: 06), followed by Pubmed (n:

03), Scopus (n: 03) and Scielo (n: 03). Regarding the Qualis of the journals in the sample, 08 articles are classified as A1 or A2 by CAPES. As for the impact factor of these journals, PloS one had the highest factor (2.776). Regarding the approach of the found articles, it was verified that most of them used the cohort study (n: 12), which means that, the most common level of evidence was III - moderate. The analyzed publications involved 10.504 pediatric patients with 11.831 peripheral venous accesses used. The most commonly used access sites were the dorsum of the hand (n: 4.514) and the cubital fossa (n: 1.466), while the least common was the ankle (n: 83) and cervical region (n: 03). Table 2 shows the risk factors for the occurrence of complications in pediatric AVP as well as the complications themselves mentioned by the analyzed publications. It can be seen that the listed risk factors were related to the catheter, the patient's physical and clinical aspects, the infused drug, and the insertion site. It is possible to verify that the most frequently listed risk factor was the use of cefotaxime and vancomycin antibiotics and the phenytoin anticonvulsant. The most frequent complications were infiltration and extravasation, followed by catheter occlusion and obstruction.

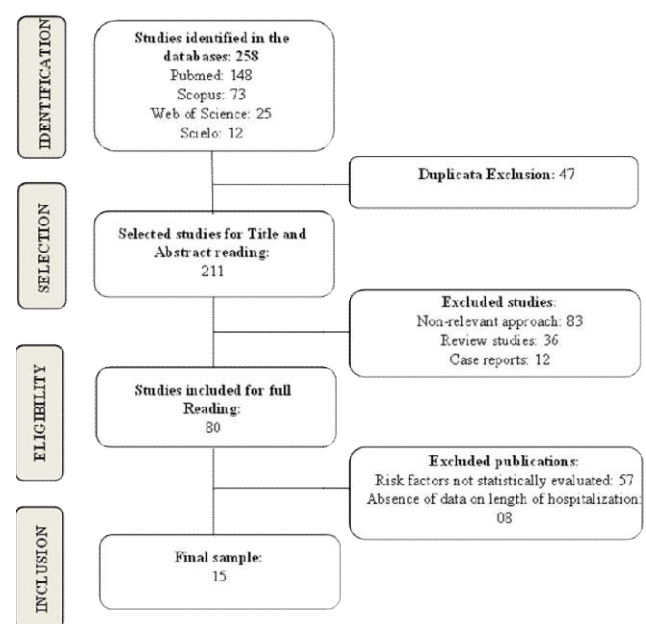


Figure 1. Flowchart of the study selection process

DISCUSSION

This review gathered scientific evidence on the risk factors for the emergence of complications of PVA in pediatric patients. Once this procedure is routine in the hospital unit, especially in pediatrics, the nurse, as the main agent of care, should focus on designing strategies to minimize the risk of complications of this therapeutic procedure (Salgueiro-Oliveira *et al.*, 2019). As for the origin of the publications found, it was found that they were most often concentrated in developed countries, although Brazil, an emerging country, was the one that published the most. This can be explained by the fact that developed countries seek to analyze more accurately factors that can trigger complications in venous accesses, seeking solutions and thus avoiding costs of health care spending (Unbeck *et al.*, 2015; Erdei *et al.*, 2015). As for the methodological design of the analyzed publications, cohort studies prevailed, which have a moderate level of scientific evidence (III), especially the multicenter ones, which were able to more accurately assess risk estimates due to the large population sample. However, differences were observed between the data analysis of the studies, from simple frequency evaluations to the application of statistical models, which allowed the detection of possible differences between the factors studied and the precision of the data estimation. No study presented randomization, which may represent a factor of concern because the absence of this method may represent a bias by presenting higher risks of confounding factor (Brasil, 2014).

Table 1. Characterization of the articles in the final sample

ID	Author/ year	Country	Journal	Databases	Qualis/JCR	Study design	Level of Evidence
01	Forni C, <i>et al.</i> / 2010	Italy	Assist Inferm Ric	Scopus	[‡] 0,429	Cohort study	III
02	De Jacinto AKL, <i>et al.</i> /2011	Brazil	J Infus Nurs	Pubmed	*A1	Cohort study	III
03	Gomes ACR, <i>et al.</i> / 2011	Brazil	Esc Anna Nery Rev Enferm.	Scielo	*B1	Cohort study	III
04	De Negri DC, <i>et al.</i> / 2012	Brazil	Rev Lat Am Enfermagem.	Scielo	A1-0,979	Cohort study	III
05	Malyon L, <i>et al.</i> / 2014	Australia	Emerg Med Australas	Web of Science	[‡] 1,500	Cohort study	III
06	Shenoy S, <i>et al.</i> / 2014	India	Indian J Pediatr	Pubmed	B1-1,136	Cohort study	III
07	Laudenbach N, <i>et al.</i> / 2014	USA	J Pediatr Nurs	Scopus	A1-1,563	Quasi-experimental study	III
08	Unbeck M, <i>et al.</i> / 2015	Switzerland	Acta Paediatr	Web of Science	B1-2,265	Cohort study	III
09	Danski MTR, <i>et al.</i> / 2016	Brazil	Rev. esc. enferm. USP	Web of Science	A2-0,945	Cohort study	III
10	Park SM, <i>et al.</i> / 2016	South Korea	PloS one	Web of Science	A1-2,776	Cohort study	III
11	Ben Abdelaziz R, <i>et al.</i> / 2017	Tunisia	BMC Pediatrics	Web of Science	A2-1,983	Cohort study	III
12	Birhane E, <i>et al.</i> / 2017	Ethiopia	BMC Nursing*	Web of Science	*A1	Cohort study	III
13	Fonzo-Christe C, <i>et al.</i> / 2018	Switzerland	Acta Paediatrica	Scopus	B1-2,265	Cohort study	III
14	Ullman AJ, <i>et al.</i> / 2019	Australia	J Pediatr Nurs	Pubmed	A1-1,563	Cross-sectional study	VI
15	Floriano CMF, <i>et al.</i> / 2019	Brazil	Rev. Bras. Enferm	Scielo	*A2	Cross-sectional study	VI

Notes: *No Qualis through Capes; [‡]No impact factor through JCR.

Table 2. Major risk factors and complications arising from peripheral venous access in pediatrics.

Variables	ID	Results found
Catheter related risk factors	11, 15	Smallcaliber catheter (24)
	12, 15	Unused venous access after insertion
	02, 11	Venous access permanence time
	02	Use of infusion pump
Risk factors related to physical and clinical aspects	11	Respiratory and infectious diseases
	13, 14	Age group under 2 years
	04, 07	Malnutrition
	01	Female gender
Factors related to the infused drug	11	Proton pump inhibitors
	01, 07	Irritating drugs
	10, 13	Combination of ampicillin and sulbactam
	10, 11, 13	Use of the antibiotics cefotaxamine and vancomycin
	06, 10, 13	Use of phenytoin
	10	Use of dextrose
	10	Use of steroids
	10	Use of high concentration electrolytes
Factors related to the access site	01	Blood transfusion
	05, 08, 14	Cubital fossa
	08, 10, 13	Peripheral venous access in lower limbs
Complications of peripheral venous access	09, 15	Insertion of the catheter in a location with signs of inflammation
	11, 14	Skin necrosis, blisters, or dislocation
	01, 08, 12, 15	Occlusion and obstruction
	05, 07, 11	Phlebitis and thrombophlebitis
	01, 02, 05, 07, 08, 11, 12, 14	Infiltration and extravasation

Regarding the main risk factors associated with pediatric PVA complications found in the studies analyzed, the most frequent ones referred to the insertion site and the type of drug infused. In this study there was a predominance of peripheral intravenous catheter insertion in the cubital fossa (Malyon *et al.*, 2014; Unbeck *et al.*, 2015; Ullman *et al.*, 2019), as a risk factor with a strong statistical association for the occurrence of infiltrations. Lower limb access, on the other hand, was associated with the occurrence of catheter occlusion in pediatric patients (Unbeck *et al.*, 2015; Park *et al.*, 2016; Fonzo-Christe *et al.*, 2018). Researchers state that PIC insertion in hospitalized children should be avoided near the joints, such as in the cubital fossa and in the wrist and ankle region (Tripathi *et al.*, 2008). Insertions near these regions may not only increase the risk of complications, but may also be uncomfortable for the child and reduce limb mobility (Tripathi *et al.*, 2008). Another consideration is that in older children, the insertion site of the PIC should be in the non-dominant limb, since the child's play and learning experiences during the hospital stay may be affected if the dominant arm or hand is used (Foster *et al.*, 2002). Regarding the risk factors related to the peripheral intravenous catheter, the results reveal that the most frequent was the use of small-caliber catheters (24) (Ben Abdelaziz *et al.*, 2017; Floriano *et al.*, 2019). Two studies in pediatric patients analyzed that the use of 24-gauge PIC reduced the length of life of the patient in comparison with the use of 22-gauge catheters, revealing that the smaller the gauge, the shorter the length of stay and the greater the risk factor for complications (Ben Abdelaziz *et al.*, 2017; Floriano *et al.*, 2019).

Other risk factors were also listed in the results such as maintaining an unused access after insertion (Foster *et al.*, 2002; Salgueiro-Oliveira *et al.*, 2019) and a shorter length of stay of the PVA (Ben Abdelaziz *et al.*, 2017). Researchers in a recent systematic review analyzing the length of stay of PIC in pediatrics found no evidence to support catheter exchange every 72 to 96 hours, suggesting that healthcare organizations consider a policy in which catheters are removed only if clinically indicated (Webster *et al.*, 2015). As for risk factors related to physical and clinical aspects, the results highlighted the following: respiratory and infectious diseases (Ben Abdelaziz *et al.*, 2017); age group under 2 years old (Ulman *et al.*, 2019); malnutrition (de Negri *et al.*, 2012; Floriano *et al.*, 2019) and; female gender (Forni *et al.*, 2010). Regarding malnutrition, a Brazilian study indicated that this condition is highly prevalent in the admission of children, but is not diagnosed (Ferreira and França, 2002). Access complications may occur due to capillary fragility and reduced tissue turgor (Hardin and Hackell, 2017).

Regarding the factors related to drugs infused in the PVA, the most frequent ones were the use of some antibiotics (cefotaxime and vancomycin), the combination of ampicillin and sulbactam, and the use of phenytoin. This can be justified by the fact that some fluids and drugs have the ability to cause venous rupture when the venous endothelium and blood vessel walls are irritated, causing intravenous infiltration or extravasation (Park *et al.*, 2016). Fluids with a high acidity or alkalinity can damage cellular proteins, reduce the durability of the venous endothelium, and inflict venous rupture. Therefore, it is recommended to use fluids with a pH range of 5 to 9 for intravenous injection (Park *et al.*, 2016). Some examples are phenytoin, an anticonvulsant with strong alkalinity, as well as the combination of ampicillin and sulbactam that also have strong alkalinity with a pH of 8 to 1, causing irritation of the vessel walls and facilitating the occurrence of infiltration, and vancomycin, a strong acid with a pH of 2.8-4.5 that can cause infiltration (Clark *et al.*, 2013).

Considering the complications of PVA arising from the risk factors listed in the results, it was found that the most frequent were infiltration and extravasation followed by occlusion and obstruction of the PIC. Although these complications occur in up to 97% of the accesses, especially in neonatal intensive care units, identifying the risk factors during clinical evaluation may be a predictor to avoid this alarming amount of complications (Legemaat *et al.*, 2016). Thus, the nursing team needs to be aware of these risk factors and devise strategies to minimize the occurrence of complications in pediatric

PVAs. Consistent data collection and a thorough physical examination are essential when the child is admitted, supporting subsequent steps of the nursing process and leading to IV therapy with the least amount of harm possible.

CONCLUSION

This review made it possible to identify several risk factors for the occurrence of complications in pediatric peripheral venous access, despite the low number of publications that had statistically significant associations. The risk factors found in the study were focused on the type of catheter used, especially those of smaller caliber, the clinical and physical conditions of children such as malnutrition, the type of drug infused as those of high acidity or alkalinity and the insertion site as the cubital fossa. The recognition of these risk factors by the nursing team can prevent various complications of access as infiltrations and occlusions and even skin necrosis, thus avoiding greater risks to children undergoing this routine procedure.

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