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FREQUENCY OF PERIPHERAL INTRAVENOUS INFILTRATION AND DETERMINATION OF RISK FACTORS IN CHILDREN: A COHORT STUDY

Aysegul Simsek[1*], Birsen Mutlu[2], Sadiye Dur[3]

[1]Istinye University, Faculty of Health Sciences, Department of Midwifery, İstanbul, Türkiye; [2]Istanbul University-Cerrahpaşa, Faculty of Florence Nightingale Nursing, Pediatric Nursery Department, Istanbul, Türkiye; [3]İzmir Demokrasi University, Faculty of Health Sciences, Department of Nursing, İzmir, Türkiye

ORCID iD: Aysegul Simsek: 0000-0002-2166-1778; Birsen Mutlu: 0000-0002-8708-984X; Sadiye Dur: 0000-0001-9801-5865

***Sorumlu Yazar / Corresponding Author:** Birsen Mutlu, **e-posta / e-mail:** bdonmez@iuc.edu.tr

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Abstract

Objective: Intravenous therapy is one of the most commonly used routes for drug administration. The aim of this study was to determine the frequency of peripheral intravenous infiltration and risk factors in children.

Methods: This cross-sectional and cohort study was conducted in a university hospital in pediatric patients. An information form and the Infiltration Rating Scale were used. Data were obtained from patients, their parents, and patient records. Infiltration data was obtained by researchers through direct observation. Significance was assumed as $p<0.05$ at 95% confidence interval.

Results: A total of 176 pediatric patients made up the study cohort. Most of the peripheral venous catheters were inserted by nurses and into upper extremities. The incidence of infiltration was 57.9%, and most of the infiltrates were first-degree. The development of infiltration was significantly associated with the medical specialty being attended ($p=0.001$) and the number of catheter insertion attempts ($p=0.013$).

Conclusion: The specific medical specialty and the number of catheter insertion attempts were shown to play a significant role in the development of infiltration.

Keywords: *Infiltration, nurse, pediatric, venous catheterization*.

Introduction

Catheters are in widespread use for diagnostic and therapeutic purposes. The majority of catheters are peripheral intravenous (IV) catheters. These catheters are often preferred to maintain vascular permeability in short-term procedures.[1] Healthcare professionals should be able to manage PIC effectively and correctly. They should have theoretical and practical knowledge and skills. They should be knowledgeable about the selection of catheter materials, the selection of the correct site, pre-catheter preparation, and the correct insertion and fixation of the catheter. They should also take precautions during catheterization by being aware of the complications associated with PIC. IV therapies are often given in PIC.[2,3] Among these IV therapy complications, infiltration (iv fluids moving into surrounding tissue) is the best known and most common.[2,4,5] Factors related to the catheter and the patient, as well as mechanical and therapeutic factors, may all lead to infiltration. The ideal treatment for infiltration is prevention.[4] Health professionals, especially nurses, should work together on preventive techniques and the management of solutions.[6] In a study examining the incidence of infiltration in patients hospitalized in an emergency department in Australia, the infiltration rate was 23%.[5] Infiltration rate was 34% in newborns,[7] and 10% in pediatric patients.[8] In a study in pediatric clinics in Turkey, it was reported that the infiltration rate was 71.7% in children aged 0-18 years, and PIC complications and infiltration developed in 3%.[9]

Pediatric patients are more exposed to infiltration than adult patients due to their physiological and developmental characteristics.[6] Pediatric patients are at high risk for infiltration during IV fluid therapy due to their relatively smaller vessel size, a finer venous network with narrower diameter vessels, and a high percentage of adipose tissue. In addition, distress in the child and a stressed parent contribute to the already difficult situation.[9,10] Also, children younger than one year have a higher incidence of PIC complications than children aged over five years.[11] PICs may cause complications, such as infection, infiltration, occlusion, or phlebitis. Age has a role in the development of PIC-related complications.[12] The incidence of complications increases as ages become younger. Complications can cause morbidity, increased health care costs, and prolongation of hospital stay, and an inadequacy of IV treatment may also be a source of stress for health professionals, the patients and their parents.[5,8,13,14] The Centers for Disease Control and Prevention and Infusion Nurses Society emphasize that health institutions should create guidelines for healthcare practitioners to periodically receive the necessary training on the PIC application process, catheter care, and registration, and that the implementation of activities should be followed.[5,6,15] The aim of this study is to determine the incidence of infiltration, which is one of the complications of PIC, and the factors that cause it. It will also show the change in the incidence of infiltration between the past and present in our country. If it is found that infiltration continues despite the development and changes in clinical practice, the aim will be to shed light on the factors causing this infiltration. In this way, it will be possible to ensure the implementation of standards for updating and correcting infiltration policies.

Methods

Aim and Design of the Study

The aim of this study was to determine the frequency of peripheral iv infiltration and risk factors in children. This study was conducted as a cross-sectional and cohort study.

Participants

A prospective, single-center study was undertaken at a tertiary level university hospital. The study was conducted between February 2017 and February 2018. Research data were collected from children who were hospitalized in the pediatric surgery general pediatric and pediatric hematology-oncology departments. The study population consisted of all pediatric patients who were hospitalized within the defined date range and who met the inclusion criteria. In line with the relevant literature,[16] the study sample was calculated to consist of 123 children to yield a 5% Type 1 error with a 95% confidence interval. Considering possible case losses, all children who were referred to the clinics between the planned dates and agreed to participate were included in the study.

The study included children aged 1 to 18 years who had a PIC catheter and were receiving IV medication or fluid therapy. The children were observed and followed up until vascular access was withdrawn. The 1-18 years age range was selected because pediatric departments in the area where the study was conducted accepted children aged between 1 and 18 years.

Data Collection Tools

A patient information form, consisting of 29 questions and the Infiltration Rating Scale were used for data collection.

Patient information form: Questions were created and developed in line with the literature.[6,7] The form consisted of 29 questions, divided into three sections in which the sociodemographic characteristics and catheter-related and infiltration-related features of the patients and the inserted catheter were recorded.

Infiltration rating scale: It was developed by the IV Nurses Association in 2006 to determine infiltration status after PIC.[5] The scale is scored from 0 to 4 points. 0: no discomfort, 4 points: Indicates the presence of complications such as redness, oedema, swelling, stiffness, and purulent discharge at the iv access site. The scale is widely used in our country and in many other countries.[1,5] No studies have been carried out to adapt the scale to Turkish. This is because the scale accurately reflects clinical symptoms, and its items are easily translated into Turkish.

Data Collection

Before starting data collection, ethical approval was obtained from the local ethics committee and institute. Participants (children and their parents) were informed about the study verbally and in writing. Their consent was obtained. After consent, the patient information form was completed by questioning the patients and their parents, and by extracting data from medical records. Completing the patient information form took around 10 minutes. Information about catheterization was obtained from medical records. In line with the Infiltration Rating Scale, the area of the catheter entry point was used in the follow-up

of infiltration, which was observed twice per day by the one researcher, and the findings were recorded. Catheter observation continued until treatment was completed or the catheter was removed, for reasons including infiltration and completion of therapy.

Ethical Aspects of the Research

The necessary written approval from the hospital and the ethics committee for non-interventional studies of the same hospital was obtained (Approval number: 2017/17). Voluntary participation in the study was ensured by providing information about the study to the patients and their parents, and by obtaining verbal and written consent from those who agreed to participate in the study.

Data Analysis

The data were analyzed using the Statistical Package for the Social Sciences for Windows (SPSS), version 25 (IBM Inc., Armonk, NY, USA). The median, minimum, and maximum values were calculated in the analysis of continuous variables, and numbers and percentages were used in the calculation of categorical variables. Normality distributions were examined using the Shapiro-Wilk test. Chi-square (X2) and Mann-Whitney U tests were used for comparisons between and within groups. In the study, a simple linear regression analysis (R^2) model was used to determine the factors causing infiltration. Significance was accepted as $p<0.05$ at the 95% confidence interval.

Results

The study included 176 pediatric patients, with a median age of 6.5 years; the majority (88.1%) were aged under 12 years. Table 1 presents the patient characteristics and catheterization procedures. During the study, one iv catheter was inserted in each patient and a total of 176 catheters were observed. Infiltration occurred in 102 patients and the infiltration rate was 57.9%.

Table 1. Distribution of descriptive features of the children, catheterization, and infiltration status (n=176)

Features	**Median**	**Min-Max**	
Age (years)	6.5	1-17	
		n	**%**
Age group	1-5.9 years	76	43.2
	6-11.9 years	79	44.9
	12 years and older	21	11.9
Sex	Boy	96	54.5
	Girl	80	45.5
Department	Hematology/Oncology	21	11.9
	General Pediatrics	77	43.8
	Pediatric surgery	78	44.3
Infiltration development status	Yes	102	57.9
	No	74	42.1
Degree of infiltration	1	85	48.3
	2	15	8.5
	3	0	0
	4	2	1.2

Table 2 shows the comparison of infiltration status with child and catheterization characteristics. Accordingly, a statistically significant difference was found between the infiltration status and the clinic where the child was hospitalized ($p<0.01$). This was found to be due to being hospitalized in the pediatric surgery clinic. There was also a statistically significant difference between the presence of infiltration and the number of attempts during catheter insertion ($p<0.01$). This was found to be due to 3 or more attempts for catheter insertion. There was no statistically significant difference between age, sex, years of professional experience of the person inserting the catheter and working time in the pediatric department, length of in-dwelling of the catheter, catheter number, catheter site, connector status, detection board usage status, drug characteristics and infiltration development (Table 2).

The features and risk factors of patients that determine the development of infiltration are shown in Table 3. Thus, the number of insertion attempts accounted for 3.9% (R^2=0.039) of the increase in the development of infiltration, 2.4% (R^2=0.024) for the status of vascular access, and 0.4% (R^2 =0.004) for the patient's medical therapy (Table 3).

Discussion

Infiltration can be prevented by standardizing PIC management in accordance with current guidelines and existing literature data.[4,5,7,10] Infiltration was found in 57.9% of the children in the present research, while other investigations found rates ranging from 5.5% to 87%.[6,9,10,18,19] These differences are thought to be caused by the child, the catheter or the purpose of the catheter.[3,9] It will be useful to find out the factors that cause the development of infiltration. This may help to reduce the incidence. In the present study, the likelihood of infiltration occurring varied from clinic to clinic where the child was hospitalized, the number of attempts to achieve catheterization, the stability of the final catheter insertion, and the medical treatment being given, in addition to the individual features of each child. Furthermore, factors that had no effect on the development of infiltration were age of the child (range 1-17 years), professional expertise of the person inserting the catheter (nearly 3 years), and catheter features, such as catheter gauge (no: 22-24) in the present study. This is in contrast to earlier studies where the age of the child, catheter gauge, catheter insertion location (particularly the lower extremities), the use of the connector, and the experience of the healthcare professional placing the catheter were all reported to play a role in the development of PIC.[10,17,18] In contrast to the findings of the present study, it has been previously reported that being a child, the experience of the healthcare professional, and the specific features of the catheter all had an effect in the development of infiltration.[12,20] This could be because of hospital protocols and experience level of the healthcare personnel differ from region to region and from country to country.

In terms of infiltration, the medical specialty where the child was hospitalized, as well as the medical diagnosis, plays a significant role.[3,12] Infiltration was reported to be most prevalent in pediatric surgical clinics (53.9%), followed by general pediatric wards in the present study (29.4%). Earlier studies showed that general pediatric clinics are the source of most hospitalizations in children, and these clinics and those dealing with chronic diseases have the highest infiltration rates (22.8%).[3,12] The medical diagnosis of the child can also contribute to the emergence of infiltration. It is also possible that recurrent iv treatment operations in diagnostic and therapeutic procedures, as well as the propensity of specific medications employed to induce vascular degeneration may also be responsible. The findings of the present investigation support these earlier reports; infiltration rates in pediatric surgical clinics were more than 50%. This indicates that factors including pre-procedure

Table 2. Comparison of the child's and catheterization characteristics and infiltration development status (n=176)

Features		Infiltration [Median (min-max)]					p
		Yes		No		Total	
Age (years)		6 (1-17)		7 (1-17)		6.5 (1-17)	**0.72
Clinical experience of the catheter inserter		3 (1-14)		3 (1-14)		3 (1-14)	**0.46
Pediatric working time of the catheter inserter		3 (1-14)		3 (1-14)		3 (1-14)	**0.56
Length of stay of the catheter (days)		2 (1-10)		2 (1-18)		2 (1-10)	**0.77
		n	**%**	**n**	**%**	**n**	
Age group	1-5.9 years	44	57.9	32	42.1	76	
	6-11.9 years	45	57.0	34	43.0	79	**0.88
	12 years and older	13	61.9	8	38.1	21	
Sex	Boy	59	61.5	37	38.5	96	*0.30
	Girl	43	53.8	37	46.3	80	
Department	Pediatric Surgery[a]	55	70.5	23	29.5	78	
	General Pediatrics[b]	30	39.0	47	61.0	77	***<0.001**
	Hematology/Oncology[c]	17	81.0	4	19.0	21	
		a>b***p*<0.001**		a>c***p*=0.343**		c>b ***p*=0.001**	
The catheter inserter	Nurse	92	57.1	69	42.9	161	
	Physician	2	100	0	0	2	***0.5
	Paramedic	8	61.5	5	38.5	13	
Number of catheters	24 gauge	80	55.5	64	44.5	144	*0.12
	22 gauge	22	68.7	10	31.3	32	
Number of catheter inserts	1st trials[a]	62	52.1	57	47.9	119	
	2nd trials[b]	20	62.5	12	37.5	32	***0.01**
	3 and above trials[c]	20	80	5	20	25	
		a>b***p*=0.296**		**a>c***p*=0.011**		b>c***p*=0.155**	
Catheter site	Upper extremity (hand)	31	56.3	24	43.7	55	
	Upper extremity (arm)	59	55.6	47	44.4	106	***0.35
	Lower extremity	12	80	3	20	15	
Medical treatment	Antibiotic	46	59.7	31	40.3	77	
	Chemotherapy drug	14	77.7	4	22.3	18	
	Antiemetic or Diuretic	1	14.2	6	85.8	7	***0.47
	Parenteral nutrition	10	58.8	7	41.2	17	
	Daily fluid	31	54.3	26	45.7	57	
	Tight	38	50.6	37	49.4	75	
PIC fixation status	Normal	60	61.8	37	38.2	97	***0.09
	Loose	4	100	0	0	4	
Connector status	Yes	96	57.1	72	42.9	168	*0.27
	No	6	75	2	25	8	
	Total	102		74		176	

*Chi Square Test; **Mann Whitney-U Test; ***Kruskal Wallis Test; p<0.05

Table 3. Regression analysis regarding the prediction of infiltration development status of the patient and catheterization (n=176)

	Features	B	Std. E.	β	t	*p*	R	R^2	F	*p*
Infiltration status	Age	.591	.075	-.014	7.936	<.001	.014	.000	.034	0.853
	Sex	.615	.051	-.078	12.166	<.001	.078	.006	1.058	0.305
	Department	.621	.053	-.084	11.784	<.001	.184	.007	1.251	**0.026**
	Clinical experience of the catheter inserter	.572	.059	.013	9.657	<.001	.013	.000	.029	0.865
	Pediatric working time of the catheter inserter	.587	.059	-.012	9.968	<.001	.012	.000	.026	0.872
	Catheter number	.424	.120	.103	3.531	<.001	.103	.011	1.869	0.137
	The catheter inserter	.574	.039	.038	14.699	<.001	.038	.001	.258	0.612
	Number of catheter inserts	.385	.082	.197	4.672	<.001	.197	.039	7.005	**0.009**
	Length of stay of the catheter	.539	.115	.028	4.962	<.001	.028	.001	.137	0.712
	Catheter site	.458	.118	.082	3.866	<.001	.082	.007	1.173	0.280
	PIC fixation status	.495	.055	.154	8.934	<.001	.154	.024	4.216	**0.042**
	Medical treatment	.612	.053	-.066	11.647	<.001	.066	.004	.761	**0.038**
	Connector status	.750	.175	-.075	4.285	<.001	.075	.006	.994	0.320

B: Regression loadings; Std. E.: Standard error; Beta: Standardized coefficients; t: Independent Sample T-Test; p: Significance; R: Regression; R2; Regression square; F: One way ANOVA test; *p*<.05

planning, urgency, and surgery may all influence the development of infiltration in acute diseases.

Teams of iv catheterization including experienced healthcare professionals are required because the professional knowledge and abilities of the personnel who insert the catheter increase success rates.[3,18,21,22] That the nurses in our study had a median of three years of experience and inserted the catheters in most cases on the first attempt shows the importance of experience. Infiltration rates when placing PICs performed by nurses with more professional experience

(11 years of experience or above) were reported to be lower in previous studies [3,21] but the experience of the nurses in another study had lower influence.[22] These data suggest that manipulation abilities improve as the nurses inserting the catheter gain practice.

In our study, the use of a connector, catheter fixation or medical treatment were not found to be among the factors affecting the development of infiltration. However, when the literature was analyzed, these factors were also found to play an important role. The use of connectors and the fixation of the catheter are key to this accomplishment in children.[3] The results in the literature showed that most infiltration after catheterization was caused by catheter displacement or dislocation.[3,12] In the present study, the infiltration rate was found to be low in those who used connectors and support boards. When PIC success is necessary, it appears to be as important to use supports as it is to correctly place the catheter.

The medications being given through the catheter have a significant impact on the development of infiltration.[7,8,20] The density and composition of the medication may damage the vessel wall, predisposing to infiltration. The fact that the specific medical treatment (mostly antibiotics and hypertonic or nutritional solutions) was identified as a risk factor in the development of infiltration in the present study validates this notion. A study including 132 catheters inserted in 113 children in a pediatric emergency and general pediatric clinic, found that 46.6% of catheterizations were used for antibiotherapy.[20] Another study found that the patient's daily fluid was effective in the development of complications (p=0.04).[21] Thus, it is important to remember that after a successful PIC, the next step is medical therapy, with the technique and duration of application adapted to the child.

In the light of the findings of our study and the literature, it was observed that infiltration is still an important complication. It is believed that the studies and protocols developed in this regard are still inadequate. It is believed that identifying the cause of the problem and providing a step-by-step solution may prevent infiltration in general or reduce its incidence.

Limitations

The limitations of the study are that the results cannot be generalized to the whole pediatric population, as the study was conducted at a limited time and in a single center.

Conclusion

Despite the use of recent PIC-related protocols, high infiltration rates were found in this study. The clinic in which the child was hospitalized, the number of attempts to successfully place a catheter, and the medication being given were all risk factors for development of infiltration. To accomplish and sustain a successful catheterization, these risk factors should be recognized, and precautions taken. Some of these precautions may include pre-determining conditions such as the child's age, mobility status, and medical treatment to be received. It is recommended that children who have had PIC should be monitored regularly to observe if infiltration develops after the catheterization.

Conflict of Interest

The authors have no potential conflicts of interest related to the research, authorship, and/or publication of this article.

Compliance with Ethical Statement

Ethical permission was obtained from Kocaeli University, Non-Interventional Research Ethics Committee (KOU GOAEK, 2017/17), and necessary permissions were obtained from the institution where the study was conducted.

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Author Contributions

AS, BM, SD: Concept and Design; AS: Materials; AS, BM: Data Collection; AS, BM: Analysis; AS, BM, SD: Literature Search; AS, BM, SD: Writing.

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