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REVIEW | REVISÃO

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Influence of vascular assessment/visualization in peripheral intravenous catheterization technologies: An integrative review

Influência de tecnologias para avaliação/visualização vascular no cateterismo intravenoso periférico: Revisão integrativa

Influencia de tecnologías para la evaluación/visualización vascular en el cateterismo intravenoso periférico: Revisión integrativa

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ABSTRACT

Objective: to verify the influence of vascular ultrasound, infrared light emission, and transdermal lighting on the success of peripheral intravenous catheterization, number of attempts, time to perform the procedure, catheter stay *in situ* and occurrence of complications in children, when compared to the traditional method. **Method:** this is an integrative literature review carried out from 2018 to 2020 at the Virtual Health Library, PubMed, Science Direct, Scopus, and Web of Science. Original studies, published between 2007 and 2019, comparing the use of these technologies with the traditional method of peripheral intravenous catheterization in children aged 0 - 18 years, were selected. **Results:** of 52 potential studies, 25 made up the final sample. Ten were related to vascular ultrasound use, 11 to infrared light and 4 to transdermal lighting. **Conclusion and implications for practice:** ultrasound seems to be the most effective technology to promote the successful achievement of peripheral intravenous catheterization. However, there is a need for further studies to better determine the effectiveness of the technologies studied in obtaining and maintaining peripheral intravenous catheterization. It may provide clinical practices based on recent evidence, improving the quality of care for hospitalized children and their families, by promoting patient safety.

Keywords: Ultrasonography; Transillumination; Child; Peripheral Catheterization.

RESUMO

Objetivo: verificar a influência da ultrassonografia vascular, emissão de luz infravermelha e iluminação transdérmica no sucesso da cateterização intravenosa periférica; número de tentativas, tempo para a realização do procedimento, permanência do cateter *in situ* e ocorrência de complicações em crianças, quando comparadas ao método tradicional. **Método:** trata-se de uma revisão integrativa da literatura realizada no período de 2018 a 2020 na Biblioteca Virtual em Saúde, PubMed, *Science Direct*, Scopus e *Web of Science*. Foram selecionados estudos originais, publicados entre 2007 e 2019, que comparassem o uso dessas tecnologias com o método tradicional da cateterização intravenosa periférica em crianças de 0 – 18 anos. **Resultados:** de 52 estudos potenciais, 25 compuseram a amostra final, 10 relacionados ao uso da ultrassonografia vascular e 11 da luz infravermelha e 4 da iluminação transdérmica. C**onclusão e implicações para a prática:** o ultrassom parece ser a tecnologia mais eficaz para promover a obtenção bem sucedida da cateterização intravenosa periférica, porém há necessidade de realização de mais estudos que determinem melhor a eficácia das tecnologias estudadas na obtenção e manutenção da cateterização intravenosa periférica. Poderá propiciar práticas clínicas baseadas em evidências recentes, melhorando a qualidade da assistência à criança hospitalizada e sua família, através da promoção da segurança do paciente.

Palavras-chave: Ultrassonografia; Transiluminação; Criança; Cateterismo Periférico.

RESUMEN

Objetivo: verificar la influencia de la ecografía vascular, la emisión de luz infrarroja y la iluminación transdérmica en el éxito del cateterismo intravenoso periférico, el número de intentos, el tiempo para realizar el procedimiento, la permanencia del catéter in situ y la aparición de complicaciones en los niños, en comparación con el método tradicional. **Método:** esta es una revisión de literatura integradora llevada a cabo desde 2018 hasta 2020 en la Biblioteca Virtual de Salud, PubMed, *Science Direct*, Scopus y *Web of Science*. Se seleccionaron estudios originales publicados entre 2007 y 2019 que compararon el uso de estas tecnologías con el método tradicional de cateterización intravenosa periférica en niños de 0 a 18 años. **Resultados:** De 52 estudios potenciales, 25 constituyeron la muestra final, 10 relacionados con el uso de ultrasonido vascular y 11 con luz infrarroja y 4 con iluminación transdérmica. **Conclusión e implicaciones para la práctica:** el ultrasonido parece ser la tecnología más efectiva para promover el logro exitoso del cateterismo intravenoso periférico, sin embargo, se necesitan más estudios para determinar mejor la efectividad de las tecnologías estudiadas para obtener y mantener el cateterismo intravenoso periférico. Puedese proporcionar prácticas clínicas basadas en evidencia reciente, mejorando la calidad de la atención para niños hospitalizados y sus familias, promoviendo la seguridad del paciente.

Palabras clave: Ultrasonografía; Transiluminación; Niño; Cateterismo Periférico.

INTRODUCTION

Regardless of their clinical or surgical condition, hospitalized children will normally need Intravenous Therapy (IVT) for their recovery, aiming at infusing solutions, drugs, nutrients, blood and its derivatives through peripheral or central venous catheter insertion. In IVT, due to the ease, low cost and time to perform the technique, the procedure most commonly performed in pediatric units is Peripheral Intravenous Catheterization (PIC).[1]

However, many patients do not have peripheral venous sites easily located, which can make PIC difficult or even impossible by the method traditionally used in hospital units, performed through visual inspection and palpation of anatomical reference points.[2] Hospitalized children are exposed due to several unsuccessful attempts, which can increase the risk of complications, pain, stress, and suffering.

Secondary analysis of a randomized clinical trial performed with 169 surgical patients found that the catheters that were successful in puncture only after the third attempt increased the risk of infiltration by 6 times, when compared to those that obtained in only one attempt (p=0.0026).[3]

Therefore, in order to promote a safe clinical practice during IVT, health facilities and their workers, especially nurses, will need to innovate it through the use of technologies that contribute to improve care results, more specifically, success of the PIC on first attempt and promoting intravenous longest catheter stay[4] *in situ*.

Vascular ultrasound, near-infrared light emission, and transillumination are some of the technologies used for this purpose.[5] Ultrasonography consists of visualizing internal structures through the emission of sound waves that are mechanical vibrations that induce alternate refractions and compressions of any physical medium that cross.[6] In turn, technologies that use infrared light are based on infrared light beam emission directly at the puncture site.[5] Transillumination consists of light emission under or around the puncture site for network venous visualization.[7]

A recent systematic review[8] published in 2017 included 15 randomized and controlled clinical trials with children and adolescents. It was conducted between 1998 and 2014, totaling 4,665 participants, aiming to identify the interventions associated with success of the PIC on first attempt in children hospitalized in emergency units. The review studies were carried out in Australia, Canada, USA, France, the Netherlands, and New Zealand in emergency units and operating rooms.

This systematic review[8] compared ultrasound, infrared light or transillumination use with the traditional clinical method and concluded that there is not enough evidence to support the use of these technologies in clinical practice during the insertion of PIC in children, aiming to reduce child pain and first attempt success. The aforementioned review followed the Crochrane Library principles and selected studies published between 1989 and 2014.

However, it is necessary to seek new scientific evidence published after the systematic review previously mentioned and that indicate the best strategy for visualizing the child's venous network, whether it is in excellent condition or already classified as difficult to access, and then insert it into the clinical care settings and offer safer care.

Therefore, it is believed that technology use can facilitate peripheral intravenous catheter insertion, guarantee safety and allow the device to remain for a longer time, being one of the solutions to alleviate the suffering of children submitted to PIC and provide an intervention faster when needed.

Therefore, this study aimed to verify the influence of vascular ultrasound, infrared light emission, and transdermal lighting on the success of peripheral intravenous catheterization, number of attempts, time to perform the procedure, catheter stay *in situ* and occurrence of complications in children, when compared to the traditional method.

METHOD

This is an integrative literature review, developed from the PICO strategy, in which "P" refers to the study population (children hospitalized with need for PIC); "I", to the studied intervention (vascular ultrasonography, infrared light emission, and transillumination use for PIC); "C", to another intervention (method traditionally used for PIC); "O", to the outcome of interest (success of peripheral intravenous catheterization, number of attempts, time to perform the procedure, catheter stay *in situ* and occurrence of complications in children, when compared to the traditional method).[9]

The following steps were used to construct this review: theme identification and research question selection, eligibility criteria establishment, literature sampling, data collection, critical analysis of studies, interpretation of results and presentation of the review.[10]

This review was based on the following guiding question: what is the influence of vascular ultrasound, infrared light emission, and transillumination on the success of PIC, number of attempts, procedure time, catheter stay *in situ* and occurrence of complications in hospitalized children, when compared to the traditional method?

A comprehensive electronic search was conducted at the Virtual Health Library, National Library of Medicine (PubMed), Science Direct, Scopus, Web of Science, and CINAHL, from October 2018 to January 2020, from crossing of the following controlled keywords "Child, Peripheral Catheterization, Adverse Effects, Ultrasonography and Transillumination" present at DeCS (*Descritores em Ciências da Saúde* - Health Sciences Descriptors) and their correspondents in English, Spanish at Medical Subject Headings (MESH). The Boolean logic was used with search terms including: Ultrasonography and child and Catheterization, Peripheral or Peripheral Catheterizations; Transillumination and child and Catheterization, Peripheral or Peripheral Catheterizations; Transillumination or Ultrasonography and child and Catheterization, Peripheral or Peripheral Catheterizations and adverse effects.

The eligibility criteria were: (1) being published in Portuguese, English or Spanish; (2) being an original article; (3) being available in full; (4) having been published between the years 2007 to 2019; (5) treating a peripheral venous catheter performed on

children aged 0-18 years; (6) comparing vascular ultrasound use, infrared light emission or transillumination with the traditional method of PIC.

Two independent evaluators participated in the collection, reading and selection of the articles. Initially, the titles and abstracts of all articles found were assessed and those that did not correspond to the objectives of this review were excluded. For each potential study, the full article was examined and, finally, the studies that fit the inclusion criteria were assessed.

The following information was extracted from the selected articles: (1) title, (2) authors, (3) year of publication, (4) country of origin of the study, (5) objective, (6) study design, (7) location of the study, (8) number of participants, (9) intervention used, (10) main results, (11) limitations and conclusion. This information was transferred to a spreadsheet and its main results were analyzed and compared for their convergences and divergences.

RESULTS

Fifty-two articles were found (38 at PubMed and 14 at Science Direct). No articles on the theme were found in the other analyzed databases. During abstract reading, 16 were eliminated for analyzing the adult/elderly population, 7 for treating a peripherally inserted central catheter, 2 for analyzing only the professionals' competence and 2 for including in the sample the age group above 18 years.

At the end, 25 articles were analyzed, 10 related to vascular ultrasound use,[5,11-19] 11 related to use of devices with infrared light emission (3 on AccuVein®,[20-22] 7 on VeinViewer®[7,23-28] and 1 on VascuLuminator®)[29] and 4 related to transillumination (LED-powred,[30] Veinlite®[31,32] and fiber optic lighting).[33] A study compared at the same time an infrared light emission device (VeinViewer®) with a transillumination device (WeeSight®).[28] Study characterization is described in Chart 1.

Chart 1. Characterization of the selected articles. Feira de Santana, BA.

	Authors/Year of Publication	Type of Study/ Technology used	Population/Sample/Age
Vascular Ultrasonography	Avelar et al.[15]	RCT/Ultrasound	335 children (0 to 18 years)
	Benkhadra et al.[11]	RCT/Ultrasound	40 children (<3 years)
	Bair et al.[12]	RCT/Ultrasound	44 children (<7 years)
	Curtis et al.[13]	RCT/Ultrasound	428 children (≤16 years)
	Oakley & Wong[14]	Observational Prospective Study/Ultrasound	84 children (<18 years)
	Avelar et al.[15]	RCT/Ultrasound	335 children (12 days to 17 years)
	Takeshita et al.[16]	RCT/Ultrasound	96 children (1 to 2 years)
	Doniger et al.[17]	RCT/Ultrasound	50 children (<10 years)
	Vinograd et al.[18]	RCT/Ultrasound	167 children (0 to 18 years)
	Gopalasingam et al.[19]	RCT/Ultrasound	50 children (> 6 months and <4 years)
Infrared light	Rothbart et al.[20]	RCT/AccuVein®	238 children (0 to 17 years)
	Kaddoum et al.[21]	RCT/AccuVein®	146 children (0 to 17 years)
	Demir et al.[22]	RCT/AccuVein®	129 children (3 to 18 years)
	Kim et al.[7]	RCT/VeinViewer®	111 children (1 month to 16 years)
	Hess[23]	Prospective non-randomized study/VeinViewer®	241 children (11 days to 17 years)
	Chapman et al.[24]	RCT/VeinViewer®	336 children (0 to 17 years)
	Szmuk et al.[25]	RCT/VeinViewer®	299 children (0 to 17 years)
	Sun et al.[26]	RCT/VeinViewer®	60 children (3 months to 17 years)
	Perry et al.[27]	RCT/VeinViewer®	123 children (0 to 20 years)
	Peterson et al.[28]	Prospective non-randomized study/WeeSight® and VeinViewer®	546 children (0 to 3 years)
	Van der Woude et al.[29]	RCT/VascuLuminator®	88 children (0 to 15 years)
Transillumination	Hosokaw et al.[30]	RCT/(LED)-powered	136 children (0 to 3.7 years)
	Katsogridakis et al.[31]	RCT/Veinlite®	240 children (5 days to 15 years)
	Gümüş et al.[32]	RCT/Veinlite®	112 children (1 to 10 years)
	Yamazaki et al.[33]	RCT/Transmitted Light Fibreoptic	100 children (2 to 5 years)

Source: prepared by the authors.

Most studies were randomized clinical trials (RCTs) (22 studies), only one of the studies was observational,[14] and two were clinical trials, but not randomized.[23,28] The studies were predominantly international, conducted in the United States,[11,13,16,18,24,25,28,31] Japan,[15,29,31] Germany,[15,24] Turkey,[22,32] France,[9] Canada,[11] Australia,[21] and Thailand.[25] Only two national studies were found, both related to ultrasound use.[5,15]

Few studies have been found on technology use, mainly vascular ultrasonography and AccuVein®, which reinforces the need for more randomized clinical trials on these technologies. No study addressed Venoscope use as a technology for transillumination, which may be due to the scarcity of national investigations on technology use to visualize the peripheral venous network as an aid in carrying out the PIC.

As for the unit, most studies were carried out in the pediatric emergency department,[12-18,21,24,30,32] followed by surgical center and hospitalization units,[5,11,15,16,19,20,28,29] which can be justified by the higher volume of PIC, the need for greater speed in its performance and also the greater dexterity required due to the patient's clinical conditions, which make the procedure more complex.[34]

Only ten studies delimited the exact lower age limits of their participants.[7,15,16,19,22,23,26,31-33] Among them, three included neonates, infants, preschoolers, schoolchildren, and adolescents in the same study;[15,23,31] two included infants, preschoolers, schoolchildren, and adolescents;[7,26] two included preschoolers and schoolchildren,[19,33] one included infants, preschoolers, and schoolchildren;[32] and another included preschoolers, schoolchildren, and adolescents.[22] However, only one of them separated the age groups at the time of the analysis of their outcomes.[15] The other 15 studies delimited only the upper age limit of their participants and did not analyze the age groups separately in their results.

Variation between the age groups of the participants interferes in the reliability of the results presented. Children age influences the success of the PIC, because due to the anatomical variation, older children have less risk for failure in the PIC.[34]

The most studied variables were first attempt success rate,[5,7,11-14,18-27,29-32] followed by the procedure time,[7,11,13,14,16-22,24,26,29,30,32] the overall success rate[5,11,12,14,16-18,28,31,33] and the number of attempts.[11,13,17-24,26,32] Only two studies analyzed the occurrence of complications (infiltration and phlebitis)[15,18] and two analyzed the catheter's stay time,[5,18] all related to ultrasound use.

It is observed that not all studies analyzed all variables, demonstrating gaps that still exist in the literature, mainly regarding the occurrence of complications and the catheter's stay time, since these were analyzed in only two studies. Article synthesis is described in Chart 2.

Chart 2. Synthesis of selected articles. Feira de Santana, BA, 2020.

Authors	Objectives	Results
Avelar et al.[15]	Verifying if vascular ultrasound increases the assertiveness in peripheral intravenous catheter and catheter stay time use when compared to the traditional puncture method.	No significant differences were observed in the overall success rate (p=0.970), in first attempt success rate (p=0.232), or in the catheter stay time (p=0.121).
Benkhadra et al.[11]	Comparing vascular ultrasound use with the standard technique in children <3 years of age who require general anesthesia.	Ultrasound reduced the average PIC time (63.5 seconds versus 420.5 seconds, p<0.001); the average number of punctures (1 versus 2.5, p= 0.004); and increased the first attempt success rate (85% versus 35%, p=0.0012), when compared to the traditional method. The overall success rate did not differ significantly between groups (90% versus 85%, ultrasound versus standard technique, p=0.63)
Bair et al.[12]	Determining whether a static ultrasound technique use could: a) allow clinicians to view peripheral veins; b) improve PIC success rates.	The groups that used ultrasound had the same success rate when compared to the traditional method (57%). Success of PIC on first attempt was greater in the ultrasound group when compared to the traditional method (35%, versus 29%).
Curtis et al.[13]	Determining whether ultrasound or infrared use to guide PIC would be more effective than the standard method in obtaining a successful catheter on first attempt.	There were no significant differences in the first attempt success rate - **general population:** (p=0.3) **younger than 3 years:** (p=0.2); nor in the procedure time (p <0.5) as well as the number of attempts both for the total sample (Ultrasound: 1 versus traditional method: 1) and in children under 3 years old (Ultrasound: 1.5 versus traditional method: 1).

Source: prepared by the authors.

Chart 2. Continued...

Authors	Objectives	Results
Oakley & Wong[14]	Assessing the implantation and usefulness of vascular ultrasound to assist PIC in a pediatric emergency department.	Ultrasound increased the success rate in the general sample (42% versus 38%, p=0.08) and in patients with difficult access (success 35% versus 18%, p=0.003), as well as first attempt success rate (64% versus 49%, p=0.08). Attempts with vascular ultrasound use took longer than attempts with the traditional method (4 minutes versus 2 minutes and 15 seconds, p <0.001).
Avelar et al.[15]	Analyzing whether vascular ultrasound use during the routine insertion of peripheral catheters increases the success rate and reduces the incidence of infiltration and phlebitis, compared to the standard reference method for catheter insertion.	There were no significant differences in the success rate in any of the subgroups analyzed: **> 2 years** (p=0.148); **2-7 years** (p=0.848); 7–12 years (p=0.538); 12 - **18 years old:**(p=0.055). Regarding the occurrence of complications, infiltration increased significantly with vascular ultrasound use (73.9% versus 51.1%; p=0.026).
Takeshita et al.[16]	Examining the factors that affect the PIC of invisible and impalpable veins in children and assess the best site for ultrasound-guided catheterization.	Vascular ultrasound use increased the success rate of PIC (68% versus 39%; (p=0.002) and reduced the procedure time (54 “versus 180”; p=0.003)
Doniger et al.[17]	Assessing whether ultrasound use improves the success rate, reduces the number of attempts, the number of needle redirects and the total time for PIC in pediatric patients with difficult access in a pediatric emergency.	The overall success rates for the ultrasound group were 80% and for the control group 64% (p=0.208). Ultrasound reduced the total time (6.3 versus 14.4 minutes, p= 0.001); the number of attempts (average, 1 against 3; p= 0.004), when compared to the traditional method.
Vinograd et al.[18]	Determining whether ultrasound improves first attempt success rates at PIC compared to traditional palpation methods for children with difficult access.	Ultrasound increased the first attempt success rate (85.4% versus 45.8%), reduced the average number of attempts (2 versus 1) and the time to perform the procedure (28 minutes versus 14 minutes) and increased catheter stay (4.5 days versus 2.6 days). No significant differences were found in the occurrence of complications (48% in the control group versus 40% in the ultrasound group) (p> 0.05).
Gopalasingam et al.[19]	Comparing ultrasound use with the standard palpation technique for PIC in anesthetized children undergoing low-risk elective procedures.	First attempt success rate and overall success rate were higher with ultrasound use (84% versus 60%; p=0.029) and (100% versus 84%; p=0.008), respectively. There were no significant differences in the number of attempts (p=0.05) and the procedure was slightly longer in the ultrasound group (192s versus 102s), but without statistical significance (p=0.073).
Rothbart et al.[20]	Assessing whether Accuvein® (AV300) use facilitates PIC in children	Accuvein® reduced the average time of successful PIC when compared to the traditional method (1 min versus 2 min, p <0.01), but it increased the average number of attempts (2 versus 1, p <0.01) and reduced the first attempt success rate (0.45% versus 0.73%, p <0.01).

Source: prepared by the authors.

Chart 2. Continued...

Authors	Objectives	Results
Kaddoum et al.[21]	Assessing the effectiveness of Accuvein® (AV300) to improve the first attempt success rate at PIC of anesthetized pediatric patients.	First attempt success rate did not increase with significant results in the general sample or in the subgroup of children under 2 years old (p=0.85 and 0.62, respectively), as well as the number of attempts (p=0.86) and the procedure time (p=0.047).
Demir et al.[22]	Determining the effect of using a vein visualization device on the success of the procedure based on the number of attempts per patient, duration of the procedure and the first attempt success rate.	The procedure time was shorter with AccuVein® use than with the traditional method (37.24 seconds versus 172.6 seconds; p=0.001), with fewer attempts (1.08 versus, 2.23 p <0.01). AccuVein® use also increased the first attempt success rate (91.7% versus 47.4%; p=0.001).
Kim et al.[7]	Comparing the PIC first attempt success rate between traditional method use and VeinViewer® use.	VeinViewer® use obtained a higher first attempt success rate (72% versus 57%), but without statistical significance (p=0.526). When performing logistic regression considering patients with difficult venous access, the result was significant (p=0.048).
Hess[23]	Assessing the effectiveness of a vein visualization device on the success of PICs performed by nurses in a pediatric surgical unit.	VeinViewer® use increased the first attempt success rate (80%) when compared to the traditional method (49%) (p <0.01), as well as reducing the number of attempts from 1.97 to 1.29 (p <0.001).
Chapman et al.[24]	Assessing whether VeinViewer® use reduces the time and number of attempts at PIC in children in the pediatric emergency department.	First attempt success rate did not obtain significant results neither in the general sample nor in the subgroup of 0-2 years (p=0.53 and 0.19, respectively), as well as the number of attempts (p=0.3) the procedure time obtained a significant reduction with VeinViewer® use in the subgroup of 0-2 years (121 minutes versus 167 minutes, p=0.047).
Szmuk et al.[25]	Assessing whether VeinViewer® improves the success rate in PIC by nurses experienced in pediatric patients.	PIC use obtained a higher success rate (61%) than VeinViewer® use (47%), (p=0.0003)
Sun et al.[26]	Assessing the effectiveness of VeinViewer® use to visualize the venous network in sick children.	First attempt success rate was the same both with VeinViewer® use and with the traditional method (30%), but the number of attempts and the procedure time were reduced with VeinViewer® use (1 versus 2, p=0.04 and (186.16 minutes versus. 427.87 minutes, p=0.014).
Perry et al.[27]	Determining whether infrared light device use (VeinViewer®) improves PIC first attempt success rate in a pediatric emergency department.	First attempt success rate was higher with the traditional method use (79%) than with VeinViewer® use (72.1%), but without statistical significance (p=0.36).
Rothbart et al.[20]	Assessing whether Accuvein® (AV300) use facilitates PIC in children	Accuvein® reduced the average time of successful PIC when compared to the traditional method (1 min versus 2 min, p <0.01), but it increased the average number of attempts (2 versus 1, p <0.01) and reduced the first attempt success rate (0.45% versus 0.73%, p <0.01).

Source: prepared by the authors.

Chart 2. Continued...

Authors	Objectives	Results
Peterson et al.[28]	Examining the successful visualization of veins by two PIC auxiliary devices by nurses and pediatric surgical doctors.	WeeSight® and VeinViewer® use had success rates close to (35.3% and 32.3%, respectively) and lower than those obtained using the traditional method (52.2%), (p=0.001).
Van der Woude et al.[29]	Verifying the effectiveness of an infrared device (VascuLuminator®) to facilitate PIC in children with dark skin color.	VascuLuminator® use increased the first attempt success rate (63% versus 51%) and reduced the procedure time (53 seconds versus 68 seconds), when compared to the control group, but did not obtain significant results (p=0.27 and 0.50, respectively). In the subgroup with difficult venous access, VascuLuminator® significantly increased the first attempt success rate (p=0.03).
Hosokaw et al.[30]	Comparing the success rate and duration of PIC with and without transillumination use.	The success rate with transillumination was higher (75%) when compared to the traditional method (61%), but without statistical significance (p=0.10), in children under 2 years old, transillumination achieved statistical significance (p=0.03). Regarding the procedure time, teransilumination use significantly reduced it (p=0.01).
Katsogridakis et al.[31]	Assessing PIC using Veinlite®.	The success rate in two attempts was higher with Veinlite® use (59.5% versus 56.3%, p=0.01), whereas first attempt success only obtained statistical significance after logistic regression (p=0.03).
Gümüş et al.[32]	Assessing the effectiveness of Veinlite® PEDI to improve the visualization of veins in the pediatric emergency department.	Veinlite® increased the first attempt success rate (92.9% versus 72.2%, p <0.004); reduced the number of attempts 1.07 versus 1.31 p=0.04) and the total time of attempts compared to the control group (49.98 versus 59.68 seconds p=0.01)
Yamazaki et al.[33]	Assessing success rates for PIC in children using transillumination.	Transillumination use with fiber optic lighting increased the success rate of PIC (p=0.0000002).

Source: prepared by the authors.

DISCUSSION

Overall success rate

The overall success *rate* of infrared light was analyzed in one study (VeinViewer®)[28] and transillumination was analyzed in three studies (WeeSight®,[28] Veinlite®[31] and fiber optic lighting).[33] Among the latter, the one using Veinlite® increased this rate by 11.1% when compared to the control group (p=0.01).[31] When using fiber optic lighting, the overall success rate increased by 33% (p=0.0000002).[33]

However, WeeSight® and VeinViewer® use obtained lower overall success rates, 35.3% and 32.3%, respectively (p =0.001), compared to the traditional clinical method.[28]

Among the ultrasound studies, seven of them increased the overall success rate, reaching results between 43 to 100% in the intervention group.[5,11,12,14,16,17,19] However, of these, only two obtained statistical significance when analyzing the total sample (p=0.002 and p=0.008).[16,19] When analyzing separately the accesses considered as difficult, a study obtained significance (p=0.003).[14] Articles that obtained statistical significance with ultrasound use increased the overall success rate by 16%,[19] 17%[14] and 19%,[16] when compared to the control group.

Therefore, it seems that among the technologies studied, equipment that uses fiber optic lighting transillumination increases the overall success rate of PIC more than the traditional method use. It is believed that the use of these technologies in comparison

to equipment that works on the basis of ultrasonography is more portable and easy to handle by the professional operator of the catheterization technique.

The child's movement or stress during PIC attempts can influence image formation in the studied devices, compromising the overall success rate mainly with infrared light and ultrasound use. None of the studies analyzed considered this variable.

First attempt success rate

First attempt success rate was analyzed in nine of the studies on infrared light (AccuVein®,[20-22] VeinViewer®,[7,23-27] and VascuLuminator®).[29]

In studies on VeinViewer®, the results with this technology use were between 47 to 80% and the results of the control group between 49 to 79%.[7,23-27] Of these, only two achieved statistical significance, one of which presented a 31% increase in the first attempt success rate among participants who used the technology, when compared to the traditional method (p <0.01).[23] Another presented a reduction of this rate in 15% in comparison to the control group (p=0.0003).[25]

With regard to AccuVein®, the results showed a first attempt success rate of 45 to 91.7%.[20-22] However, only two achieved statistical significance, one increased the rate by 44.3% (p=0.001).[22] The other showed a 0.28% decrease in first attempt success using the technology, in comparison to the traditional method use (p <0.01).[20] VascuLuminator® increased the first attempt success rate by 12%, but without statistical significance (p=0.27).[29]

Three studies on transillumination used this variable (1 with the LED-powered[30] and two with Veinlite®).[31,32] The LED-powered increased first attempt success by 14% when compared to the traditional method, however it did not obtain statistical significance (p=0.1).[30] Veinlite® in one study increased the first attempt success rate by 9.1% (p <0.04),[32] but in another study, it only obtained statistical significance after logistic regression (p=0.03).[31]

Seven studies on ultrasound[5,11-14,18,19] used this variable, obtaining results between 29 to 85.4%.[5,11-14,19,20] However, of these, only three obtained statistically significant results showing an increase of 50% (p=0.0012),[11] 39.6% (p <0.05)[19] and 24% (p=0.09)[20] in the first attempt success rate with the use of this technology, when compared to the traditional method.

Many studies showed increases in first attempt success rates. However, only three studies that used vascular ultrasound,[11,19,20] two that used infrared light (VenViewer® [23] and AccuVein®),[22] and two that used transillumination (Veinlite®)[31,32] obtained statistically significant results. Therefore, it is necessary to carry out further studies that include this variable in their analysis.

Among the technologies that achieved significance, the ones that most increased the first attempt success rate were AccuVein® and ultrasound.

Number of attempts

The number of attempts was assessed in six studies on infrared light (VeinViewer®[23,24,26] and AccuVein®).[20-22] Regarding VeinViewer® use, two studies calculated the average of attempts, finding the same result with technology use (average 1),[24,26] but they differed in relation to the results in the control group obtaining average 2 (p=0.04)[26] and average 1.[24] The latter had no statistical significance (p=0.5).[24] Another study on VeinViewer® averaged and obtained 1.29 with technology use and 1.97 with the traditional clinical method use (p <0.001).[23]

With regard to AccuVein®, three studies analyzed this variable, which demonstrated an increase in the number of attempts with technology use, obtaining a average 2 with technology use and 1 with the traditional method and averages 1.33[21] and 1, 08[22] with technology use; 1.29[21] and 2.23[22] using the traditional method. However, only two obtained statistically significant results (p <0.01).[20,22]

Only one study on transillumination using the Veinlite® device used this variable, obtaining an average of 1.07 attempts with technology use and 1.31 with the traditional method (p=0.04).[32]

Five studies on ultrasound use analyzed this variable[11,13,15,18,19]. Three of them obtained an average of 1,[11,17,18] whereas the control group obtained averages of: 2,[18] 2.5[11] and 3[17] with statistical significance (p=0.004)[11,17] and (p <0.05)[18] in their results, reducing by half or more the number of attempts when compared to the control group. A study separately analyzed patients aged 16 years or less, 3 years or less and more than three years obtaining averages of 1, 1.5 and 1, respectively,[13] but without statistical significance.

Ultrasound, among the technologies, was the one that obtained the most significant results in terms of reducing the number of attempts, therefore, it seems that, when comparing it with the traditional clinical method of PIC, it can provide benefits, such as the immediate onset of IVT, minimizing the stress of children and their families and helps to preserve the vascular anatomy of the damage caused by this procedure.

Procedure time

Procedure time was assessed in seven studies on infrared light (VeinViewer®,[7,21,24,26] AccuVein®,[20-22] and VascuLuminator®).[29] VeinViewer® reduced the procedure time when compared to the traditional method,[7,21,24,26] However, the statistical significance was observed in only two studies. One showed a reduction of 311.05 seconds in the procedure time, in comparison with the control group (p=0.014),[26] and the other showed a reduction of 46 seconds in the subgroup composed of children under two years old when comparing technology use to the traditional method (p=0.047).[24]

AccuVein® also reduced the procedure time in all studies,[20-22] but there was statistical significance in only two studies, in which AccuVein® use reduced the procedure time by 60 (p <0, 01)[20] and 135.6 (p=0.001)[22] seconds, when compared to the traditional method. Finally, VascuLuminator® reduced the time by 15 seconds when compared to the traditional method, but without statistical significance (p=0.50).[29]

Two studies on transillumination assessed this variable (LED-powered[30] and Veinlite[32]). The LED-powered time was reduced by 21 seconds, when compared to the traditional

method (p=0.01).[30] With Veinlite® use, this time was reduced by 9.7 seconds (p=0.01).[32]

Seven studies on ultrasound analyzed this variable, obtaining results between 54 to 510 seconds.[11,13,14,16-19] Of these, five found statistically significant values, noting that the use of this technology reduced the procedure time by 486 seconds (p=0.001);[17] 126 seconds (p=0.003),[16] 105 seconds (p <0.001),[14] 357 seconds (p< 0.001),[11] and 14 minutes (p <0.05).[18]

Therefore, it seems that among the technologies, the one that most reduced the procedure time, when compared to the traditional method was ultrasound. The reduction of this time generates faster interventions and, in this way, improves the assistance and eases the stress of the child and his/her family.

Occurrence of complications

The occurrence of complications was assessed in only two articles,[15,18] one of which found higher rates of infiltration in the group with ultrasound use (73.9%), compared to the control group (51.1%) (p=0.026). However, phlebitis rates decreased with technology use by 11.3%, despite not having reached statistical significance (p=0.09).[15] The other found a reduction of 8% in the occurrence of complications with ultrasound use, but without statistical significance (p> 0.05).[18]

The reduction in the number of complications may favor an increase in the catheter's stay time, since it will not need to be removed before the end of IVT, which will reduce extra costs caused by a new procedure, in addition to reducing damage to the physical integrity of the contributing to the promotion of safe practices. The scarcity of studies with this variable prevents the achievement of more concrete results on the reduction or not of complications, especially with respect to technologies based on transillumination that have not been assessed for this variable in any study.

Catheter residence time

The two studies that used this variable were performed with ultrasound,[5,18] one of which demonstrated a reduction in the period of stay of the device with technology use (22.0 hours), when compared to the control group (23.1 hours), but without statistical significance (p=0.121).[5] The other found a longer stay (4.5 days) compared to the control group (2.6 days) (p <0.05).[18]

Therefore, it is necessary to develop investigations about this variable, both in relation to ultrasound, as well as to technologies based on transillumination, in order to obtain more concrete results to aid in clinical practice.

Limitations and advantages of studies

The articles had several limitations that influenced their final results, the most common were sample size, given as small or insufficient in eight studies;[12-15,17,20,23,30] enlargement of the vein far beyond its normal size by the device, giving a false idea of depth and favoring the occurrence of transfixation, indicated by five studies;[7,20,21,25,27] and difference in the age groups among children of the control and intervention groups, also in five of the studies analyzed in this review.[5,14,15,23,28]

Despite these limitations, the technologies presented many advantages when compared to the traditional PIC method, as they increase first attempt success and reduce procedure time and number of attempts. Consequently, it will preserve the integrity of the vascular endothelium and decrease the episodes of stress and suffering that this procedure causes both the child and his/her family, thus promoting patient safety.

CONCLUSION

Technology use for direct visualization of the venous network allows a faster and more accurate identification of the insertion site, when compared to standard techniques that are based on superficial anatomy and estimate the location of the vessel. Thus, they reduce the time and the number of attempts, mainly in venous networks considered difficult to catheterize.

Among the technologies discussed in this study, ultrasound seems to be the most effective technology to promote the successful achievement of PIC. It achieved more satisfactory results in terms of first attempt success, procedure time and number of attempts compared to the method traditional clinical practice.

However, incipient production and publication of knowledge made it difficult to obtain more conclusive results to better determine the effectiveness of the technologies studied in obtaining and maintaining PIC. As for the national literature, it was noticed that there are few studies with this theme highlighting transillumination technologies, since no research was found.

Moreover, most studies have analyzed the reality of the pediatric emergency, therefore it is necessary to carry out research in other contexts of clinical reality, such as, for instance, medical, surgical and oncological units, in order to understand the performance of the PIC in different situations of care for hospitalized children.

Therefore, this review generated new polls that demonstrate the need to conduct other clinical trials on the use of these technologies, in order to reduce limitations and fill the gaps in the literature on the subject, in addition to providing clinical practices based on recent evidence, improving the quality of care for hospitalized children and their families, by promoting patient safety.

AUTHOR'S CONTRIBUTIONS

Review study design, acquisition, data analysis and interpretation of results, writing and critical review of the manuscript, approval of the final version of the article, responsibility for all aspects of the content and the integrity of the published article: Sarah Almeida Santos and Luciano Marques dos Santos. Acquisition, data analysis and interpretation of results, writing and critical review of the manuscript, approval of the final version of the article, responsibility for all aspects of the content and the integrity of the published article: Ariane Ferreira Machado Avelar, Bianka Souza Martins Silva, and Rosana Castelo Branco de Santana.

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