

## **CONSTRUCTION AND APPLICATION OF A DECISION-MAKING FLOWCHART FOR DIFFICULT PERIPHERAL INTRAVENOUS PUNCTURE IN CHILDREN**

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### **ABSTRACT**

**Objectives:** to construct and verify the clinical applicability of a flowchart for assessing children and adolescents who will undergo peripheral intravenous catheterization, according to risk factors for procedure failure.

**Method:** this is a methodological and observational study, which followed the AGREEII instrument guidelines and steps for the construction of a decision-making flowchart for difficult peripheral intravenous puncture. Afterwards, clinical applicability with children and adolescents was verified after approval of ethical merit, with the main outcome being the success rate in the first puncture attempt. It was verified, through statistical analysis, the association of the outcome with the risk factors raised.

**Results:** in the first stage of the study, a literature review was carried out to survey the risk factors for difficult puncture, and prematurity, less than three years, more pigmented skin, obesity, chronic diseases, dehydration, vein difficult to see and/or not palpable, history of multiple punctures and complications of intravenous therapy were found. After applying the flowchart, it was found that 96.3% of the children and adolescents assessed were at risk of being punctured more than once and that 43.9% underwent more than one procedure for success. Those who were unsuccessful on the first attempt were younger than three years old, had chronic disease, vein difficult to see, not palpable vein and a history of multiple punctures.

**Conclusion:** flowchart construction was based on the risk factors for difficult puncture identified in the literature. Clinical applicability showed that it can be a useful tool to identify children and adolescents at risk for puncture failure.

**DESCRIPTORS:** Pediatric nursing. Catheterization peripheral. Infusions intravenous. Risk factors. Risk assessment.

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# CONSTRUÇÃO E APLICAÇÃO DE FLUXOGRAMA DECISÓRIO PARA PUNÇÃO INTRAVENOSA PERIFÉRICA DIFÍCIL DE CRIANÇAS

## RESUMO

**Objetivos:** construir e verificar a aplicabilidade clínica de um fluxograma para avaliação de crianças e adolescentes que serão submetidos à cateterização intravenosa periférica, segundo fatores de risco para insucesso do procedimento.

**Método:** estudo metodológico e observacional, que seguiu diretrizes e etapas do instrumento AGREEII para a construção do fluxograma decisório para punção intravenosa periférica difícil. Depois, verificou-se a aplicabilidade clínica com crianças e adolescentes, após aprovação do mérito ético, sendo o desfecho principal o índice de sucesso na primeira tentativa de punção. Verificou-se, por análise estatística, a associação do desfecho com os fatores de risco levantados. A coleta dos dados foi realizada entre os meses de novembro de 2018 e fevereiro de 2019.

**Resultado:** na primeira etapa do estudo realizou-se revisão de literatura para levantamento dos fatores de risco para a difícil punção sendo encontrados prematuridade, menos de três anos, pele mais pigmentada, obesidade, doenças crônicas, desidratação, vasos difíceis de serem visualizados e/ou palpados, história de múltiplas punções e complicações da terapia intravenosa. Após aplicação do fluxograma, verificou-se que 96,3% das crianças e adolescentes avaliados tinham risco para serem puncionados mais de uma vez, e que 43,9% foram submetidos a mais de um procedimento para o sucesso. Os que não obtiveram sucesso na primeira tentativa tinham menos de três anos, possuíam doença crônica, difícil visualização e palpação dos vasos e histórico de múltiplas punções.

**Conclusão:** a construção do fluxograma foi fundamentada nos fatores de risco para a difícil punção identificados na literatura. A aplicabilidade clínica mostrou que pode ser instrumento útil para identificar crianças e adolescentes com risco para insucesso da punção.

**DESCRITORES:** Enfermagem pediátrica. Cateterismo periférico. Infusões intravenosas. Fatores de risco. Avaliação de risco.

# CONSTRUCCIÓN Y APLICACIÓN DE UN DIAGRAMA DE FLUJO DE TOMA DE DECISIONES PARA LA PUNCIÓN INTRAVENOSA PERIFÉRICA DIFÍCIL EN NIÑOS

## RESUMEN

**Objetivos:** construir y verificar la aplicabilidad clínica de un diagrama de flujo para la evaluación de niños y adolescentes que serán sometidos a cateterismo intravenoso periférico según factores de riesgo de falla del procedimiento.

**Método:** estudio metodológico y observacional, que siguió las pautas y pasos del instrumento AGREEII para la construcción del diagrama de flujo de toma de decisiones para la punción intravenosa periférica difícil. Posteriormente, se verificó la aplicabilidad clínica con niños y adolescentes, previa aprobación del mérito ético, siendo el resultado principal la tasa de éxito en el primer intento de punción. Se verificó, a través del análisis estadístico, la asociación del desenlace con los factores de riesgo planteados.

**Resultado:** en la primera etapa del estudio se realizó una revisión bibliográfica para relevar los factores de riesgo de la punción difícil, encontrándose prematuridad, menos de tres años, piel más pigmentada, obesidad, enfermedades crónicas, deshidratación, vasos difíciles de visualizar y/o palpar, antecedentes de múltiples punciones y complicaciones de la terapia intravenosa. Después de aplicar el diagrama de flujo, se encontró que el 96,3% de los niños y adolescentes evaluados tenían riesgo de ser puncionados más de una vez, y que el 43,9% se sometió a más de un procedimiento con éxito. Los que no tuvieron éxito en el primer intento eran menores de tres años, tenían enfermedad crónica, dificultad para la visualización y palpación de los vasos y antecedentes de múltiples punciones.

**Conclusión:** la construcción del diagrama de flujo se basó en los factores de riesgo para punción difícil identificados en la literatura. La aplicabilidad clínica demostró que puede ser una herramienta útil para identificar a niños y adolescentes con riesgo de fracaso de la punción.

**DESCRIPTORES:** Enfermería pediátrica. Cateterismo periférico. Infusiones intravenosas. Factores de riesgo. Medición de riesgos.

## INTRODUCTION

Intravenous therapy (IVT) in hospitalized children is part of the care provided by the health team. Among the actions involving this practice, peripheral intravenous catheter insertion stands out, a procedure often performed by nurses. When success is not achieved on the first attempt, multiple procedures can often be performed to install the intravenous device. Faced with this clinical condition, there is a need to institute, in advance, interventions to perform catheter puncture and maintenance<sup>1-4</sup>.

Identifying risk factors that would make puncture success difficult, especially in the first attempt, collaborates in care planning, in order to carry out a safe practice and contribute to clarifying patients and their families about how professionals will perform the procedure, the strategies used to minimize pain and discomfort, based on care protocols, thus managing children's and families' expectations<sup>1-2,4-7</sup>.

Care protocols are guiding instruments for planning care related to IVT and help to identify children with vein difficult to be puncture. These instruments are prepared, in the vast majority of cases, systematically, by a professional specialist in the subject, based on scientific evidence and professionals' experiences, guiding the step-by-step conduct and clinical procedures. The flowchart can be one of the ways to identify and direct care to children with difficult to be puncture, being represented with algorithms by a well-defined sequence of instructions<sup>1,3,4,7</sup>.

Thus, a decision-making flowchart that identifies children and adolescents with risk factors for difficult to be puncture can help nurses to decide the best conduct for a successful procedure and to minimize the stress and suffering of children, adolescents and families, seeking that only one puncture attempt is performed and that the intravenous catheter remains until the end of treatment, consequently, avoiding damage to the veins related to multiple punctures<sup>4,8</sup>.

Considering the aforementioned factors, this study was carried out with the objective of constructing and verifying the clinical applicability of a flowchart for the assessment of children and adolescents who will undergo peripheral intravenous catheterization, according to risk factors for procedure failure.

## METHOD

This is a methodological and observational study. To construct the flowchart, we followed the guidelines and steps recommended by the AGREEII instrument, being the delimitation of an objective for a specific population the use of systematic methods for search of evidence and determination of clear criteria for evidence selection and flow construction<sup>7</sup>.

### Delimitation of an objective for a specific population

For objective and population delimitation, the search question was elaborated: which risk factors for difficult peripheral intravenous puncture, related to children and adolescents, can cause multiple procedures?

### Systematic methods for searching for evidence

To identify the main risk factors for difficult puncture, a systematic search for scientific evidence was carried out, following the steps recommended for the elaboration of an integrative review<sup>9</sup>. Thus, the controlled descriptors "pediatric nursing" and "peripheral catheterization" were used, which are present in the Health Science Descriptors (DeCS), and "pediatric nursing" and "catheterization, peripheral", which appear in the MeSH (Medical Subject Headings). To make the crossing between

the terms, the Boolean logical operator “AND” was used, with the objective of obtaining the largest number of articles that answered the guiding question.

The research was carried out in the National Library of Medicine (PubMed) and Scientific Electronic Library Online (SciELO) libraries, and in the Cumulative Index to Nursing and Allied Health Literature (CINAHL), Excerpta Medica dataBASE (EMBASE), Latin American Literature of Health Sciences (LILACS) and Nursing Database (BDENF) databases. After searching the six databases, the results found were exported to EndNote® in a single database for analysis and synthesis of results. The fields of authors’ names, year of publication, title, journal, volume, number, pages, Digital Object Identifier (DOI) for article location, keywords, abstract and full text were the items analyzed and stored for each article.

## **Evidence selection criteria**

The first selection took place by reading studies’ titles and abstracts, managed by EndNote®, in which duplicate studies were excluded. Then, those that were not in Portuguese, English or Spanish were eliminated. Thus, abstracts of publications were analyzed.

Theses, dissertations, editorial opinions, qualitative studies were eliminated. Research that had as an approach “puncture technique”, “installation of central venous catheters”, “dressings and coverings”, “device maintenance”, “drug infusion”, “IVT-related cost”, “catheter-related complications”, “procedure teaching” and “other types of catheterizations” were excluded.

Only studies that were available in full and those with the terms “risk factors” and “peripheral catheterization in children” in the title, abstract or descriptors were included. There was no limitation of the publication period for study selection.

## **Flowchart construction**

To construct the flowchart, all the information referring to the risk factors that hinder the peripheral intravenous puncture in children and adolescents was extracted from the articles.

All articles were analyzed by two independent evaluators. Both applied the checklists Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA), Consolidated Standards of Reporting Trials (CONSORT) and Strengthening the Reporting of Observational studies in Epidemiology (STROBE), to verify if they had the main steps required for each type of method<sup>10</sup>.

After the analysis, information on year, type of study, participants, intervention/comparison and main results were extracted.

The level of evidence of the studies was also classified, using the level of evidence classification proposed by the Oxford Center for Evidence-Based Medicine, in which 1a is intended for systematic reviews (with homogeneity) of controlled clinical trials and randomized; 1b, controlled and randomized clinical trials with narrow confidence intervals; 1c, all-or-nothing therapeutic outcomes; 2a, systematic reviews (with homogeneity) of cohort studies; 2b, cohort studies (including lower quality randomized clinical trials); 2c, observational studies of therapeutic results (outcome research) and ecological study; 3rd, systematic review (with homogeneity) of case-control studies; 3b, to the case-control study; 4, case reports (including cohort or lower quality case-control); 5, opinions devoid of critical assessment, based on consensus, physiological studies, with biological material or animal models<sup>11</sup>.

## Clinical application procedure

To verify the clinical applicability of the proposed flowchart, an observational study was carried out, with the main outcome being the success in the first puncture. It was carried out in the Pediatric Emergency Room and Surgical Pediatric Ward of a university hospital in the city of São Paulo.

The sample consisted of children and adolescents from zero to 17 years, 11 months, and 29 days old who would be submitted to puncture by the nursing team.

To participate in the study, children and adolescents should sign the Informed Assent Form, when applicable, and their parents or guardians, the Informed Consent Form.

The sample calculation considered previous studies, which demonstrated that 50% of children who have risk factors for puncture failure require a new attempt at the procedure. To confirm this estimate, it would be necessary to sample 97 patients, which would estimate failure incidence with 95% confidence and an accuracy of at least 10% plus or minus<sup>12-14</sup>. Additionally, this sample would have about 80% power to identify equally distributed binary risk factors with odds ratios of approximately 3.00, with a significance level of 5% from logistic regression models.

Data collection was carried out between November 2018 and February 2019, after approval by the institution's Research Ethics Committee. The data collection instrument was created in REDCap<sup>®</sup> and completed by the researcher herself.

Data collection began when parents and patients were approached to verify the possibility of inclusion in the study, after explaining the objectives. Afterwards, interviews with guardians and clinical assessment of children or adolescents were carried out before puncture and observation of the procedure performed by professionals.

The interview contained the variables age, skin pigmentation, reason for hospitalization, history of prematurity, presence of chronic disease, continuous medication use, history of multiple punctures and complications prior to this hospitalization related to IVT. Then, clinical assessment was performed, checking weight and height, whether veins were visible and palpable with and without using a tourniquet, and whether there were complications related to IVT used in the current hospitalization.

Such procedures were performed to assess the risk of failure of peripheral intravenous catheterization, according to the flowchart constructed for this purpose, as this was one of the objectives of this study. Children or adolescents were considered at risk for peripheral intravenous puncture failure if they presented one or more risk factors.

During the observation of the procedure performed by professionals, the gauge of the device used, procedure success, the number of attempts, the professional category and the time of experience in pediatric nursing were verified.

## Data analysis

The data obtained were stored in an Excel<sup>®</sup> Microsoft for Windows electronic spreadsheet and analyzed using the statistical package R version 3.5.3.

An analysis of the association between the outcome success in the first puncture and demographic and clinical variables was carried out, using the chi-square, Kruskal-Wallis, and Fisher's exact tests. For all tests applied, a significance level was set at 5%.

## RESULTS

### Scientific evidence

The association between the DeCS controlled descriptors “pediatric nursing” AND “peripheral catheterization” resulted in 119 studies, of which 62 were indexed in PubMed, 26 in LILACS, 21 in BDNF and 10 in SciELO. The combination of MeSH terms “pediatric nursing” and “catheterization, peripheral” resulted in 286 publications, with 138 indexed in MEDLINE, six in EMBASE, 133 in CINAHL and nine in SciELO.

Thus, the search resulted in 405 searches, excluding 378 articles, as 262 had subjects not related to the main approach, 102 were duplicated, in 10 the method was of the qualitative type, two were in a language other than Portuguese, English or Spanish and two were editorial, thus including 27 surveys.

The year, method used, participants, intervention, comparison and results were included in the analysis of the 27 publications. Thus, it was verified that the research was carried out between 1999 and 2018. As for designs, the studies were 48.1% observational, 33.3% randomized controlled, 7.4% cohorts, 7.4% systematic reviews and 3.8% before and after. Researchers from the United States of America produced 63.6% of published studies. The period between 2010 and 2013 presented 51.9% of publications.

Regarding the predisposing factors for failure of puncture, it was identified that 34.9% were related to veins (difficult-to-see and palpable veins), with levels of evidence 1b, 2b, 2c; 31.7%, age (prematurity and age less than three years), with levels of evidence 1a, 1b, 2b and 2c; 14.3%, previous history of multiple punctures, with levels of evidence 1b, 2b and 2c; 9.5%, clinical history (chronic diseases, infectious conditions and dehydration), with levels of evidence 2b and 2c; 4.8%, skin pigmentation (more pigmented skin), with levels of evidence 1b and 2c; 4.8%, obesity, with levels of evidence 2b and 2c, as shown in the summary in Chart 1.

**Chart 1** – Articles according to authorship and year of publication, objective, intervention/outcome, results and level of evidence for predisposing factors for difficult peripheral intravenous catheterization in children. São Paulo-SP. Brazil, 2019 (n=27)

Author/Year/Study design/ Sample	Intervention/Comparison	Results	Evidence
Hartman <i>et al.</i> , 2018. <sup>1</sup> Study: Before and after. Sample: 419 pre-intervention children, 302 post-intervention children.	Check puncture success rate before and after using a multicomponent algorithm.	Each year added to age, the higher the success rate on the first attempt.	2b.
Gerceker <i>et al.</i> , 2018. <sup>2</sup> Study: Observational. Sample: 155 children: 4 to 10 years.	Check the success rate on the first attempt and the relationship with children's degree of anxiety and past history of difficult puncture.	There was a correlation between success in the first attempt and age and previous history of difficult puncture.	2c.
Choden <i>et al.</i> , 2018. <sup>3</sup> Study: Observational. Sample: 200 children: 0 to 12 years.	Check the first attempt success rate and potential factors that could influence success.	Success in the first puncture attempt was influenced by age, more pigmented skin and the veins not being visible.	2c.

Chart 1 – Cont.

Author/Year/Study design/ Sample	Intervention/Comparison	Results	Evidence
Demir <i>et al.</i> , 2017. <sup>15</sup> Study: Randomized controlled. Sample: 129 children: 72 in the experimental group and 57 in the control group	Assess the degree of difficulty in visualizing and palpating the veins, the presence of venous damage.	Children whose veins were difficult-to-see and palpable and the presence of a lesion at the puncture site benefited from infrared equipment use.	1b.
Parker <i>et al.</i> , 2016. <sup>5</sup> Study: Systematic review. Sample: 15 studies were included in the final review.	Identify interventions associated with success in the first puncture attempt in hospitalized children.	Children with difficult-to-see or non-palpable veins benefited from ultrasound and transillumination use to visualize the veins.	1b.
Guillon <i>et al.</i> , 2015. <sup>16</sup> Study: Random multicentric. Sample: 450 children with hematological problems, 229 of which made up the intervention group and 221, the control group	Check the clinical usefulness of infrared to help visualize the veins of children with and without risk for difficult puncture and risk factors associated with difficult puncture.	Risk for puncture failure was caused by unavailable veins, young age, overweight and difficult-to-see veins.	2b.
Kiger <i>et al.</i> , 2014. <sup>17</sup> Study: Observational. Sample: 907 professionals who performed peripheral intravenous puncture.	Identify common practices performed during puncture.	Using heat to facilitate the puncture was more used in children that was difficult-to-see or palpable veins and with a previous history of difficult puncture.	2c.
Graaff <i>et al.</i> , 2013. <sup>18</sup> Study: Randomized and controlled. Sample: 1,383 children were divided into four groups. 444 composed the control group; 357, intervention group 1; 292, intervention group 2; and 290, the intervention group 3.	Compared the use of three infrared devices to visualize the veins with the conventional technique in children.	In the subgroup of children whose veins were not visible, the equipment helped to visualize the veins.	1b.
Van der Woude <i>et al.</i> , 2013. <sup>19</sup> Study: Randomized and controlled. Sample: 88 children: 45 composed the control group and 43, the experimental group.	Check whether children with dark skin color who would use transillumination to assist in puncture had greater success in the procedure on the first attempt.	Children younger than three years old and whose veins were difficult to visualize and palpate had greater success in the first attempt in the group that used infrared.	1b.
Heinrichs <i>et al.</i> , 2013. <sup>20</sup> Study: Systematic review. Sample: nine studies.	Assess whether ultrasound-guided puncture in children decreases procedure failure and the number of attempts.	Children under 10 years of age had fewer attempts and less procedure time when ultrasound was used.	1a.

Chart 1 – Cont.

Author/Year/Study design/ Sample	Intervention/Comparison	Results	Evidence
Chiao <i>et al.</i> , 2013. <sup>21</sup> Study: Randomized and crossed. Sample: 384 pediatric patients.	Assess factors related to patients that make it difficult-to-see veins and verify whether using transillumination technology helps in locating the veins.	Vein visualization was more difficult among children aged zero to two years with dark skin color and infrared equipment helped to locate at least six veins.	1b.
Goff <i>et al.</i> , 2013. <sup>22</sup> Study: Observational. Sample: 592 children who were punctured 1,135 times.	Check the cost of puncture performed by non-specialist nurses, its increase when other professionals or resources are needed and its association with child characteristics.	Children younger than two years old and between two and five years old suffered more than one puncture attempt, with a higher cost to perform the procedure. Dehydration was also a factor in the increase in cost.	2c.
Kaddoum <i>et al.</i> , 2012. <sup>23</sup> Study: Randomized and controlled. Sample: 146 children: 72 composed the experimental group and 74, the control.	Check the effectiveness in increasing the success of puncture when infrared equipment is used to assist the procedure.	Children with more pigmented skin and whose vein was difficult-to-see and/or palpable had a higher success rate with infrared puncture.	1b.
Peterson <i>et al.</i> , 2012. <sup>24</sup> Study: Observational. Sample: 546 children who were punctured 1,354 times in up to four attempts.	Check if the success of puncture would be greater with transillumination equipment use compared to the traditional method.	Children's age influenced the success of puncture, with every six months of increase in age, the better procedure success when the equipment with LED is used.	2c.
Negri <i>et al.</i> , 2011. <sup>12</sup> Study: Cohort Sample: 335 children and adolescents.	Determine predictive variables or those that influenced the success of puncture.	Clinical history of failed previous punctures, malnutrition, previous hospitalizations and previous IVT use influenced procedure success.	2b.
Champman <i>et al.</i> , 2011. <sup>25</sup> Study: Randomized and controlled. Sample: 326 children and adolescents: 163 in the control group and 163 in the experimental group.	Check the procedure time, number of attempts, pain referred by patient and degree of satisfaction of professionals and parents in relation to transillumination equipment use.	Children younger than two years had a shorter puncture time when the infrared was used to aid the puncture.	2b.
Perry <i>et al.</i> , 2011. <sup>26</sup> Study: Randomized and controlled. Sample: 123 children between zero and 20 years old: 61 composed the experimental group, and 62, the control.	Compare success in the first attempt at guided puncture with and without infrared equipment in children with compromised veins.	Children younger than one year old, weighing less than 10 kg, who had some chronic disease, who were dehydrated and who had a history of difficult puncture had a better success rate for puncture when infrared was used.	2b.

Chart 1 – Cont.

Author/Year/Study design/ Sample	Intervention/Comparison	Results	Evidence
Riker <i>et al.</i> , 2011. <sup>14</sup> Study: Observational. Sample: 366 children, 75 for each age group, between 0 and 11 months, 12 and 23 months, 24 and 25 months and 36 months or more.	Check the success rate in the first puncture attempt using tourniquet among patients who were assessed in terms of skin color and whether the veins were visible and palpable.	Non-palpable veins, non-visible veins, age and history of admission to the Neonatal Intensive Care Unit significantly influenced puncture success in the first attempt.	2c.
Nafiu <i>et al.</i> , 2010. <sup>27</sup> Study: Observational. Sample: 103 children between 2 and 18 years.	Check the relationship between Body Mass Index and the ease of obtaining a successful puncture.	Obese children with non-visible and non-palpable veins had a lower rate of success in the first attempt, a greater number of attempts and time for the procedure to be successful.	2c.
Hess HA, 2010. <sup>28</sup> Study: Observational. Sample: 241 children between zero and 17 years old: 91 composed the experimental group, and 150, the control group.	Check first puncture attempt success, procedure time and number of attempts using transillumination equipment.	Children under six years of age were successful in the first attempt at a larger puncture in the group that used infrared.	2c.
Larsen <i>et al.</i> , 2010. <sup>13</sup> Study: Observational. Sample: 592 children between zero and 18 years old who were punctured 1,135 times.	Check the number of attempts and the time required by pediatric nurses for a successful puncture and which characteristics related to children and professionals could interfere with the time and number of puncture attempts.	Children under two years of age with a history of difficult puncture had a higher rate of failure in the first puncture attempt.	2c.
Simhi <i>et al.</i> , 2008. <sup>29</sup> Study: Randomized and controlled. Sample: 202 children between 3 months and 17 years old: 101 composed the control group, and 101, the experimental group.	Check first attempt success, number of attempts and the total time for the procedure to be successful, after assessing the veins with and without devices to facilitate the intravenous catheter insertion.	Children with veins that are difficult-to-see and not palpable benefited from using the device to facilitate puncture.	2b.
Yen <i>et al.</i> , 2008. <sup>30</sup> Study: Cohort. Sample: 650 children between zero and 21 years old.	Develop an instrument with clinical, sensitive and easy-to-apply factors to identify children who may be difficult to puncture.	Age, history of prematurity, veins visibility and palpation were the effective variables to assess children difficult to be punctured.	2b.

Chart 1 – Cont.

Author/Year/Study design/ Sample	Intervention/Comparison	Results	Evidence
Atalay <i>et al.</i> , 2005. <sup>31</sup> Study: Observational. Sample: 334 children aged 0-36 months who were punctured 434 times.	Investigate the effectiveness of the transillumination technique to perform puncture.	Children with a mean age of 20 months, non-visible or non-palpable veins and previous IVT use benefited from LED equipment use. Obesity and previous history of multiple punctures were the variables that prevented success.	2c.
Goren <i>et al.</i> , 2001. <sup>32</sup> Study: Observational. Sample: 100 children aged between 2 and 36 months: 40 of them required transillumination use.	Investigate the effectiveness of using transillumination in the palmar region to perform puncture.	Children with a mean age of 16.7 months, dehydrated, septic and with veins difficult-to-see had a better success rate with LED equipment use.	2c.
Franck <i>et al.</i> , 2001. <sup>33</sup> Study: Observational. Sample: 57 children who were punctured 264 times.	Establish the prevalence of complications related to puncture and identify risk factors.	Gestational age influenced the number of puncture attempts.	2c.
Fein <i>et al.</i> , 1999. <sup>34</sup> Study: Observational. Sample: 4,926 children were assessed and 2,052 were included.	Assess nurses' ability to verify whether screened patients would be punctured and determine risk factors for puncture failure.	Children younger than one year old, with chronic diseases, had a higher risk of being punctured and not being successful.	2c.

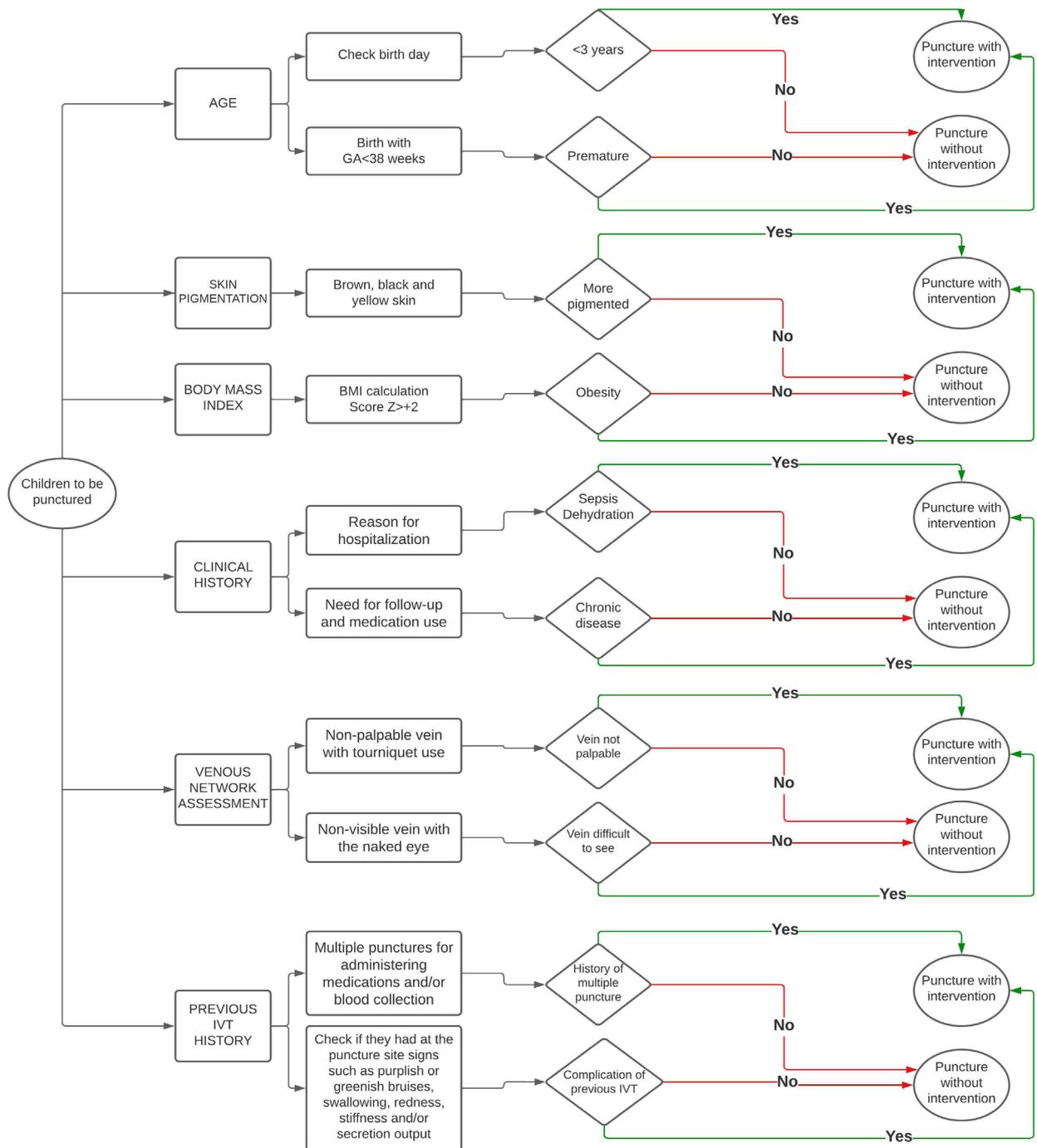
## Construction of recommendations

After analyzing the content of the articles and surveying the predisposing factors for difficult peripheral intravenous catheterization in children and adolescents, a decision-making flowchart was constructed to assess the patients who would be punctured, considering all the risk factors found for difficult peripheral intravenous catheterization, as shown in Figure 1. Intravenous puncture with intervention refers to any intervention used to facilitate veins assessment and assist in the procedure, such as transillumination and ultrasound use.

## Clinical application

A total of 107 children and adolescents participated in the clinical application stage of the flowchart for assessing patients who would undergo peripheral intravenous catheterization, 96.3% of whom were at risk of puncture failure. Of these, in 56.1%, success was obtained in the first attempt; 22.4%, in the second; 11.2%, in the third; 7.5%, on fourth; and 2.8% in five or more; with a mean of  $1.8 \pm 1.2$  attempts. The sample consisted of a newborn, 29 infants, 27 preschoolers, 33 schoolchildren and 15 adolescents.

Regarding the comparisons between participants who were successful in the first puncture attempt, it was verified that they were predominantly boys, eutrophic, with more pigmented skin, submitted to clinical treatment, with chronic affections, without previous use and with complications of peripheral IVT, who were punctured with 24-gauge catheters. Patients who were punctured twice or more for the procedure to be successful were preschoolers and had a mean time of prior IVT use of 6.3 days (Table 1).



**Figure 1** – Flowchart for assessing children who will undergo peripheral intravenous puncture. Sao Paulo-SP. Brazil, 2019.

**Table 1** – Participant demographic characteristics according to the number of attempts for successful puncture. São Paulo-SP. Brazil, 2019. (n=107).

Variables	Number of attempts		p
	1 (n=60)	2 or more (n=47)	
	f(%)	f(%)	
Age (years)			0.233*
Mean ± SD <sup>§</sup>	6.6±4.5	5.5±5.3	
Sex			0.936 <sup>†</sup>
Female	26 (43.3)	20 (42.6)	
Male	34 (56.7)	27 (57.4)	
Body Mass Index			0.883 <sup>†</sup>
Thinness	7 (11.7)	7 (14.9)	
Eutrophy	42 (70.0)	32 (68.1)	
Obesity	11 (18.3)	8 (17.0)	
Skin pigmentation			0.686 <sup>†</sup>
More	27 (45.0)	23 (48.9)	
Less	33 (55.0)	24 (51.1)	
Type of treatment			0.493 <sup>†</sup>
Clinical	48 (80.0)	40 (85.1)	
Surgical	12 (20.0)	7 (14.9)	
Clinical condition			0.095 <sup>†</sup>
Acute	26 (43.3)	13 (27.7)	
Chronic	34 (56.7)	34 (72.3)	
Previous IVT use <sup>  </sup>			0.795 <sup>†</sup>
Yes	19 (31.7)	16 (34.0)	
No	41 (68.3)	31 (66.0)	
Time of previous IVT use <sup>  </sup> (days)			0.888 <sup>‡</sup>
Mean ± SD	4.5±4.5	6.3±8.8	
Previous complication related to IVT <sup>  </sup>			0.205 <sup>†</sup>
No	25 (41.7)	14 (29.8)	
Yes	35 (58.3)	33 (70.2)	
Intravenous catheter gauge (Gauge)			0.491 <sup>†</sup>
22	23 (38.3)	15 (31.9)	
24	37 (61.7)	32 (68.1)	

Caption: \*t test; <sup>†</sup>Chi-square; <sup>‡</sup>Kruskal-Wallis; <sup>§</sup>standard deviation; <sup>||</sup>intravenous therapy.

Regarding the predisposing factors for difficult peripheral intravenous catheterization identified in the literature and listed to build the flowchart for assessing children and adolescents who would undergo peripheral intravenous puncture, it was verified that the patients who were not successful in the first attempt were younger than three years old (p=0.003), had difficult-to-see veins (p=0.046) and a history of multiple punctures (p=0.025), as shown in Table 2.

**Table 2** – Predisposing factors for peripheral intravenous puncture failure, according to the number of attempts. São Paulo-SP. Brazil, 2019. (n=107).

Predisposing factors for peripheral intravenous puncture failure	Number of attempts		p
	1 (n=60)	2 or more (n=47)	
	f(%)	f(%)	
Premature birth history			0.961*
Yes	10 (55.5)	8 (44.5)	
No	50 (56.2)	39 (43.8)	
Less than 3 years			0.003*
Yes	14 (36.8)	24 (63.2)	
No	46 (66.7)	23 (33.3)	
More pigmented skin			0.686*
Yes	33 (57.9)	24 (42.1)	
No	27 (54.0)	23 (46.0)	
Obese			0.860*
Yes	11 (57.9)	8 (42.1)	
No	49 (55.7)	39 (44.3)	
Chronic disease			0.095*
Yes	34 (50.0)	34 (50.0)	
No	26 (66.7)	13 (33.3)	
Dehydration			0.129†
Yes	4 (100.0)	Z‡	
No	56 (54.4)	47 (45.6)	
Difficult-to-see veins			0.046*
Yes	18 (43.9)	23 (56.1)	
No	42 (63.6)	24 (36.4)	
Veins not palpable			0.064*
Yes	10 (40.0)	15 (60.0)	
No	50 (61.0)	32 (39.0)	
History of multiple punctures			0.025*
Yes	38 (49.4)	39 (50.6)	
No	22 (73.3)	8 (26.7)	
Complication of previous IVT§			0.389*
Yes	36 (52.9)	32 (47.1)	
No	24 (61.5)	15 (38.5)	

Caption: \*Chi-square; †Fisher's exact; ‡absolute zero; §intravenous therapy.

Regarding professionals, it was found that nursing technicians performed puncture in 71.4% of the children in which the procedure was successful in the first attempt as well as in 68.6% who were punctured two or more times. Nurses, on the other hand, achieved success of 28.6% in the first puncture attempt and 31.4% in two or more puncture attempts, with no statistically significant difference (p=0.764).

It was also observed that the mean time of nursing professionals' experience in pediatrics was 8.9±8.4 years among those who were successful in the first attempt and 7.4±8.2 years for those who procedure success was achieved in two or more attempts, this result being statistically significant (p<0.001).

## DISCUSSION

The present research verified, through the integrative review, that premature children<sup>14,30,33</sup>, with less than three years old<sup>1-3,13-14,16,19-22,24-26,28,30-33</sup>, obese<sup>16,27,31</sup>, with more pigmented skin<sup>3,21,23</sup>, dehydrated<sup>22,26,32</sup>, who had chronic diseases<sup>26,34</sup>, with veins not palpable<sup>5,14,17,19,23,27,29-31</sup> and/or veins not-visible<sup>3,5,14-19,21,23,27,29-32</sup>, with a history of difficult puncture or who already had complications related to IVT in previous hospitalizations<sup>12-13,17,26,31</sup> may undergo multiple punctures to obtain success in the procedure.

For this reason, these risk factors were included in the proposed flowchart for assessing children and adolescents who will undergo peripheral intravenous puncture.

In the flowchart's clinical application, it was detected that almost all of the children and adolescents assessed were at risk of being submitted to more than one puncture attempt, and just under half of the observed patients were catheterized more than once for the procedure to be successful. The higher frequency of patients at risk for puncture failure was verified due to the characteristics of children and adolescents who participated in this research, as most had some chronic disease, requiring frequent hospitalizations due to decompensation or for surgical corrections.

Regarding the predisposing factors for failure of puncture, it was found that 63.2% of patients submitted to more than one puncture attempt had less than three years. Studies show that children under three years of age have veins adhered to the hypodermis, making them more fragile and difficult-to-see<sup>35,38-39</sup>.

It was also observed that 56.1% of children and adolescents who had veins difficult-to-see and 60.0% of patients who had veins not palpable were also punctured more than once for the procedure to be successful. Research indicates that patients who have a chronic disease have tortuous veins that are difficult to palpate, visualize and fragile due to continuous medication use, multiple punctures, and long hospital stays, compromising their venous system<sup>35-36,38-39</sup>. Pain, anxiety, fear and agitation presented by children before and during the procedure cause vasoconstriction, making it difficult to palpate and visualize the veins<sup>1-2</sup>.

Thus, knowing the predisposing factors for procedure failure that may hinder the success of puncture in children and the characteristics of the IVT to be installed may help in planning this care, to preserve the venous system of these patients.

Flowcharts can help in the initial assessment of children and adolescents and in planning IVT installation, as they incorporate evidence-based practices, guidelines and recommendations that help professionals make decisions, from admission of children or adolescents to their discharge, thus ensuring greater safety in the institution of therapy and reduction in the risk of complications<sup>37,39</sup>.

Research carried out with the objective of verifying how children and adolescents who had risk factors for difficult puncture were identified by nurses found that these professionals reported that it was important to have formal processes to detect and refer these patients, and expressed frustration with the informal processes that lead children and/or adolescents to be subjected to a greater number of puncture attempts. They also highlighted the need to have a defined flowchart and care protocols to avoid the multiples attempts of the procedure<sup>6,37,39</sup>.

Nurses are the professionals with the best scientific and technical knowledge to assess children and plan care related to IVT and perform puncture<sup>4</sup>. However, in the present study, nursing technicians were the ones who most performed the procedure and perhaps this was due to the reduced number of nurses, mainly in the Children's Emergency Room, where nurses perform initial assessment, but delegates the procedure to a technician.

Therefore, children and adolescents who have risk factors for difficult peripheral intravenous catheterization should be previously assessed using appropriate tools so that nurses can choose the best locations, the most appropriate device and use equipment that can help in veins assessment and guide the procedure.

Experimental studies show that the success rate in the first puncture attempt in children and adolescents classified as difficult to puncture could vary from 43.2% to 50% and that using technology to facilitate veins visualization could increase the success rate by between 10% and 30%<sup>5,15,39</sup>.

Thus, strategies should be encouraged so that the puncture is obtained in the first attempt, such as using equipment to visualize the veins, adequate intravenous devices and care protocols applied by pediatric nurses.

A limitation of this study was that some full articles that had been selected initially were not included, as they were in Mandarin and German. Another limitation was in relation to the children and adolescents assessed to verify the clinical applicability of the study, as they were treated at a tertiary hospital and many had risk factors for difficult catheterization, which may not represent the population of other health services.

## CONCLUSION

Flowchart construction for assessing children and adolescents who will undergo peripheral intravenous catheterization was based on predisposing factors for difficult puncture identified in the literature through the integrative review carried out. They were: prematurity, age less than three years, obesity, more pigmented skin, chronic disease, dehydration, difficult-to-see veins, not palpable veins and with a history of difficult puncture or complications related to IVT in previous hospitalizations.

The flowchart's clinical applicability demonstrated that it can be a useful tool to identify children and adolescents at risk of undergoing more than one attempt puncture. Patients aged less than three years, with difficult-to-see veins and a history of multiple punctures are submitted to two or more attempts of the procedure.

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## NOTES

### ORIGIN OF THE ARTICLE

This study is part of a thesis – *Sucesso na cateterização intravenosa periférica de crianças de difícil punção, segundo duas tecnologias para visualização de vasos: estudo randômico, controlado e cruzado*, presented to the Graduate Program in Nursing at the *Universidade Federal de São Paulo*, in 2021.

### CONTRIBUTION OF AUTHORITY

Study design: Floriano CMF, Avelar AFM, Peterlini MAS.

Data collection: Floriano CMF.

Data analysis and interpretation: Floriano CMF, Avelar AFM, Peterlini MAS.

Discussion of results: Floriano CMF, Avelar AFM, Peterlini MAS.

Writing and/or critical review of content: Floriano CMF, Avelar AFM, Peterlini MAS.

Review and final approval of the final version: Floriano CMF, Avelar AFM, Peterlini MAS.

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### APPROVAL OF ETHICS COMMITTEE IN RESEARCH

Approved by the Research Ethics Committee of *Hospital São Paulo* – university hospital, Opinion 369/2018, CAAE (*Certificado de Apresentação para Apreciação Ética* – Certificate of Presentation for Ethical Consideration) 90664818.6.0000.5505.

### CONFLICT OF INTEREST

There is no conflict of interest.

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