Effectiveness of ultrasound-guided peripheral intravenous cannulation in pediatric patients aged under three years: a systematic review protocol

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Review question: The objective of this systematic review is to identify, evaluate and synthesize evidence of effectiveness on ultrasound-guided peripheral intravenous cannulation in pediatric patients aged under three years.

Specially, the review question is: In pediatric patients aged under three years, what is the effect of ultrasound-guided peripheral intravenous cannulation on the first attempt and on the overall success rate, time to cannulation and number of attempts for successful cannulation compared with the traditional blind approach?

Keywords child; peripheral intravenous cannulation; ultrasonography; ultrasound; vascular access


Introduction

The peripheral intravenous cannulation procedure for diagnostic or therapeutic purposes is often a vital component for all patients in the clinical setting. However, the success rate of the first attempt at peripheral intravenous cannulation in children is generally lower than that in adults.1,2 A failed procedure results in the loss of diagnostic information and delay of treatment, and the patient experiences pain and discomfort with multiple cannulation attempts.3 Therefore, establishing a method to improve this success rate, especially a first-attempt success rate of peripheral intravenous cannulation, is important.

The traditional method of peripheral intravenous cannulation requires knowledge of vascular anatomy to estimate the location of the target vein and requires visualization or palpation of the vein. The use of ultrasound guidance allows real-time visualization of target veins that are invisible and impalpable. This method provides precise information on the size and location of the target vein and its relative distance from neighboring arteries or nerves that need to be avoided.4,5 Therefore, ultrasound-guided peripheral intravenous cannulation has fewer complications than the traditional method,6,7 and leads to facilitation of peripheral intravenous cannulation.8,9

Several systematic reviews have reported the effectiveness of ultrasound-guided peripheral intravenous cannulation for improving the success rate.5,8,9 However, almost all of them included patients of all age groups, and there have been few studies on pediatric patients. Therefore, the evidence for effectiveness of ultrasound-guided peripheral intravenous cannulation in pediatric patients has not been evaluated.

Pediatric patients have a lower success rate of peripheral intravenous cannulation than that of adult patients, and they have a high level of distress from this procedure. Failed attempts at peripheral intravenous cannulation also negatively affect nurses, including causing frustration, worry and diminished self-confidence.10-12 Therefore, establishing evidence on a method for peripheral intravenous cannulation for pediatric patients is important.

A systematic review in pediatric patients failed to demonstrate the effectiveness of ultrasound-guided peripheral intravenous cannulation.13 This review included a meta-analysis by stratified setting. The
outcomes examined in this review included the success rate, number of attempts and procedure time, which were compared with those of the traditional method. However, this review had the following limitations: i) a small number of studies used meta-analysis for each variable in each setting (n = 1 or 2); ii) limited settings (intensive care unit, emergency department and operating room); and iii) mixed outcome of the success rate (first-attempt success rate and overall success rate). Furthermore, the inclusion criteria for age differed among selected studies in the systematic review (<3, <7, or <10 years).14-16

In our review, we will define our target participants as pediatric patients aged under three years. The reason for this age limitation is that the success rate of peripheral intravenous cannulation differs among age groups of pediatric patients. Pediatric patients differ in developmental stage and physical development, depending on age. In particular, pediatric patients aged under three years (youngest pediatric group) have a lower success rate in peripheral intravenous cannulation than that in older pediatric patients17-19 because the youngest pediatric group has fragile veins.10 Additionally, these patients have a high level of distress and anxiety during venipuncture because their cognitive function is underdeveloped. They also have difficulty in understanding a detailed explanation of an invasive procedure, such as peripheral intravenous cannulation.10,11,18 Therefore, the youngest pediatric group clinically presents a challenge in relation to peripheral intravenous cannulation.

Several randomized controlled studies have showed the effectiveness of ultrasound-guided peripheral intravenous cannulation in the youngest pediatric group compared with the traditional method.16,20 However, there have been no published meta-analyses of randomized, controlled trials evaluating ultrasound-guided peripheral intravenous cannulation in the youngest pediatric group.

Our primary objective is to determine whether ultrasound-guided peripheral intravenous cannulation improves the first-attempt success rate of peripheral intravenous cannulation in pediatric patients aged under three years. Our secondary objectives are to determine whether ultrasound-guided peripheral intravenous cannulation affects the overall success rate, the time to successful cannulation, and the number of attempts for successful cannulation.

**Inclusion criteria**

**Participants**

This review will consider studies that include participants limited to pediatric patients under three years of age undergoing peripheral intravenous cannulation. We will contact the authors of the study if inclusion of pediatric patients under three years is unclear, or results were not stratified by the three-year age cutoff.

**Intervention(s)/phenomena of interest**

This review will consider studies that have evaluated ultrasound-guided peripheral intravenous cannulation using an ultrasound system. We will include all interventions conducted in any clinical setting. The review will exclude studies that have used devices to visualize veins without an ultrasound system, such as transillumination and near-infrared light devices. In cases where we are unsure if the intervention of the study has included visual methods (e.g. transillumination and near-infrared light devices), we will contact the authors to clarify data. In the absence of answers from authors, the data will be excluded.

**Comparator**

The comparator will be considered as the traditional blind approach. The traditional blind approach is a non-visual technique for performing insertion and placement of cannulas by manual localization of the target vein.

**Outcomes**

This review will consider studies that have used the first-attempt success rate at peripheral intravenous cannulation as the outcome measure. Secondary outcomes will include the overall success rate of peripheral intravenous cannulation, the time to successful cannulation, and the number of attempts at successful cannulation.

**Types of studies**

This review will consider all randomized, controlled trials and quasi-randomized, controlled trials for inclusion. If there are no randomized, controlled trials, we will include any experimental study design as non-randomized, controlled trials and quasi-experimental, before and after studies for inclusion.
Methods

Search strategy

The search strategy aims to identify published and unpublished studies. A three-step search strategy will be used in this review. An initial limited search of MEDLINE and CINAHL will be undertaken. This will be followed by analysis of the text words that are contained in the title and abstract, and of the index terms used to describe the article. A second search using all identified keywords and index terms will then be undertaken across all included databases. Finally, the reference list of all identified reports and articles will be searched for additional studies. Studies that are published in English and Japanese will be considered for inclusion in this review. Studies that are published from 1999 to the present date will be considered for inclusion in this review. The reason for this year limit is that, to the best of our knowledge, the earliest use of ultrasound-guided peripheral intravenous cannulation was published in 1999.21 The initial search was conducted by two reviewers independently.

The databases to be searched include MEDLINE, CINAHL, Embase, Cochrane Central Register of Controlled Trials and Igaku Chuo Zasshi. The search for unpublished studies will include ClinicalTrials.gov. The following initial keywords will be used:

- ultrasound: ultrasonic, ultrasonography, ultrasound.
- intravenous: intravenous, vascular, vessel, vein, venous.
- cannulation: catheterization, cannula, cannulation, access.

We will not limit keywords regarding the pediatric field, such as the terms pediatric, child, and children. This is because studies might have included participants with various age groups, including those under three years.

Assessment of methodological quality

Titles, abstracts and full texts (if necessary) will be independently reviewed by the primary and secondary reviewers to determine if the studies fit the inclusion criteria of this systematic review. Thereafter, papers that are selected for retrieval will be assessed by two independent reviewers for methodological validity prior to inclusion in the review using standardized critical appraisal instruments from the Joanna Briggs Institute.22 Any disagreements that arise between the reviewers will be resolved through discussion, or with a third reviewer. The results of critical appraisal will be reported in a narrative form and in a table. The results of critical appraisal will be reported in a narrative form and in a table. We will consider studies on a case-by-case basis because study designs may differ.

Data extraction

Data will be extracted from papers that are included in the review using standardized data extraction with the standardized data extraction tool from the Joanna Briggs Institute System for the Unified Management, Assessment and Review of Information (JBI SUMARI).22 The extracted data will include specific details regarding the interventions, populations, study methods, and outcomes of significance to the review question and specific objectives. Authors of primary studies will be contacted for missing information or for clarification of information.

Data synthesis

Quantitative data will, where possible, be pooled in statistical meta-analysis using JBI SUMARI.22 All of the results will be subject to double data entry. Effect sizes will be expressed as either odds ratios (for dichotomous data) and weighted (or standardized) mean differences (for continuous data) and their 95% confidence intervals will be calculated for analysis. Heterogeneity will be assessed statistically using the standard chi-squared and I squared tests. The choice of model (random or fixed effects) and method for meta-analysis will be based on the guidance by Tufanaru et al.23 Where statistical pooling is not possible, the findings will be presented in narrative form, including tables and figures, to aid in data presentation where appropriate. We will also consider sub-group analysis if potential confounders, such as age, can be stratified. Where statistical pooling is not possible, the findings will be presented in narrative form, including tables and figures, to aid in data presentation where appropriate. We will perform sub-group analysis by the clinical setting, if it can be identified, such as the emergency department and operating room. Sensitivity analyses will be conducted to test decisions made regarding text as appropriate. Where statistical pooling is not possible the findings will be presented in narrative form including tables and figures to aid in data presentation where appropriate. A funnel plot will
be generated to assess publication bias if there are 10 or more studies included in a meta-analysis. Statistical tests for funnel plot asymmetry (Egger test, Begg test, Harbord test) will be performed where appropriate.

References


