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Effectiveness of interventions for adult peripheral intravenous catheterization: A systematic review and meta-analysis of randomized controlled trials

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ABSTRACT

Background: Peripheral intravenous catheterization (PIVC) is commonly performed on emergency departments and inpatient units. Unsuccessful PIVC first attempts increase pain, and lead to treatment and diagnostic delays.
Objective: To determine strategies associated with PIVC first attempt success in adult emergency department patients and inpatients.
Methods: We searched MEDLINE, EMBASE, CINAHL, TRIP, Cochrane Central Register of Controlled Trials (OVID), and grey literatures databases such as Proquest Dissertation and Theses Global, and Open Grey databases between November and December, 2014. The search was updated on January 28, 2016. We included full text reports of randomized controlled trials testing PIVC interventions versus standard of care. Risk of bias was assessed using the Cochrane Collaboration's tool.
Results: We included 14 randomized controlled trials involving 3201 participants. Interventions included the AccuVein™, AccuCath™ catheter system, ultrasound, safety catheters, and topical anesthetics. Three studies compared AutoGuard and Insyte catheters and were suitable for meta-analysis. There was no difference in first attempt success with a relative risk of 0.0 (95% CI, −0.04, 0.04). There was limited evidence to support the use of ultrasound to increase first attempt success.
Conclusions: Well-designed and reported randomized controlled trials examining the effectiveness of ultrasound compared to standard of care are warranted.
Registration: PROSPERO registration: CRD42014015428.

1. Introduction

Health care professionals often perform peripheral intravenous catheterization (PIVC) on adult inpatients and emergency department (ED) patients. PIVC prevalence rates of 85% are expected to rise with increased intravenous therapeutics use (Dychter et al., 2012). Many PIVCs are unsuccessful with first attempt success rates as low as 50% in the published literature (Idemoto et al., 2014). PIVC success on the first attempt ensures prompt administration of intravenous therapeutics thereby enhancing patient outcomes, reducing the number of painful procedures patients must endure, and decreasing catheter-related infections and phlebitis (Dychter et al., 2012; Ober and Craven, 2011).

PIVC first attempt success requires competent skill performance. Traditionally, PIVC involves vein and equipment selection before catheterization. Clinicians select peripheral veins based upon vein palpability and visibility, and may use vein stimulation, limb positioning, tourniquets or other techniques to improve first attempt success. Authors have examined the effect of interventions such as intravenous catheter types (Prunet et al., 2008) and ultrasound (Heinrichs et al., 2013). Others have investigated the relationship between patient (Sebbane et al., 2013), or clinician characteristics (Jacobson and Winslow, 2005) and PIVC first attempt success.

To date, no systematic investigation to determine the most effective PIVC insertion intervention for a general or emergency

Abbreviations: PIVC, peripheral intravenous catheterization; RCT, randomized controlled trial; ED, emergency department.

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patient population has been published. Published reviews and practice guidelines have focused on patients with difficult intravenous access (Crowley et al., 2012; Liu et al., 2014), combined PIVC and venipuncture despite inherent differences in these procedures (Heinrichs et al., 2013), or did not utilize rigorous systematic searches (Egan et al., 2013; Lamperti et al., 2012; Sabri et al., 2013). Authors have called for large well-designed randomized controlled trials (RCT) to examine the effectiveness of strategies to improve first attempt success for PIVC (Egan et al., 2013; Heinrichs et al., 2013; Liu et al., 2014). A systematic review and meta-analysis of available RCTs may provide evidence to determine which interventions increase PIVC first attempt success for adult ED patients and inpatients.

The objective of our review was to systematically examine RCTs that compared interventions to increase PIVC first attempt success to the standard of care with adult ED patients and inpatients who required intravenous fluid infusion. Our aims were to: (1) identify interventions that increase PIVC first attempt success, (2) establish evidence quality, (3) offer practice recommendations for health care professionals, and (4) inform health care administrators' decisions to support the use of effective interventions.

2. Methods

2.1. Search strategy for identification of studies

The Cochrane Handbook for Systematic Reviews of Interventions guided this review. We published the protocol on the University of York, Centres for Reviews and Dissemination PROSPERO website (registration number CRD4201405428). Search methods, study eligibility criteria, and outcomes to be reported were outlined in advance. The Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines was followed to increase reporting clarity (Liberati et al., 2009). A health sciences librarian (KAH) and investigator (SP) developed the search strategy based upon a previously published search (Heinrichs et al., 2013). The search was completed on November 22, 2014 using truncated keywords and subject headings. Keywords included peripheral intravenous catheterization, success/fail, adult, and relevant synonyms. Each search was internally deduplicated to remove multiple reports of the same study. To ensure a rigourous search methodology we pretested our search and received peer review feedback from a Health Sciences Librarian based upon the Peer Review of Electronic Search Strategies Guidelines (McGowan et al., 2010). We searched MEDLINE (OVID), EMBASE (OVID), Cumulative Index to Nursing and Allied Health Literature (EBSCO), and the Cochrane Database of Interventions for relevant articles published in English. We also chose to search the TRIP, Cochrane Central Register of Controlled Trials (OVID), Canadian Agency for Drugs and Technology in Health, Proquest Dissertation and Theses Global, and Open Grey databases. To capture new and conventional interventions no date limits were incorporated. Each search was saved to re-run for updating. The MEDLINE search strategy was translated for each database. Two independent reviewers (SP and KB) screened the first 100 titles and abstracts with a 99% inter-rater agreement. Disagreement was settled by consensus. SP obtained the full text of all potentially relevant study reports for comparison to the inclusion criteria. If the full text was not available the study was excluded. It was not feasible to contact authors for full text reports nor hand search journals.

SP completed data extraction using a published tool (Liu et al., 2014) modified for this review and the Cochrane Collaboration tool (Higgins and Green, 2011). Our tool was piloted and refined using 20 randomly selected studies. Potentially duplicate reports were compared using juxtapositions of author names and sample sizes. The most recent report was included in the review. Data extracted included: characteristics of trial participants, intervention type and characteristics, outcome measures (first attempt success rate, number of attempts, procedure time), participant rating of intervention, patient rating of intervention, funding source, and primary conclusion. We consulted a project team consisting of nurse and physician clinical experts to ensure all clinically relevant outcomes were included. No authors were contacted for further information.

2.2. Inclusion and exclusion criteria and definitions

Research reports written in English, with human participants who were inpatients or ED patients 18 years of age or greater, and reported PIVC first attempt success rate or overall success rate were included in this review. Interventions had to be attempted into a peripheral vein with a catheter of three to five centimeters in length. Studies with quasi-experimental and observational designs were excluded during full-text screening. We excluded studies that: (1) were not randomized, (2) included participants younger than 18 years of age, (3) did not report first attempt success rate or number of skin punctures, (4) included healthy volunteers or outpatients, (5) did not report PIVC site, (6) did not report catheter length, or (7) reported peripherally inserted central catheters.

2.3. Data collection and analysis

Prior to deduplication all search results were exported to separate labeled folders in Refworks citation management software. Inclusion and exclusion criteria were applied after all search results were merged to one folder. This process was tracked using an Excel spreadsheet and unique study identifiers (Rader et al., 2014). SP obtained and screened the full text of all potentially relevant reports to confirm studies met the inclusion criteria before beginning data extraction.

SP, with input from KB and KAH, created and piloted a data extraction tool based a published review (Higgins and Clark, 2011; Liu et al., 2014). This tool was used to record intervention type, key risks of bias, participant characteristics, operational definitions, methodology, and all primary and secondary outcomes. Duplicate reports of the same study were excluded. SP read all included articles and entered relevant data into data extraction forms and RevMan 5.1.

3. Results

3.1. Search results and study selection

Database searches yielded 2694 results with 1713 reports remaining after deduplication. After title and abstract screening 1660 articles clearly did not meet the inclusion criteria. Of the 53 reports assessed for inclusion, six were excluded due to authors' failure to report catheter length, or puncture attempts. Of the others 35 were excluded due to: (a) participants were not randomized, (b) participants were not inpatients or ED patients, (c) catheter length longer than 5 cm, (d) a centralized catheterization site was used, or (e) a full-text report was unavailable. This left 12 articles with two additional articles identified through reference screening of included reports for a total of 14 studies that met the inclusion criteria. No unpublished studies met the inclusion criteria. See Fig. 1 for the PRISMA study selection flow diagram.

3.2. Characteristics of included studies

The studies were conducted in Australia/New Zealand (Page and Taylor, 2010; Russell et al., 1996), France (Aulagnier et al., 2014;