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Pediatric Vascular Access Peripheral IV Algorithm Success Rate

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ABSTRACT

Purpose: Determine if the pediatric peripheral vascular access algorithm (PPVAA) led to differences in first-attempt and overall peripheral intravenous (PIV) success, staff attempting PIV access per episode and overall attempts and first PIV attempt success by provider.
Design/Methods: A two-cohort pre-/post-implementation comparative design involved pediatric nurses and patients. The PPVAA included four components: a patient comfort plan, PIV grading score, nurses' self-assessed IV access capability and nurse decision to stop-the-line. Two sample *t*-test or Wilcoxon rank sum test and Pearson's chi-square test were used to evaluate differences between groups and measures.
Results: Healthcare providers ($N = 96$) attempted 721 PIV insertions (pre-PPVAA, $n = 419$ and post-PPVAA, $n = 302$). Of 78 nurse providers, mean (SD) age was 37.4 (11.0) years and 20.0% self-assessed PIV capability as expert. Of children, mean age was 8.3 (7.0) years. Post-PPVAA, first-attempt ($p = 0.86$) and overall ($p = 0.21$) success did not change, though fewer staff were needed per episode to initiate PIV; $p = 0.017$. Overall rate of success after one attempt in the post-PPVAA period compared to pre-PPVAA was reduced ($p = 0.002$), reflecting greater awareness to stop-the-line. Compared to pre-PPVAA, advanced practice nurses and non-clinician providers were more likely to achieve success on first attempt.
Conclusions: The PPVAA did not increase first-attempt or overall PIV success; however, it decreased overall IV attempts and the number of staff attempting access per episode.
Practice Implications: The multi-component PPVAA provided a guide for nurses during PIV and assisted decision making to stop attempts in difficult cases.

Vascular access initiation is a critical component for any healthcare organization; but has been a particularly difficult task in the pediatric population due to both patient and nurse factors (House, Cheptinga, Rusyniak, & Vreeman, 2017; Parker, Benzies, & Hayden, 2017; Petroski, Frisch, Joseph, & Carlson, 2015). Patient factors associated with difficult intravenous (IV) access were dehydration, young age, non-white or non-black race, limited vasculature and pain during insertion (House et al., 2017; Parker et al., 2017; Petroski et al., 2015). Nurse factors associated with difficult IV access were vein visualization and inexperience in vascular access (Parker et al., 2017).

In the literature, only a few objective reports of data on the number of attempts and length of time required for successful pediatric peripheral IV (PPIV) placement were found. In a prospective study of 592 children up to age 18 years of age and involving 1135 venipunctures, researchers attempted to establish whether nursing experience (in years) and competency (using Benner's Dreyfus Model) had an effect on PPIV placement. They also considered expected difficulty of IV placement, uncooperativeness of patients and other patient characteristics (Larsen et al., 2010). Of PPIV access episodes, 73% were successful with one or two attempts and 84% required up to two nurses during the attempt. Larsen et al. (2010) concluded that nurses underestimated the degree of difficulty of attaining IV placement and recommended that experienced, competent nurses initiate vascular access, especially in children younger than 2 years of age. In a consensus panel paper entitled *Difficult Venous Access in Children*: *Taking Control*, the authors recommended early identification of children with potentially difficult vascular access (to improve success rates) and a need for standards of practice and treatment algorithms that ensure successful IV access (Kuensting et al., 2009).

Two tools are available to guide nursing practice during PPIV initiation, the *Difficult IV Access* (DIVA) score (Yen, Riegert, & Gorelick, 2008) and the *Assessment Tool for Grading IV Access* (Kuensting et al., 2009). The DIVA score, a four-factor, 10-point proportionately weighted risk score, was used to identify difficult IV access in 615 children in an

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emergency department. It predicted failure of first IV attempt success of 49.5% or higher when the score was 4 or higher; however, overall sensitivity, specificity and positive predictive value were not better than nurse judgment and was evaluated as unready for clinical use (Yen et al., 2008). The second tool, the *Assessment Tool for Grading IV Access*, was cited as a resource to identify children with difficult access (Kuensting et al., 2009); however, no research reports were found to substantiate its validity, reliability and clinical usefulness. Both tools only seek to grade patients' difficulty of IV start, thereby informing nurses of the skill level required for successful IV placement. Since an IV start is a process, not a task that only requires the right level of nurse expertise, an IV access grading tool may not independently facilitate IV first attempt success, decrease the number of overall IV attempts or stop IV access attempts when futile. Further, difficult IV access tools do not consider patient comfort at the time the IV is to be started.

A pediatric peripheral vascular access algorithm (PPVAA) that is designed to match nurses' competence with patient comfort and difficulty of IV start was designed to improve first attempt success rate and overall number of IV attempts per patient. It is important to determine if use of a PPVAA achieves preset goals. The specific aims of this research study were to compare IV access attempts and success rates before and after use of a multi-component algorithm (including an IV access grading tool). Five research questions were analyzed. Compared to pre-algorithm use, does use of the PPVAA (a) improve IV first attempt success, (b) improve overall IV attempt success, (c) decrease number of staff attempting access per episode, (d) decrease the number of overall staff attempts at vascular access and (e) pair patients- based on IV difficulty, to providers- based on self-assessed IV competency, when a first-attempt was successful?

Methods

Using a non-equivalent, two-group, comparative design and convenience sampling, patients received IV placement before or after PPVAA implementation by clinical nurses who worked on the study units. The study was approved by the health system Institutional Review Board prior to implementation. Nurses nor patients were required to give written informed consent. Nurses received a research information sheet and consent was assumed when they returned documentation about themselves (nurse characteristics) and completed case report forms of IV attempts.

Setting and Sample

This study was conducted at a 120 bed urban children's hospital that was part of a 1400 bed quaternary-care hospital in Northeast Ohio. All nurses caring for pediatric patients on non-intensive care units were eligible. There were no nurse exclusion criteria. Nurse participation was voluntary; study information was distributed to their personal unit mailboxes. Nurses who agreed to participate provided IV attempt data in both the pre- and post-intervention periods. Pediatric patients were children aged newborn to 27 years of age who received care on one of five non-intensive care units and required an IV start. Those over 21 years of age were adults with congenital heart conditions that were treated by pediatric cardiologists. Patients were excluded if nurses did not agree to participate or forgot to provide IV attempt data. Patient groups were non-equivalent in that there was a gap of three months between pre- and post-intervention data collection.

The sample size was determined by a power analysis (performed using SAS software, version 9.2; Cary, NC) and based on assumptions that were derived from pre-intervention data available to investigators. With 80% power, use of a two-sided test of significance and an alpha of 0.05, approximately 420 patients would allow for a minimally detectable mean attempt decrease of 15% and a first success rate increase of 10% over a six month period, based on assumptions of a mean number of two attempts per subject and a first attempt success rate of approximately 55% at baseline. Power calculations were performed assuming that the attempt rate was log-normally distributed with a coefficient of variation of 0.75. Power calculations approximated use of a Poisson regression model and allowed for imbalance in recruitment pre- and post-intervention.

Intervention

The PPVAA had four components that were assessed in a specific order. First, a comfort plan was initiated; defined as non-pharmacological (for example, comfort positioning, support from a child life specialist and/or distractions, such as spinners, movies and game apps on iPads), and pharmacological interventions (for example, 4% topical anesthetic cream, oral sucrose or benzodiazepines). Second, a revised *Assessment Tool for Grading Intravenous (IV) Access* was used to grade patients' current state of IV access availability and complexity/difficulty. It included six items; four were related to patients (available access sites, cooperativeness, age [by three categories: zero to two years, three to five years and six years or older] and anticipated length of IV use), one item was related to parents (cooperativeness [anxiety], expressing concern, can assist or willing to leave the room) and the final item was obtained from a parent or the medical record and provided patients' history related to vascular access (dehydration, nausea/vomiting, developmentally delayed or other). The tool originated at Scottish Rite Children's Hospital in Atlanta, Georgia and was adapted with permission by J. Patricia Catudel to meet her institution's needs (Catudel, 1999). In this study, the tool was adapted from Catudel's version after receiving verbal permission. For each item, response options and associated scores varied. A total score (that ranged between seven and 21) reflected the likelihood of difficult vascular access, with higher scores equating to greater difficulty. Despite that this tool lacks reliability data, it was selected for two reasons; first, the other available tools had either poor sensitivity and specificity or no publications of psychometric testing and second, the principal investigator, a pediatric clinical nurse specialist, and the tool author are both pediatric vascular access experts who believed that the six-item tool was robust in that it included patient physical, past history and emotional factors and parents' emotional responses to IV access attempts. Further, internal consistency of the tool was not expected, as each of the six items provided unique dimensions of PIV difficulty.

The third component involved a nurse self-assessment of their skill level in vascular access to determine if it was appropriately matched to patients' IV grading score (IV access difficulty). The final component was a stop sign to reflect stopping IV access attempts. It was expected that nurses would engage healthcare providers earlier in IV access initiation to assist with problem solving, determine necessity for vascular access and determine if non-vascular access options were appropriate. Stopping-the-line was further defined as pausing the IV start process after two IV placement attempts and notifying a medical resident. After full consideration, if the resident indicated that an IV was still in the best interest of the patient, then the level of nurse expertise was escalated. After two further attempts without success by an advanced or expert vascular access clinician, a stop in the process was required and a senior resident and staff pediatric physician were notified and asked to select the best course of action.

Outcomes and Measurement

In this study, four outcomes were assessed related to vascular access attempts: IV first attempt success, number of attempts per patient, number of staff attempting access per episode and overall vascular access attempts. Outcomes were measured using an investigator-developed case report form that included patient's medical record number and age and nurse responses to date, time, initial IV start, number of attempts and overall success.