


Difficult Peripheral Venous Access in Children: An International Survey and Critical Appraisal of Assessment Tools and Escalation Pathways

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Key words

Pediatrics, peripheral catheterization, difficult intravenous access, survey of practice

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Abstract

Background: Peripheral venous cannulation is considered a routine procedure, yet 50% of first attempt insertions fail, necessitating repeat insertion attempts. Identification of children with difficult intravenous access (DIVA) can help promote prompt escalation to an appropriately skilled clinician.

Objective: To describe current international practice regarding the identification and management of children with DIVA, and to systematically review clinical tools and clinical pathways for children with DIVA.

Methods: A cross-sectional, international survey; followed by a systematic review and critical appraisal of clinical pathways using the Appraisal of Guidelines for Research Evaluation (AGREE) II checklist.

Results: A total of 148 clinicians from eight countries completed the survey. The majority were nurses ($n = 92$; 62%), practicing as vascular access specialists ($n = 27$; 18%). Twenty-three respondents (16%) reported using a DIVA tool, of which the DIVA Score was most common ($n = 5$; 22%). Five clinical pathways were identified from the survey and review. Based on the AGREE II domains, pathways generally scored well for scope and purpose, and for clarity of presentation areas. Information on the rigor of development and editorial independence was infrequently detailed. Based on AGREE II findings, one pathway was recommended for clinical practice, and four were recommended for use with modification.

Conclusions: Resources for the identification and escalation of children with DIVA are not standardized or consistently used. Further work is needed to streamline processes for DIVA identification and escalation to the appropriate clinician, with technology-assisted insertion capability. This will enhance patient experiences and reduce harm from multiple insertion attempts.

Clinical Relevance: Multiple failed insertion attempts come at great cost to the child, family, and healthcare service. Early identification and management of the child with DIVA can ensure prompt escalation and management, improving the patient and family experience.

More than 50% of children admitted to a healthcare facility require the insertion of a peripheral intravenous cannula (PIVC) to administer medical treatment (2019). Despite this, more than 50% of first attempt insertions fail (Kleidon et al., in press). Estimates suggest half of all children who present to hospital have difficult intravenous access (DIVA; Whalen, Maliszewski, & Baptiste, 2017), due to intrinsic and extrinsic factors. In general, DIVA is defined as a clinical situation where multiple attempts or special interventions are required to obtain and maintain peripheral venous access (Rauch et al., 2009). While the average child receives two needle sticks to successfully achieve cannulation (Hartzog, Eldridge, & Larsen, 2008), children with DIVA are reported to experience upwards of nine cannulation attempts (Kleidon et al., in press).

PIVC insertion failure results in patient harm and wastes valuable healthcare resources. Two thirds of both children and parents describe PIVC insertion as the worst thing to happen during hospital admission (Hands, Round, & Thomas, 2010). Repeated insertion attempts deplete children of usable veins for the future, obstructing long-term and even lifelong vascular access. PIVC insertion failure delays medical treatment, which may reduce therapy efficacy, prolong recovery, and extend inpatient bed days (Goff et al., 2013; Seymour et al., 2014). For the health service, vascular access is a key contributor to healthcare expenditure, with the cost of three or more insertion attempts estimated to be \$US69 to \$US125 compared to \$US41 for a single insertion attempt (Goff et al., 2013). Multiple insertion attempts cost the Australian health care system nearly \$AU450 million annually (Tuffaha et al., 2018).

The prospective identification and management of DIVA in children is complex, with several predisposing factors. These include patient (e.g., age, adiposity, and prematurity), illness and injury (e.g., dehydration and sepsis), and provider (e.g., inserter experience, skills, and confidence) variables (Kuensting et al., 2009; Larsen et al., 2010; Yen, Riegert, & Gorelick, 2008). These risk factors can equate to an inexperienced clinician inserting a device in a noncompliant child with poor vein palpability, venous fragility, and a limited number of available PIVC access sites (Kuensting et al., 2009; Scott-Warren & Morley, 2015). Recommendations from an expert panel propose PIVC insertion failure to be preventable via the prospective identification of DIVA children, use of vessel assessment tools, high-quality standards of practice, and decision-promoting or escalation pathways (O'Neill, Dillane, & Hanipah, 2012; Rauch et al., 2009). It is not currently known

what pediatric DIVA tools and pathways are currently used in practice, or whether their quality is adequate to recommend in routine practice. Therefore, the objectives of the study were to: (a) Describe current, international practice regarding the identification and management of children with DIVA; and, (b) Identify additional DIVA tools and systematically review clinical practice guidelines or clinical pathways for children with DIVA.

Methods

Design

This was a two-phase study, involving an international, cross-sectional survey, followed by a systematic review and critical appraisal. The survey was conducted to current practice for DIVA identification and management in pediatrics, while the systematic review was undertaken to identify additional DIVA tools and critically appraise DIVA clinical practice guidelines (CPGs) or clinical pathways in the absence of CPGs.

Phase 1: International Survey

Setting and Participants. A purposive sample of multidisciplinary clinicians who currently insert PIVCs in children under 18 years of age were invited to participate in an online survey (Lime Survey®). The survey link was distributed to clinicians through professional vascular access networks (e.g., the Australian Vascular Access Society), international organizations (e.g. Association for Vascular Access), and social media (Facebook; Twitter). Because the survey was distributed in English, exclusion criteria included non-English-reading clinicians and those only inserting PIVCs in patients over 18 years of age.

Survey Development and Distribution. The survey was developed after a review of the literature and previous vascular access surveys (Broadhurst, Moureau, & Ullman, 2016). This identified three key domains: operator characteristics (e.g., clinician experience), patient factors (e.g., age), and resources and policies (e.g., availability of vessel-locating technology). From these domains, 20 survey items were generated and formatted as multiple-choice or 5-point Likert scale questions. Two open-ended response questions were included to capture clinicians' experiences with pediatric DIVA. Demographic questions were included to describe respondent characteristics (11 items).

Content validity and feasibility of the survey were established prior to distribution. Item validity was determined using a content validity index (CVI; Polit

& Beck, 2017). A panel of experts ($n = 4$) comprising multidisciplinary pediatric vascular access specialists were asked to provide feedback on the appropriateness and relevance of survey items using a 4-point level of agreement (1 = *not*; 2 = *somewhat*; 3 = *quite*; 4 = *highly*). Item level CVIs were calculated as the number of experts giving a score of 3 or 4 (item cut-off score of 0.75). The CVIs of individual items are described in Table S1. Experts were then asked to make one of the following recommendations: 1 = *delete the item*; 2 = *make a major revision*; 3 = *make a minor revision*; or 4 = *keep the item as it is*. Overall, experts recommended minor revisions to 10 items. Two items were recommended for major revisions by one expert. These questions had multiple subquestions, and the answers to these questions were revised. No items were recommended for deletion. Feasibility of the tool was established with the panel reporting it took between 10 and 15 minutes to complete the survey, with questions easy to understand and presented in a logical sequence. No technical difficulties were reported.

Data analysis

Basic frequencies and descriptive statistics were used to summarize sample characteristics and survey results. Means and standard deviations were used to report normally distributed continuous data; medians and interquartile ranges were used for interval data that could not be approximated with a normal distribution. Data were managed in Microsoft Excel (Microsoft Corporation, Redmond, WA, USA) and analyzed in IBM SPSS version 25.0 (IBM Corp., Armonk, NY, USA). Qualitative comments yielded in survey questions were analyzed using thematic analysis (Braun & Clarke, 2006).

Ethical considerations

The study received ethical clearance from Griffith University (reference no. 2018/420). A participant information and consent form preceded the survey questions, and informed consent was implied by survey completion.

Phase 2: Systematic Review and Critical Appraisal

Review framework

The systematic review of DIVA tools and CPGs (or clinical pathways in the absence of CPGs) was conducted in line with the Cochrane review methodology (Higgins & Green, 2011) and the Meta-analysis of Observational Studies in Epidemiology (MOOSE) group (Stroup et al., 2000).

Eligibility criteria

The review included studies of a minimum level of design, observational with no comparator, which described DIVA tools, CPGs, or clinical pathways in children under 18 years of age. We excluded studies not published in English, or before 2008 (10-year limit), or abstracts where adequate data could not be extracted. We included clinical pathways in the absence of CPGs as we aimed to describe all DIVA resources available to pediatric clinicians to inform practice.

Search strategy and study selection

A systematic search was undertaken in the following electronic databases: Cochrane Library, U.S. National Library of Medicine National Institutes of Health (PubMed), Cumulative Index to Nursing and Allied Health Literature (CINAHL) and Embase (from January 2007). Databases were independently searched on March 6, 2018 (by J.A.S. and R.P.). MeSH and key words were developed with a healthcare librarian and included peripheral intravenous catheters, peripheral vein assessment, difficult venous access, DVA, difficult intravenous access, DIVA, escalation pathways, clinical practice guidelines, clinical decision-making and pediatrics; the Boolean operators AND and OR; and the truncation symbol *. Hand searches of systematic article bibliographies were also undertaken. Study authors did not need to be contacted as inclusion eligibility and data were extractable from the published reports.

Data extraction and critical appraisal

Data were extracted using a standardized data extraction form, and references were screened and managed in EndNote (Clarivate Analytics, Philadelphia, PA, USA). Data extracted included study origin, tool, CPG or pathway, setting for psychometric testing, and participants. A DIVA tool was defined as a clinical assessment or scoring tool for clinicians to identify DIVA in the clinical setting (Ehrhardt, Givens, & Lee, 2018). A DIVA clinical pathway was defined as a clinical resource that provided guidance regarding the identification and management of DIVA in the clinical setting (Sou et al., 2017). CPGs were defined in accordance with the National Health and Medical Research Council and the Institute of Medicine (Graham, Mancher, Wolman, Greenfield, & Steinberg, 2011; National Health and Medical Research Council, 2017). The methodological quality of identified CPGs or clinical pathways in the absence of CPGs was assessed using the Appraisal of Guidelines for Research Evaluation (AGREE) II instrument (Brouwers, Kerkvliet, & Spithoff, 2016; Brouwers et al., 2010).

DIVA tools were not assessed using the AGREE II instrument. CPG or clinical pathway evaluation was undertaken by two appraisers (J.S. and A.U.). Each appraiser independently scored the CPGs or clinical pathway using the 7-point scale across the six domains, with a score of 7 indicating that the quality of reporting was exceptional. Domain scores were calculated by a summation of appraiser scores and by scaling the total as a percentage of the maximum possible score for that domain.

Results

Phase 1: International Survey

Sample

Overall, 165 healthcare practitioners accessed the survey. Of these, 17 responded “no” to the initial screening question “Do you currently insert PIVCs in children” and therefore did not complete the survey. Table S2 outlines the demographics of the remaining 148 respondents, who originated from eight countries, primarily the United States ($n = 69$; 47%) and Australia ($n = 54$; 37%).

Operator characteristics

Clinicians spent more than 50% of their time in the clinical setting ($n = 133$; 90%), inserting 10 to 20 PIVCs per week ($n = 112$; 76%), with most respondents working in vascular access teams ($n = 27$; 18%) or as nurses ($n = 92$; 62%). Forty-six percent ($n = 68$) of inserters did not hold a qualification related to vascular access; however, most reported more than 10 years’ experience inserting PIVCs ($n = 97$; 65%).

Patient factors

Overall, children perceived to be DIVA (45%) were most likely to have their preferences ascertained prior to insertion, with previous PIVC insertion experience the most common question (86%). When asked to rank factors impacting PIVC insertion decisions (1 = *most important*, 10 = *least important*), reason (indication) for PIVC (median rank 2; interquartile range [IQR] 1–5) was most likely to be of influence, and patient skin color (median rank 8; IQR 6–10) of least influence (Table S3).

Tools and pathways

As outlined in Table S4, 23 respondents (16%) reported using a DIVA tool in their practice, with the DIVA Score (Yen et al., 2008; 20%) the most commonly used tool. Vein grade (i.e., quality) was the most common variable assessed in individual tools,

with severity of illness the least frequently represented item. Fifty-seven percent ($n = 13$) of respondents believed tools were not routinely used due to factors such as “clinicians forget it’s there,” “it’s not necessary for every child,” “more experienced nurses feel like they do not need it,” and it impacts the “immediacy of needing access.” Respondents also listed technology aids such as ultrasound guidance (USG) as vessel assessment tools. Both tools and technology were most commonly utilized by vascular access services (VASs) or in critical care areas such as intensive care or emergency.

Overall, VAS members were most likely to attempt first insertion in children with DIVA ($n = 51$; 34%). Other clinicians responsible for PIVC insertion included the treating doctor ($n = 38$ participants; 26%), ward nurse ($n = 31$; 21%), consultant ($n = 25$; 23%), or anyone willing ($n = 21$; 14%). Most respondents reported clinical policies that allowed inserting clinicians two attempts ($n = 91$; 61%); however, 20 respondents (14%) reported having policies that allowed the first inserter three or four attempts to secure access before escalation. When considering the total number of insertion attempts made by all clinicians, 75% ($n = 111$) of respondents reported no cap on the total number of insertion attempts allowed to achieve successful PIVC placement.

Three DIVA clinical pathways were identified by respondents (these pathways were not published in peer review journals) from tertiary hospitals in the United Kingdom, Australia, and the United States (available online; Children’s Hospital of Philadelphia, 2018). Further, 71 respondents (48%) reported having a DIVA escalation pathway. In general, these escalation processes were described as “informal practices” that were “just known” rather than formal escalation pathways. Of these, 78% involved referral to a vascular access specialist, 83% involved the use of ultrasound technology, and 52% involved the use of other technology (VeinViewer, Christie Digital Systems, Cypress, CA, USA). Overall, 75% ($n = 111$) of respondents perceived escalation pathways for children with DIVA as valuable. Scaled domain percentages and overall assessment of included clinical pathways are presented in Table S5.

A total of 82 qualitative comments were collected in response to two open-ended questions (43 participants and 39 participants, respectively). Responses were categorized into two themes: (a) recognition and support of a formal escalation pathway; and (b) competency, training, and resources.

Recognition and Support of a Formalized Escalation Process. The importance of implementing a formalized escalation process was consistently identified by

participants: “We need a formal pathway to be implemented”; “. . . a pediatric specific pathway developed and put in place”; and “make it mandatory to escalate after a child has already had multiple attempts at access.” Participants expressed frustration at the informal processes and the subsequent number of insertion attempts children experience. With participants describing the need for a “step-by-step or pathway” to avoid “multiple attempts at access.” The difficulty of developing and rolling out an escalation pathway was not lost on participants, with one stating, “[people believe] it is difficult to change . . . the plan needs an entire overhaul, and a dedicated team to do insertions.” However, even when hospitals had escalation processes in place, namely referrals to a VAS, clinicians’ frustrations were evident:

I would just like my hospital to acknowledge that vascular access is difficult in children and to understand the importance and role of the six RNs [registered nurses] who are VA-BC [vascular access board certified] and the amount of work done on a daily basis to ensure kids do have the best possible IV placement the first time.

Respondents discussed the importance of thorough implementation of the policy to minimize “push back from people” and ensure “more awareness and agree on a unified process,” and “it would be great, if everyone followed it.”

Competency, training, and resources

For many respondents, having the right person insert the right device using the appropriate technology and achieving first attempt success was the main aim of escalation pathways. The “goal is first attempt success on all children.” Participants explained that it all comes down to “clinician experience and comfort of [the] inserter” and “skilled staff” rather than “crossing your fingers and praying” until someone successfully cannulates. The need for accredited and skilled staff was repeatedly discussed in the context of a child with DIVA and USG PIVC insertion: “we need skilled staff in ultrasound guidance” and “more staff training particularly in ultrasound.” The importance of having the right resources was also raised by participants with one commenting, “Timing and preparation, having the appropriate support team and resources.” Access to ultrasound technology was repeatedly discussed:

At my current facility, the ultrasound is only available for the vascular access team and the emergency department to use. I

would like to see more people throughout the facility certified in using ultrasounds to place PIVCs and more ultrasounds available for PIVC guidance.

Further, participants discussed the need for resources to help “encourage parental involvement,” and to reduce parent and child anxiety “we need education for family members” and techniques to minimize “parent and child emotional stress and nerves.” Solutions such as “play therapy” were proposed.

Phase 2: Systematic Review and Critical Appraisal

Identification and Selection of Relevant Studies. Figure S1 describes the flow of studies included in the review (Moher, Liberati, Tetzlaff, & Altman, 2009). Following removal of duplicates ($n = 23$), the title and abstracts of 79 articles were screened; 37 papers were excluded as they did not meet the inclusion criteria. The full texts of 42 articles were retrieved and reviewed, with 34 articles excluded. A total of eight studies met the inclusion criteria and were included in the review.

Characteristics of included studies

Studies were undertaken in the United States ($n = 3$ studies; 38%; Hartman, Baker, Bena, Morrison, & Albert, 2018; Riker, Kennedy, Winfrey, Yen, & Dowd, 2011; Yen et al., 2008), Brazil ($n = 1$ study; 12.5%; de Souza Freire, Arreguy-Sena, Souza, & de Souza Müller, 2017), Ireland ($n = 1$ study; 12.5%; O’Neill et al., 2012), Iran ($n = 1$ study; 12.5%; Yan et al., 2016), Australia ($n = 1$ study; 12.5%; Sou et al., 2017), and the United Kingdom ($n = 1$ study; 12.5%; Hallam et al., 2016). Study populations were both pediatric specific (de Souza Freire et al., 2017; Hartman et al., 2018; O’Neill et al., 2012; Riker et al., 2011; Yan et al., 2016; Yen et al., 2008) and all age patients (Hallam et al., 2016; Sou et al., 2017).

Peripheral venous assessment tools

Four tools were identified by the review, and these are further described in Table S3. Tools included the three-variable (Riker et al., 2011), four-variable (O’Neill et al., 2012; Riker et al., 2011; Yen et al., 2008), and five-variable DIVA Score (de Souza Freire et al., 2017); a peripheral venous grading system (Yan et al., 2016); a peripheral vein assessment tool (Hallam et al., 2016); and a revised assessment tool for grading PIVC access (Hartman et al., 2018). Study designs included pre and post methods (Hartman et al., 2018), prospective cohort and observational (O’Neill et al., 2012; Yan et al., 2016), discussion papers (Hallam et al., 2016), and

cross-cultural adaption and validation (de Souza Freire et al., 2017). Tool development and psychometric testing were most commonly undertaken in pediatric emergency settings (O'Neill et al., 2012; Riker et al., 2011; Yen et al., 2008) and general pediatric hospitals (de Souza Freire et al., 2017; Hartman et al., 2018; Yan et al., 2016). Tools were evaluated using various outcome measures, including first attempt success, number of attempts, overall success rate, and number of people attempting insertion.

Of the four tools identified, there were published data on the psychometric properties only for one tool, the DIVA Score, which is a four-variable proportionally weighted score, ranging from 0 to 10 (Yen et al., 2008). The four items are vein palpability, vein visibility, age, and history of prematurity. A score of 4 or more indicates a 50% increase in the likelihood of first attempt failure. The tool originally included skin shade as a fifth variable, but this was omitted in the final model. Since its inception, the DIVA score has been modified to a three-item version (Riker et al., 2011), adapted for nonwesternized cultures (de Souza Freire et al., 2017) and refined for adult patients (A-DIVA; van Loon, Puijn, Houterman, & Bouwman, 2016).

Methodological Quality of CPGs

We identified no documents pertaining to pediatric DIVA entitled CPGs. A total of five clinical pathways were identified, three by survey respondents and two by systematic review. Scaled domain percentages and overall assessments for each pathway are presented in Table S5. Based on the AGREE II domains, pathways generally scored high in scope and purpose, and in clarity of presentation areas. Information on the rigor of development and editorial independence were infrequently detailed. Overall, one pathway (Hallam et al., 2016) scored highly (76.0) using the AGREE II criteria (Brouwers et al., 2016), providing a valuable resource for clinicians and health services. Of the five pathways, three were specific to pediatrics and two were developed for a broader age range (Hallam et al., 2016; Sou et al., 2017). Clinical pathways were not developed with the rigor or resources of CPGs; however, these resources provided a combination of clinical practice recommendations and decision-making trees to guide practice.

Discussion

A key finding of this study is that while the systematic identification and management of children with DIVA is occurring in siloed facilities, in general,

children with DIVA are not consistently identified and managed. Most clinicians (84%) reported not using DIVA assessment tools and only limited, informal DIVA pathways in their workplace. How these clinicians identify and manage children with DIVA is unknown; however, this judgment is likely a combination of clinician gestalt (Rippey, Carr, Cooke, Higgins, & Rickard, 2016) and experience. Of the tools used, the DIVA Score (Yen et al., 2008) was the most common (23%). This tool has undergone clinometric testing with good results in emergency settings (O'Neill et al., 2012; Riker et al., 2011), with a positive predictive value of 49% to 84% (O'Neill et al., 2012; Yen et al., 2008) and moderate inter-rater reliability of tool variables (McHugh, 2012). However, further testing outside the emergency setting is needed, given that inpatient populations have insertion success rates as low as 35% (Benkhadra et al., 2012; Vukovic, Frey, Byczkowski, Taylor, & Kerrey, 2016). Three respondents reported escalation policies that incorporated decision-making trees and electronic resources, but all identified room for improvement and modification. These policies were not developed with the resources or rigor of national guidelines (Graham et al., 2011; AGREE II rating range 4.0–5.0). Specifically, there was a need for more information regarding stakeholder involvement (e.g., target population preferences and group membership) and rigor of development (e.g., evidence selection criteria and search methods). Despite this, they scored above the AGREE II threshold of 3.0 for a high-quality guideline (Brouwers et al., 2016; Brouwers et al., 2010).

This review identified several DIVA tools and clinical pathways not currently used in clinical practice. The pediatric peripheral vascular access algorithm (PPVAA; Hartman et al., 2018) is the first tool to combine a comfort plan and nursing self-assessment of skill, with a vein assessment prior to PIVC insertion. Initial testing in 721 insertions demonstrated the tool significantly reduced total number of attempts ($p = .002$) and number of staff members attempting access per episode ($p = .017$). Preliminary testing of this tool provided positive results, but further testing is needed to determine its reliability and generalizability. Sou et al. (2017) developed a clinical pathway for the management of difficult venous access, which was activated following two failed attempts by ward staff. Implementation of this after-hours pathway led to a significant reduction in number of insertion attempts (after hours) from two (IQR 2–4) to one (IQR 1–1; $p < .001$), with an average insertion time of 13.6 min, substantially less than the previously reported time of 33 min (Rauch et al., 2009). However, further testing in other clinical settings is needed. Preliminary evidence suggests the

adoption of DIVA tools and pathways can positively enhance clinical outcomes, but at present there is limited international consensus and standardization of DIVA resources in clinical practice. Overall, participants strongly supported the development of a pediatric DIVA escalation CPG, believing this is pivotal in driving improvements in the quality of care patients receive.

The results of this study highlight the inconsistent use of clinical resources in the context of the child with DIVA. Despite many survey respondents ascertaining patient and family preferences for insertion in children with DIVA, identified tools generally failed to incorporate child or family preferences, with the exception of the PPVAA (Hartman et al., 2018). Given children and families consistently report PIVC insertion as one of the most traumatic procedures experience in their hospitalization (Hands et al., 2010), ascertaining children's preferences is important. From the resources identified, vein quality or grade was the most commonly assessed patient variable. Vein quality predicted the "difficulty" of insertion, which when combined with an assessment of inserter skill and confidence may help ensure the right person is inserting the PIVC the first time. Two tools included a competence self-assessment for the inserter (Hallam et al., 2016; Hartman et al., 2018), with DIVA pathways generally including escalation to an appropriately skilled clinician with skills in technology assisted insertion. Greater inserter confidence and skill has been shown to positively influence insertion success (Larsen et al., 2010). Hartman and colleagues (2018) demonstrated that competent self-assessment promotes early escalation to better qualified inserters, resulting in greater first attempt success (Yan et al., 2016). Clinicians consistently described the need for additional training and improved resources to support insertion-related skills, perceiving insertion skills such as USG capabilities to increase the chance of first attempt success.

DIVA tools guide objective description of vessel quality and practice variables. However, equally important to improve patient outcomes is the provision of management strategies when a DIVA is identified. The early identification of children with DIVA is more likely to guide the use of technology-assisted insertion modalities such as ultrasound. USG PIVC insertion can improve insertion success for DIVA patients of all ages when compared with the traditional technique ($n = 7$ studies, odds ratio 3.96; 95% confidence interval 1.75–8.94) (Stolz, Stolz, Howe, Farrell, & Adhikari, 2015). In children with DIVA, USG PIVC insertion significantly improved first insertion success compared to the traditional technique (85% vs. 35%, $p < .01$) (Benkhadra

et al., 2012). Survey respondents highlighted PIVC training and particularly USG accreditation as needed, a finding that has important implications for future workforce education planning. Many facilities may not have access to resources such as ultrasound; however, in these situations the early identification of the child with DIVA and the appropriate escalation to a skilled inserter may still optimize the insertion attempt (Petroski, Frisch, Joseph, & Carlson, 2015).

Limitations of the study include the potential for bias introduced through self-reporting and limited respondent representation from many countries. Further, given the nature of survey distribution, denominators and thus sampling bias are unknown; therefore, it is not known how well the results may be generalized across countries and within differing pediatric specialties. A key strength of the survey dissemination, however, was its distribution to clinicians in professional groups or organizations who would have skills and knowledge regarding pediatric PIVC insertion and resources available within their institution.

Conclusions

This study identified the existence of limited DIVA resources to guide PIV insertion decisions in children with DIVA. The DIVA Score is the most common clinical assessment tool, with few escalation pathways identified. Additional work to develop a consensus regarding the identification and appropriate management of children with DIVA is needed. Specifically, higher quality practice guidelines are needed that incorporate tools which have undergone extensive clinometric evaluation, evaluation of patient and family preferences, and escalation recommendations. Considering the demonstrated benefits of USG PIVC insertion in patients identified as DIVA, any recommendation should encourage its use when available. Further, these resources should be developed under a co-creation framework with consumers and key stakeholders to ensure the acceptability and usability of the resource.

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Clinical Resources

- Alliance Vascular Access Teaching and Research webpage. <https://www.avatargroup.org.au/>
- Association for Vascular Access. Pediatric Special Interest Group. <https://www.avainfo.org/page/PediSIG>
- EA-DIVA score: A new scale to predict difficult preoperative venous cannulation in adult surgical patients. <https://www.ncbi.nlm.nih.gov/pubmed/30324841>
- National Health Service, Great Ormond Street Hospital for Children. Peripheral venous cannulation of children. <https://www.gosh.nhs.uk/health-professionals/clinical-guidelines/peripheral-venous-cannulation-children>

References

- Benkhadra, M., Collignon, M., Fournel, I., Oeuvrard, C., Rollin, P., Perrin, M., ... Girard, C. (2012). Ultrasound guidance allows faster peripheral IV cannulation in children under 3 years of age with difficult venous access: A prospective randomized study. *Paediatric Anaesthesia*, 22(5), 449–454. <https://doi.org/10.1111/j.1460-9592.2012.03830.x>
- Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77–101.
- Broadhurst, D., Moureau, N., & Ullman, A. J. (2016). Central venous access devices site care practices: An international survey of 34 countries. *Journal of Vascular Access*, 17(1), 78–86. <https://doi.org/10.5301/jva.5000450>
- Brouwers, M. C., Kerkvliet, K., & Spithoff, K. (2016). The AGREE Reporting Checklist: A tool to improve reporting of clinical practice guidelines. *British Medical Journal*, 352. <https://doi.org/10.1136/bmj.i1152>
- Brouwers, M. C., Kho, M. E., Browman, G. P., Burgers, J. S., Cluzeau, F., Feder, G., ... for the AGREE Next Steps Consortium. (2010). AGREE II: Advancing guideline development, reporting and evaluation in healthcare. *Canadian Medical Association Journal*, 182, E839–E842.
- Children's Hospital of Philadelphia. (2018). *Pathway for inpatient vascular access*. Retrieved from <https://www.chop.edu/clinical-pathway/vascular-access-inpatient-clinical-pathway>
- de Souza Freire, M. H., Arreguy-Sena, C., Souza, d., & de Souza Müller, P. C. (2017). Cross-cultural adaptation and content and semantic validation of the Difficult Intravenous Access Score for pediatric use in Brazil. *Revista Latino-Americana de Enfermagem*, 25, e2920. <https://doi.org/10.1590/1518-8345.1785.2920>
- Ehrhardt, B. S., Givens, K. E. A., & Lee, R. C. (2018). Making it stick: Developing and testing the Difficult Intravenous Access (DIVA) tool. *American Journal of Nursing*, 118(7), 56–62. <https://doi.org/10.1097/01.naj.0000541440.91369.00>
- Goff, D. A., Larsen, P., Brinkley, J., Eldridge, D., Newton, D., Hartzog, T., & Reigart, J. R. (2013). Resource utilization and cost of inserting peripheral intravenous catheters in hospitalized children. *Hospital Pediatrics*, 3(3), 185–191.
- Graham, R., Mancher, M., Wolman, D. M., Greenfield, S., & Steinberg, E. (Eds.). (2011). *Clinical practice guidelines we can trust*. Washington, DC: National Academies Press.
- Hallam, C., Weston, V., Denton, A., Hill, S., Bodenham, A., Dunn, H., & Jackson, T. (2016). Development of the UK Vessel Health and Preservation (VHP) framework: A multi-organisational collaborative. *Journal of Infection Prevention*, 17(2), 65–72. <https://doi.org/10.1177/1757177415624752>
- Hands, C., Round, J., & Thomas, J. (2010). Evaluating venepuncture practice on a general children's ward. *Paediatric Nursing*, 22(2), 32–35. <https://doi.org/10.7748/paed2010.03.22.2.32.c7597>
- Hartman, J. H., Baker, J., Bena, J. F., Morrison, S. L., & Albert, N. M. (2018). Pediatric vascular

- access peripheral IV algorithm success rate. *Journal of Pediatric Nursing*, 39, 1–6. <https://doi.org/10.1016/j.pedn.2017.12.002>
- Hartzog, T. H., Eldridge, D. L., & Larsen, P. G. (2008). *Putting in the pediatric IV: Does confidence and competence make a difference?* Paper presented at the American Academy of Pediatrics National Conference & Exhibition, Boston, MA., October 11–14, 2008.
- Higgins, J. P. T., & Green, S. (Eds.). (2011). *Cochrane handbook for systematic reviews of interventions* (Ver. 5.1.0). London, UK: Cochrane Collaboration.
- Kleidon, T. M., Cattanach, P., Mihala, G., & Ullman, A. J. (2019). Implementation of a paediatric peripheral intravenous catheter care bundle: A quality improvement initiative. *Journal of Paediatrics and Child Health*, (Early View). <https://doi.org/10.1111/jpc.14384>
- Kuensting, L. L., DeBoer, S., Holleran, R., Shultz, B. L., Steinmann, R. A., & Venella, J. (2009). Difficult venous access in children: Taking control. *Journal of Emergency Nursing*, 35(5), 419–424. <https://doi.org/10.1016/j.jen.2009.01.014>
- Larsen, P., Eldridge, D., Brinkley, J., Newton, D., Goff, D., Hartzog, T., ... Perkin, R. (2010). Pediatric peripheral intravenous access: Does nursing experience and competence really make a difference? *Journal of Infusion Nursing*, 33(4), 226–235. <https://doi.org/10.1097/NAN.0b013e3181e3a0a8>
- McHugh, M. L. (2012). Interrater reliability: The kappa statistic. *Biochemia Medica*, 22(3), 276–282.
- Moher, D., Liberati, A., Tetzlaff, J., & Altman, D. G. (2009). Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *PLoS Medicine*, 6(7), e1000097. <https://doi.org/10.1371/journal.pmed.1000097>
- National Health and Medical Research Council. (2017). *Australian clinical practice guidelines*. Canberra, ACT, Australia: Author.
- O'Neill, M. B., Dillane, M., & Hanipah, N. F. (2012). Validating the difficult intravenous access clinical prediction rule. *Pediatric Emergency Care*, 28(12), 1314–1316. <https://doi.org/10.1097/PEC.0b013e3182768bc9>
- Petroski, A., Frisch, A., Joseph, N., & Carlson, J. N. (2015). Predictors of difficult pediatric intravenous access in a community emergency department. *Journal of Vascular Access*, 16(6), 521–526. <https://doi.org/10.5301/jva.5000411>
- Polit, D., & Beck, C. (Eds.). (2017). *Nursing research: Generating and assessing evidence for nursing practice*. Philadelphia, PA: Wolters Kluwer.
- Rauch, D., Dowd, D., Eldridge, D., Mace, S., Schears, G., & Yen, K. (2009). Peripheral difficult venous access in children. *Clinical Pediatrics*, 48(9), 895–901. <https://doi.org/10.1177/0009922809335737>
- Riker, M. W., Kennedy, C., Winfrey, B. S., Yen, K., & Dowd, M. D. (2011). Validation and refinement of the difficult intravenous access score: A clinical prediction rule for identifying children with difficult intravenous access. *Academic Emergency Medicine*, 18(11), 1129–1134. <https://doi.org/10.1111/j.1553-2712.2011.01205.x>
- Rippey, J. C., Carr, P. J., Cooke, M., Higgins, N., & Rickard, C. M. (2016). Predicting and preventing peripheral intravenous cannula insertion failure in the emergency department: Clinician 'gestalt' wins again. *Emergency Medicine Australasia*, 28(6), 658–665. <https://doi.org/10.1111/1742-6723.12695>
- Scott-Warren, V. L., & Morley, R. B. (2015). Paediatric vascular access. *BJA Education*, 15(4), 199–206. <https://doi.org/10.1093/bjaceaccp/mku050>
- Seymour, C. W., Cooke, C. R., Heckbert, S. R., Spertus, J. A., Callaway, C. W., Martin-Gill, C., ... Angus, D. C. (2014). Prehospital intravenous access and fluid resuscitation in severe sepsis: An observational cohort study. *Critical Care (London, England)*, 18(5), 533. <https://doi.org/10.1186/s13054-014-0533-x>
- Sou, V., McManus, C., Mifflin, N., Frost, S. A., Ale, J., & Alexandrou, E. (2017). A clinical pathway for the management of difficult venous access. *BMC Nursing*, 16, 64. <https://doi.org/10.1186/s12912-017-0261-z>
- Stolz, L. A., Stolz, U., Howe, C., Farrell, I. J., & Adhikari, S. (2015). Ultrasound-guided peripheral venous access: A meta-analysis and systematic review. *Journal of Vascular Access*, 16(4), 321–326. <https://doi.org/10.5301/jva.5000346>
- Stroup, D. F., Berlin, J. A., Morton, S. C., Olkin, I., Williamson, G. D., Rennie, D., ... Thacker, S. B. (2000). Meta-analysis of observational studies in epidemiology: A proposal for reporting. Meta-analysis Of Observational Studies in Epidemiology (MOOSE) group. *Journal of the American Medical Association*, 283(15), 2008–2012.
- Tuffaha, H. W., Marsh, N., Byrnes, J., Gavin, N., Webster, J., Cooke, M., & Rickard, C. M. (2018). Cost of vascular access devices in public hospitals in Queensland. *Australian Health Review*, (online early). <https://doi.org/10.1071/ah18102>
- van Loon, F. H. J., Puijn, L. A. P. M., Houterman, S., & Bouwman, A. R. A. (2016). Development of the A-DIVA Scale: A clinical predictive scale to identify difficult intravenous access in adult patients based on clinical observations. *Medicine*, 95(16), e3428–e3428. <https://doi.org/10.1097/MD.0000000000003428>

- Vukovic, A. A., Frey, M., Byczkowski, T., Taylor, R., & Kerrey, B. T. (2016). Video-based assessment of peripheral intravenous catheter insertion in the resuscitation area of a pediatric emergency department. *Academic Emergency Medicine, 23*(5), 637–644. <https://doi.org/10.1111/acem.12927>
- Whalen, M., Maliszewski, B., & Baptiste, D. L. (2017). Establishing a dedicated difficult vascular access team in the emergency department: A needs assessment. *Journal of Infusion Nursing, 40*(3), 149–154. <https://doi.org/10.1097/nan.00000000000000218>
- Yan, Y., Gong, M., Li, D., Huang, Y., Li, A., Qiu, J., ... Lu, Q. (2016). Grade management in establishing pediatric peripheral venous access. *Iranian Journal of Pediatrics, 26*(6), e6321. <https://doi.org/10.5812/ijp.6321>
- Yen, K., Riegert, A., & Gorelick, M. H. (2008). Derivation of the DIVA score: A clinical prediction rule for the identification of children with difficult intravenous access. *Pediatric Emergency Care, 24*(3), 143–147. <https://doi.org/10.1097/PEC.0b013e3181666f32>

Supporting Information

Additional supporting information may be found in the online version of this article at the publisher's web site:

Table S1. Content Validity Index of Survey Items

Table S2. Demographic Characteristics of Survey Respondents ($N = 148$)

Table S3. Factors Influencing Provider PIVC Insertion Decisions

Table S4. DIVA Tools

Table S5. Scaled Domain Percentages and Overall Assessment of Hospital Policies and Published Pathways

Figure S1. PRISMA flow diagram.