

Difficult peripheral venous access in children: An international survey and critical appraisal of assessment tools and escalation pathways.

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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 AGREE II checklist.

Results: A total of 148 clinicians from eight countries completed the survey. The majority were nurses (92; 62%), practising as vascular access specialists (27; 18%). Twenty-three (16%) respondents reported using a DIVA tool, of which the DIVA Score was most common (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 clarity of presentation areas. Information on the rigour of development and editorial independence were 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 standardised 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 difficult intravenous access can ensure prompt escalation and management, improving the patient and family experience.

Introduction

More than 50% of children admitted to a healthcare facility require the insertion of a peripheral intravenous cannula (PIVC) to administer medical treatment (Kleidon, Mihala, Cattanach, & Ullman, 2018). Despite this, more than 50% of first attempt insertions fail (Kleidon et al., 2018). 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 and/or special interventions are required to obtain and maintain peripheral venous access (Rauch et al., 2009, p. 895). While the average child receives two ‘needle sticks’ to successfully achieve cannulation (Hartzog TH, Eldridge DL, & Larsen PG, 2008), children with DIVA are reported to experience upwards of nine cannulation attempts (Kleidon et al., 2018).

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 useable 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 multiple insertion attempts costing the Australian health care system nearly \$450 million [AUD] 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 non-compliant 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:

- 1) Describe current, international practice regarding the identification and management of children with DIVA; and,
- 2) To identify additional DIVA tools and systematically review clinical practice guidelines or clinical pathways for children with DIVA

Methods

Design

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 (CPG), 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 aged < 18 years 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 organisations (e.g. Association for Vascular Access) and social media (Facebook®; Twitter®). As the survey was distributed in English, exclusion criteria included non-English reading clinicians and those only inserting PIVCs in patients older than 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 was established prior to distribution. Item validity was determined using a content validity index (CVI) (Polit & Beck, 2006; Polit, Beck, & Owen, 2007). 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 four-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). CVI of individual items are described in supporting material 1. Experts were then asked to recommend whether to 1, delete the item; 2, major revision; 3, 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 sub questions 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.

➤ *Insert Supporting Material 1. Content validity of survey items*

Data analysis

Basic frequencies and descriptive statistics were used to summarise sample characteristics and survey results. Mean and standard deviation were used to report normally distributed continuous data, median and interquartile range was used for interval data that could not be approximated with a normal distribution. Data was managed in Microsoft Excel and analysed in IBM SPSS version 25.0. Qualitative comments yielded in survey questions were analysed using thematic analysis (Braun & Clarke, 2006).

Ethical considerations

The study received ethical clearance from Griffith University (Ref 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 CPG (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 or CPG or clinical pathways in children, aged less than 18 years. We excluded studies not published in English, or before 2008 (ten-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 electronic databases: Cochrane Library, United States National Library of Medicine National Institutes of Health (PubMed), Cumulative Index to Nursing and Allied Health (CINAHL) and Embase (from January 2007). Databases were independently searched on the 6th March 2018 (JS, RP). 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; Boolean operators AND, OR; and 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 standardised data extraction form and references screened and managed in EndNoteTM. 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 which 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 (JS, AU). Each appraiser independently scored the CPGs or clinical pathway using the 7-point scale across the 6 domains, with a score of 7 indicating the quality of reporting is 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. High quality guidelines are those with a domain score of 3 >70%.

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. Supporting material 2 outlines the demographics of the remaining 148 respondents, who originated from eight countries, primarily the United States of America (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%) and/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%).

➤ *Insert Supporting Material 2. Demographic characteristics of survey respondents*

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; IQR 1-5) was most likely to be of influence, and patient skin colour (8; 6-10) of least influence (supporting material 3).

➤ *Insert Supporting Material 3. Factors influencing provider PIVC insertion decisions*

Tools and pathways

As outlined in supporting material 4, 23 respondents (16%) reported using a DIVA tool in their practice with the *Difficult Intravenous Assessment (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 utilised by vascular access services (VASs) or in critical care areas such as intensive care or emergency.

➤ *Insert Supporting Material 4. DIVA tools*

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%) and finally, anyone willing (n= 21; 14%). Most respondents reported clinical policies which allowed inserting clinicians two attempts (n= 91; 61%), however 20 (14%) respondents reported having policies which 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 from tertiary hospitals in the United Kingdom (unpublished), Australia (unpublished) and the United States of America (Children's Hospital of Philadelphia, 2018). Further, 71 (48%) respondents reported having a DIVA escalation pathway. In general, these escalation processes were described as ‘*informal practices*’ which 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®). 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 supporting material 5.

➤ *Insert Supporting Material 5. Scaled domain percentages and overall assessment of included clinical pathways*

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

Recognition and support of a formalised escalation process

The importance of implementing a formalised 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 6 RN's (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 minimise ‘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 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 reduce parent and child anxiety ‘we need education for family members’ and techniques to minimise ‘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

Supporting material 6 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 and 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.

➤ *Insert Supporting material 6. PRISMA flow diagram*

Characteristics of included studies

Studies were undertaken in the United States of America (3 studies; 38%) (Hartman et al., 2018; Riker et al., 2011; Yen et al., 2008), Brazil (1 study; 12.5%) (de Souza Freire et al., 2017), Ireland (1 study; 12.5%) (O'Neill et al., 2012), Iran (1 study; 12.5%) (Yan et al., 2016), Australia (1 study; 12.5%) (Sou et al., 2017) and the United Kingdom (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, these are further described in Supporting material 3. Tools included the three (Riker et al., 2011), four (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); *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 4-variable proportionally weighted score, ranging from 0-10 (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 5th variable, however this was omitted in the final model. Since its inception, the DIVA score has been modified to a 3-item version (Riker et al., 2011), adapted for non-westernised 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 CPG. A total of 5 clinical pathways were identified, three by survey respondents and two by the systematic review. Scaled domain percentages and overall assessments for each pathway are presented in Table 5. Based on the AGREE II domains, pathways generally scored high in scope and purpose, and clarity of presentation areas. Information on the rigour of development and editorial independence were infrequently detailed. Overall one pathway (Hallam et al., 2016) scored highly (≥ 6.0) 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 whilst 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 judgement 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 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 which incorporated decision-making trees and electronic resource, 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, the 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).

The 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 attempting access per episode ($p=0.017$). Preliminary testing of this tool provided positive results, however, further testing is needed to determine its reliability and generalisability. Sou et al. (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 2 (IQR 2-4) to 1 (IQR 1,1; $p<.001$), with an average insertion time of 13.6 minutes, substantially less than previously reported times of 33 minutes (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, however, at present there is limited international consensus and standardisation 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 PPVA (Hartman et al., 2018). Given children and families consistently report PIVC insertion as one of the most traumatic procedures experience in their hospitalisation (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 demonstrated that competence self-assessment promotes early escalation to better qualified inserters (Hartman et al., 2018), 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 ultrasound guidance 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 all age DIVA patients, when compared traditional technique (7 studies, OR 3.96; 95% CI 1.75-8.94) (Stolz, Stolz, Howe, Farrell, & Adhikari, 2015). In children with DIVA, USG PIVC insertion significantly improved first insertion success compared to traditional technique (85% versus 35%, $p < 0.01$) (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 optimise 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 generalised across countries and within differing pediatric specialities. A key strength of the survey dissemination, however, was its distribution to clinicians in professional groups/organisations who would have skills and knowledge regarding pediatric PIVC insertion and resources available within their institution.

Conclusions

This study identified the existence of various DIVA resources, yet, additional work to develop a consensus regarding the identification and appropriate management of children with DIVA is needed. Specifically, higher quality guidelines 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.

Clinical resources

1. The Alliance Vascular Access Teaching and Research webpage
<https://www.avatargroup.org.au/>
2. Association for Vascular Access, Paediatric Special Interest Group
<https://www.avainfo.org/page/PediSIG>
3. The Great Ormond Street Hospital for Children Peripheral Venous Cannulation of children guideline is available online at:
<https://www.gosh.nhs.uk/health-professionals/clinical-guidelines/peripheral-venous-cannulation-children>
4. For non-pediatric based clinicians the enhanced adult DIVA score publication may support difficult peripheral venous cannulation in adult patients.
<https://www.ncbi.nlm.nih.gov/pubmed/30324841>

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