Original research article

JVA The Journal of Vascular Access

Defining difficult intravenous access (DIVA): A systematic review

The Journal of Vascular Access
1–7

DOI: 10.1177/11297298211059648
journals.sagepub.com/home/jva
SAGE

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Abstract

Background: The term "difficult intravenous access" (DIVA) is commonly used but not clearly defined. Repeated attempts at peripheral intravenous catheter (PIVC) insertion can be a traumatic experience for patients, leading to sub-optimal clinical and economic outcomes. We conducted a systematic literature review (SLR) to collate literature definitions of DIVA, with the aim of arriving at an evidence-driven definition.

Methods: The SLR was designed to identify clinical, cost, and quality of life publications in patients requiring the insertion of a PIVC in any setting, including studies on US-guidance and/or guidewire, and studies with no specific intervention. The search was restricted to English language studies published between 1st January 2010 and 30th July 2020, and the Ovid platform was used to search several electronic databases, in addition to hand searching of clinical trial registries.

Results: About 121 studies were included in the SLR, of which 64 reported on the objectives relevant to this manuscript. Prevalence estimates varied widely from 6% to 87.7% across 19 publications, reflecting differences in definitions used. Of 43 publications which provided a definition of DIVA, six key themes emerged. Of these, themes 1–3 (failed attempts at PIV access using traditional technique; based on physical examination findings for example no visible or palpable veins; and personal history of DIVA) were covered by all but one publication. Following a failed insertion attempt, the most common number of subsequent attempts was 3, and it was frequently reported that a more experienced clinician would attempt to gain access after multiple failed attempts.

Conclusions: Considering the themes identified, an evidence-driven definition of DIVA is proposed: "when a clinician has two or more failed attempts at PIV access using traditional techniques, physical examination findings are suggestive of DIVA (e.g. no visible or palpable veins) or the patient has a stated or documented history of DIVA."

Keywords

DIVA, DVA, difficult venous access, venous access, hard stick

Date received: 30 July 2021; accepted: 19 October 2021

Introduction

Peripheral intravenous catheters (PIVCs) are the most commonly used invasive medical device, with up to 70% of patients requiring a peripheral venous line during their hospital stay.[1] They are particularly important in the emergency setting, where timely insertion may be crucial for the management of critically ill patients.[2]

The insertion of PIVCs can be time intensive, with multiple venipuncture attempts sometimes required for successful insertion.[3] This can cause pain and anxiety for the patient, and increases the risk of healthcare worker exposure to needlestick injuries, blood splashes, and bloodborne pathogens.[4,5] Furthermore, failed attempts may lead to catheters being inserted in less than optimal locations (such as the feet, thumbs, and wrists) increasing the risk of complications.[6] Delayed, partial, or total loss of the prescribed dose of medication may extend the length of hospital stay.[6] Ultimately, detrimental clinical outcomes can result in increased costs and inefficient use of resources.[7]

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The term "difficult intravenous access" (DIVA) is used in the literature to describe this patient population, but there is inconsistency in how DIVA is defined, and to our knowledge no systematic search has been undertaken to evaluate these definitions.

The resulting uncertainty around identification and management of DIVA patients in clinical practice may lead to sub-optimal clinical outcomes and unnecessary patient burden and resource use. Therefore, a systematic review was conducted to collate literature definitions of DIVA with the aim of arriving at an evidence-driven definition.

Methods

A systematic literature review (SLR) was designed to identify clinical, cost, and quality of life publications in patients requiring the insertion of a PIVC in any setting, including studies on US-guidance and/or guidewire, and studies with no specific intervention. The search was restricted to English language studies published between 1st January 2010 and 30th July 2020. Full details of study eligibility criteria are provided in Supplemental Table S1. The SLR had a broader scope than the objectives described in the introduction; this paper focuses on the publications relevant to these objectives. The methodology and results of the study are reported in accordance with PRISMA guidelines (Supplemental Table S7).[8] The protocol was not registered with any protocol registry.

The Ovid platform was used to search the following electronic databases on 30th July 2020: Embase; MEDLINE Daily, In-Process & Other Non-indexed citations, and e-pub ahead-of-print; Cochrane library—Cochrane Central Register of Controlled Trials (CENTRAL); Cochrane library—Cochrane Database of Systematic Reviews (DSR); Cochrane library—Database of Abstracts of Reviews of Effects (DARE); Cochrane library—Health Technology Assessment (HTA).

Hand searching was also performed as a supplementary measure. To obtain details of potentially relevant published and ongoing trials, the following clinical trial registry databases were accessed: clinicaltrials.gov (https://clinicaltrials.gov/); International Clinical Trials Registry platform (http://apps.who.int/trialsearch/); ISRCTN Register (https://www.isrctn.com/); UK Clinical Trials Gateway (https://www.ukctg.nihr.ac.uk/); EU Clinical Trials Register (https://www.clinicaltrialsregister.eu/ctr-search/search). Bibliographic reference lists of included publications and of relevant SLRs were also screened.

The database search strings identified all relevant publications indexed in Embase and were modified for performing searches in Medline and the Cochrane Library to account for differences in syntax and thesaurus headings. The Embase, Medline, and Cochrane Library search strings can be found in Supplemental Tables S2–S4.

Two independent reviewers screened citations by title/abstract, with any conflicts resolved by a third, more senior investigator. Full-text articles were then evaluated by a single reviewer, and final inclusion and exclusion of citations were verified by a second reviewer. Disputes regarding eligibility were referred to a third, more senior investigator (KH and AB). A record was kept of papers excluded at this stage together with a clear justification for their exclusion. Data from the included publications were extracted by one reviewer into a data extraction sheet; this information was checked and validated by conducting an independent internal data check once all required data had been entered.

Results

The electronic database search identified 2490 citations. On removal of 1711 citations at title and abstract screening stage, and 115 publications at full text screening stage, 114 publications from the electronic database searches were relevant for inclusion in the SLR. Hand-searching the reference list of relevant SLRs identified a further 7 publications, resulting in a total of 121 publications being included in the broader SLR. Those of relevance to the objectives described in the introduction are discussed in this manuscript (Figure 1).

Prevalence of DIVA

All prevalence data identified in the SLR were from the hospital setting. However, prevalence estimates varied depending on the definition used; when studies defined DIVA by a prior history of difficult access (which included multiple failed attempts to insert the IV line, no visible or palpable veins, or escalation to advanced techniques) prevalence ranged from 45%[9,10] to 59.3%.[6] However, in studies assessing the prevalence of DIVA based on multiple failed attempts within the study (regardless of prior history), the prevalence ranged from 6% to 11.8%.[11–14]

Definition of DIVA

Forty-three publications provided a definition of DIVA in adult, pediatric, or mixed populations. Of the 43 publications reporting a DIVA definition[9–50], 35 publications reported a definition for adult patients only[9–12,15,17–30,33–38,40–43,45–49] 5 publications reported a definition for pediatric patients only,[13,14,31,44,50] and in 3 publications the age of the included patients was not clear.[16,32,39] In terms of geographic origin, 27 studies were from the US, 11 were European, 2 were from the Middle East, 2 were from East Asia, and 1 was from the Caribbean. Further study characteristics are reported in Supplemental Table S6.

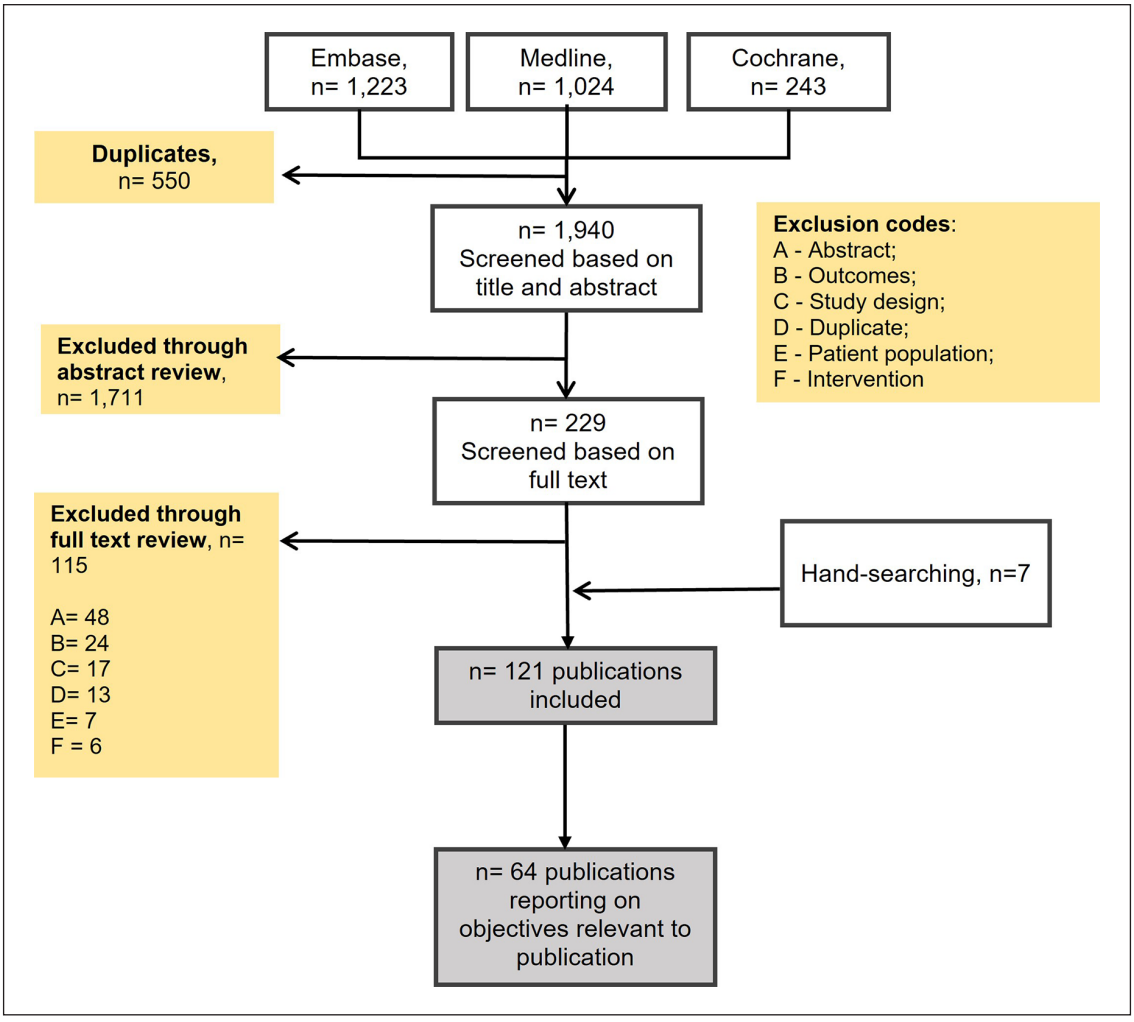

Figure 1. PRISMA flow diagram.

The definitions generally covered one or more of six key themes (Table 1). Theme 1 was the most reported, with 32 publications including failed attempts at peripheral IV (PIV) access in the DIVA definition (Figure 2). The next most reported themes were themes 2 and 3, which were reported in 14 and 11 publications, respectively. Of the 43 publications, only one did not include any of themes 1–3.[9]

Figure 2 illustrates the number of publications whose definition of DIVA included the identified theme, in adult and pediatric populations. When considering adult and pediatric populations separately, a similar trend was observed for the definition of DIVA, as compared with the total population, with theme 1 consistently being the most reported.

Number of failed attempts. Of the publications which included theme 1 (failed attempts at PIV access using traditional technique) and which specified the number of failed attempts, the most common number of failed attempts was two or more (12 publications), followed by three or more (9 publications) and one or more (6 publications). Five publications did not specify a minimum number of failed attempts.

Risk factors. The risk factors for DIVA reported across the publications align with the common themes reported for the definition of DIVA. Although there was great variability in the factors proposed, significant indicators included vein characteristics (palpability, visibility, poor vein condition, vein diameter, veins with many valves) (seven publications) [theme 2]; patient age (six publications); arthrometric values (patients classed as obese or underweight) (five publications); chronic health conditions (IV drug abuse, edema, cancer chemotherapy, diabetes, sickle cell disease, end-stage renal disease) (four publications) [theme 4]; gender (female) (four publications).

A history of difficult IV access was also regularly associated with DIVA (six publications) [theme 3]. Fields et al.[11] defined DIVA as three or more IV attempts or use of a

Table 1. Type of publications supporting the six key themes identified from DIVA definitions.

Theme	Number of publications supporting theme	Type of publications supporting theme
Theme 1: Failed attempts at PIV access using traditional technique (vein visualization, palpation, and landmarking)	32	Prospective: 16 publications[11,12,16–18,21,22,27,29,32–34,36–38,40] RCT: 5 publications[20,31,43,45,46] Retrospective: 4 publications[14,15,26,35] Cross-sectional: 2 publications[13,24] Literature review: 2 publications[19,30] Secondary analysis of RCT data: 1 publication[10] Secondary analysis of prospective data: 1 publication[23] Quasi-experimental study: 1 publication[39]
Theme 2: Based on physical examination findings for example no visible or palpable veins	14	Prospective: 5 publications[16,22,25,34,47] RCT: 4 publications[28,44,49,50] Retrospective: 2 publications[15,35] Literature review: 1 publication[30] Secondary analysis of prospective data: 1 publication[23] Cross-sectional: 1 publication[6]
Theme 3: Personal history of DIVA	11	Prospective: 5 publications[18,25,34,37,38] RCT: 4 publications[41,42,44,48] Secondary analysis of prospective data: 1 publication[23] Cross-sectional: 1 publication[6]
Theme 4: History of ESRD, IV drug abuse, or other chronic medical condition	5	RCT: 4 publications[20,41,42,48] Literature review: 1 publication[30]
Theme 5: Those where another operator was required to place the IV line	3	Prospective: 1 publication[9] Retrospective: 1 publication[15] Secondary analysis of RCT data: 1 publication[10]
Theme 6: Use of a method of rescue vascular access to establish an IV line	2	Prospective: 1 publication[11] Retrospective: 1 publication[14]

DIVA: difficult intravenous access; ESRD: end-stage renal disease; IV: intravenous; PIV: peripheral intravenous; RCT: randomized controlled trial.

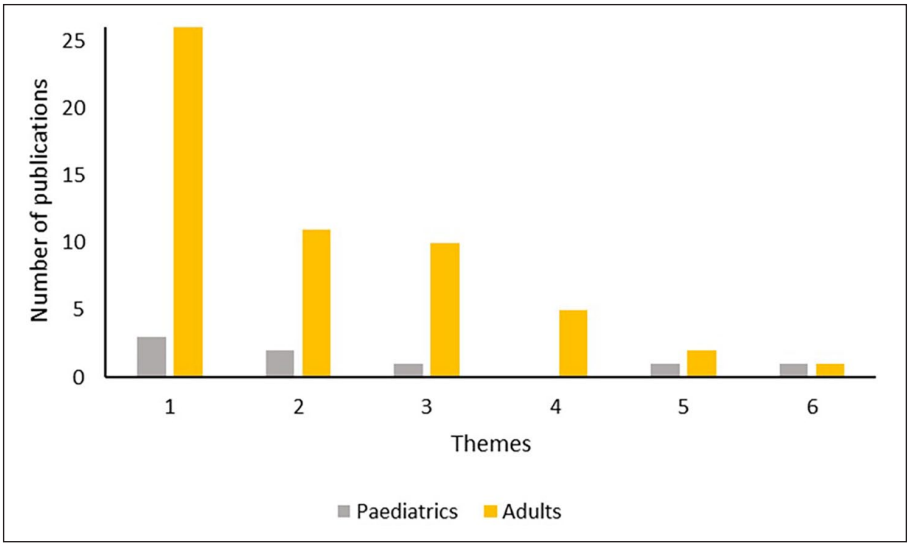

Figure 2. Number of publications with definition including each theme.

method of rescue vascular access to establish IV access, and they found that patients with a history of DIVA were more likely to meet these criteria. Of patients who reported a history of requiring "multiple IV attempts" in the past for IV access, 14% met criteria for DIVA on the visit (odds ratio (OR): 7.7; 95% confidence interval (CI): 3.0–18.0) [theme 1]. Of patients who reported previously requiring an external jugular, US-guided peripheral intravenous (USGPIV), or central venous catheter (CVC) for IV access, 26% met criteria for DIVA (OR: 16.7; 95% CI: 6.8–41.0) [theme 6].

Discussion

The key objective of this study was to review current definitions of DIVA with the aim of arriving at an evidence-driven definition. There was a high level of variation in the prevalence of DIVA reported, in line with the definitions presented. In addition, the prevalence data captured in this SLR are all from the hospital setting, limiting generalizability to other settings. However, the volume of DIVA prevalence estimates and definitions in the literature shows there is clearly a subgroup of patients in the healthcare system who are difficult to cannulate. The lack of a consistent definition across studies hinders estimation of the true prevalence; for example, studies which defined DIVA by a history of difficult access tended to provide higher prevalence estimates than those with a definition that excluded patient history.

Of the 43 publications which provided a definition for DIVA in adult, pediatric, or mixed age populations, there was near-universal coverage of themes 1–3: (1) failed attempts at PIV access using traditional techniques; (2) based on physical examination findings for example no visible or palpable veins; (3) personal history of DIVA (Table 1). These themes were further supported by a review of the risk factors for DIVA, with significant indicators including chronic health conditions, vein characteristics, and a history of DIVA.

Considering themes 1–3 and the finding that most common number of failed attempts was two or more, an evidence-driven definition of DIVA is proposed:

> "*A patient is considered to have DIVA if any of the following elements are present: a clinician has two or more failed attempts at PIV access using traditional techniques, physical examination findings are suggestive of DIVA (e.g. no visible or palpable veins) or the patient has a stated or documented history of DIVA*"

The inclusion of patient history in the definition highlights the importance of documenting the assessment and listening to patients when they say they have experience of difficult access. In one study, 7 out of 10 patients described deficits in communication with the clinician placing the PIVC.[1] Such a history can be used to guide the decision on whether to attempt traditional methods or to escalate immediately. However, it is important that patient history is considered alongside a clinical assessment of the vasculature; patients who were difficult to cannulate previously may no longer be. Consideration of both factors could avoid the unnecessary pain and discomfort associated with escalation pathways that rely on a specific number of traditional attempts before escalation (even when clinicians know their attempts will be unsuccessful).

The evidence-driven definition also includes "two or more failed attempts." Ideally, multiple failed attempts would not form part of a formal DIVA definition or escalation pathway; this would be replaced by standardized clinical assessment of venous anatomy and patient history to ensure that DIVA patients are identified before the first cannulation attempt. This supports a patient-centric approach; by basing assessment on a known history of DIVA and clinical assessment of the vasculature and comorbidities, unnecessary patient pain can be avoided, promoting escalation prior to attempting potentially unsuccessful IV access. Additional benefits may include minimizing healthcare worker exposure risk and costs and resource use associated with multiple failed attempts. Guidance from the Infusion Nurses Society (INS) also recognizes the harms caused by multiple unsuccessful attempts; the INS recommends that PIVC insertion is restricted to no more than two attempts per clinician.[51] Following two unsuccessful attempts, they recommend escalation to a clinician with a higher skill level, or use of alternative routes of administration.

Our definition broadly aligns with the definition used in the 2021 Infusion Therapy Standards of Practice, which also includes the themes of multiple attempts, physical assessment, and patient history.[51]

Conclusions

Failure to identify DIVA patients, and the use of informal or inappropriate escalation processes, may result in patients being given unnecessary and costly follow-up procedures when alternatives are available. Moreover, the lack of a clearly defined patient population hinders planning of resource allocation and training programs. The goal of future research endeavors should be to test the hypothesis that the proposed evidence-based definition can improve early identification of DIVA; it is hoped that this will prevent complications and additional patient discomfort.

There is also a need for future research to understand how evolving and novel medical technologies can be incorporated into standard assessment algorithms for DIVA patients to improve clinical and economic outcomes. More research is also needed to better define the impact of escalation pathways; it is important that such studies consider the level of competence of the individuals inserting the PIVCs using US-guidance, as this has the potential to impact on outcomes. A suggestion would be the need to flag DIVA patients in every patient's EMR to reduce needle-phobia especially in children requiring multiple hospitalizations. Given this, future research could also investigate the level of training (at an individual or vascular access team level) required for optimal outcomes.

Author's note

All authors are members of INS, AVA. Externally collected contributor form attached.

Acknowledgements

The authors recognize the valuable contributions of Neil Webb, Jenna Stephens, and Chris Hellmund, who are employees of Source Health Economics, the HEOR company that conducted the systematic literature review and provided writing services.

Author contributions

KA, AM, and SG designed the trial, conceived the study and obtained research funding. AB, SJ, KH, and SG supervised the conduct of the trial and reviewed data collection. KA and KH managed the data, provided statistical advice, including quality control. All authors reviewed and revised the manuscript.

Declaration of conflicting interests

The author(s) declared the following potential conflicts of interest with respect to the research, authorship, and/or publication of this article: Bahl: *Research Grants* from Access Vascular, Adhezion Biomedical, Becton Dickinson, B. Braun, Medline, Teleflex *Consultancy*: B. Braun, Teleflex, The Clinician Exchange, Lineus Medical, Interrad Medical. Johnson: no conflicts of interest. Hoerauf, Alsbrooks, Gala, and Mares: employee of BD, owns stock/stock options.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: BD supported the funding for this project. No funding for the authors was provided.

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Supplemental material

Supplemental material for this article is available online.

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