REVIEW ARTICLE

Review article: Peripheral intravenous catheter insertion in adult patients with difficult intravenous access: A systematic review of assessment instruments, clinical practice guidelines and escalation pathways

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Abstract

The optimal approach for peripheral intravenous catheter (PIVC) insertion in adult hospitalised patients with difficult intravenous access (DIVA) is unknown. The present study aimed to critically appraise the quality of (i) assessment instruments and (ii) clinical practice guidelines (CPGs) or escalation pathways for identifying and managing patients with DIVA. Cochrane Central Register of Controlled Trials, EMBASE MEDLINE, EMBASE (OVID) and EBSCO CINAHL databases were searched on 22 March 2021. Studies describing a DIVA assessment measure, CPG or escalation pathway for PIVC insertion in adults (≥18 years of age) were included. Data were extracted using a standardised data extraction form including study design, type of resource and reported clinical outcomes. Quality of DIVA assessment instruments were reviewed using the COnsensus-based Standards for the selection of health Measurement Instruments checklist. Methodological quality of CPGs and escalation pathways was assessed using the Appraisal of Guidelines for Research and Evaluation-II (AGREE-II) instrument. Overall, 24 DIVA resources comprising 16 DIVA assessment instruments and nine CPGs or escalation pathways (including one combined assessment instrument and escalation pathway) were identified. Instruments commonly focused on vein visibility and palpability as indicators of DIVA. CPGs and escalation pathways unanimously recommended use of vessel visualisation technology for patients with or suspected of DIVA. Methodological quality of the resources was mixed. Consensus and standardisation of resources to identify DIVA and recommendations for managing patients with DIVA is limited. Adopting consistent, evidence-based CPGs, escalation pathways or DIVA assessment instruments may significantly improve clinical outcomes.

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Key words: adults, clinical decision-making, inpatients, peripheral catheterization.

Introduction
Peripheral intravenous catheter (PIVC) insertion is the most common invasive clinical procedure for adult hospital patients. More than 50% of all hospitalised patients receive a PIVC to administer fluids and parenteral medications. Despite their ubiquity, PIVC insertion can be challenging, even for experienced practitioners. Across all hospital settings, between 35% and 40% of first-attempt PIVC insertions fail, resulting in repeated painful insertion attempts and significant treatment delays. Ensuring first-time PIVC insertion success is crucial for preventing avoidable patient harm and wasting of healthcare resources, particularly in the ED where PIVCs are the device of choice for emergent access to treatment but where first-time insertion failure ranges between 14% and 27%.

Approximately, 30% of adults who receive a PIVC experience difficult intravenous access (DIVA), typically defined as two or more failed insertion attempts. DIVA is characterised by non-visible and/or non-palpable veins, often necessitating the use of technological aids to assist the successful insertion of vascular access devices. Increased risk of DIVA is associated with age, chronic and complex disease, a history of intravenous drug-use, body mass index and chemotherapy treatment. Patients with DIVA may undergo repeated, failed insertion attempts, increasing their risk of adverse events associated with vessel damage and venous depletion. In addition, every time a PIVC fails and a new one is required the protective barrier of the skin is breached increasing the risk of infection. A large proportion of patients describe repeated insertion attempts as moderately to extremely painful. Failed PIVC insertion can result in lengthy treatment delays, missed medication administration, or escalation to a more invasive device (e.g. central venous catheter). Multiple failed attempts are also associated with escalating healthcare expenditure, with one study reporting a sevenfold increase in costs following multiple failed insertion attempts compared to a single insertion attempt. Prospective identification of patients with DIVA using vessel assessment instruments, combined with the use of high-quality clinical guidelines or escalation pathways is recommended to maximise first-time insertion success and prevent PIVC insertion failure. In recent years, the use of ultrasound-guided (USG) PIVC insertion in the ED has become increasingly available for increasing first-time insertion success in patients with difficult or impossible intravenous access. In the Australian context, repeat traditional insertion is still the default following insertion failure, and identification and management of patients with DIVA remains complex and multifactorial.

Despite growing recognition of the importance of patients with DIVA, the scope of DIVA assessment instruments, clinical practice guidelines (CPGs) and escalation pathways, to guide clinical practice, particularly when providing emergency care, is currently not known. In addition, there is little appraisal of the quality of these resources to determine their appropriateness for use in routine clinical practice. Therefore, the objectives of this review are to identify and evaluate the quality of (i) assessment tools for identifying adult patients with DIVA and (ii) CPGs or escalation pathways for managing adult patients with DIVA who require a PIVC.

Methods
Review framework
A systematic review of assessment tools, CPGs or escalation pathways that aid the identification and management of DIVA patients was conducted in line with the Cochrane review methodology and reported according to the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) statement. The review was prospectively registered with PROSPERO (CRD42020173987).

Eligibility criteria
Included studies described an assessment instrument, CPG or escalation pathway for the insertion of a PIVC in adults (≥18 years of age) with DIVA. We included escalation pathways to describe all resources available to clinicians inserting PIVCs in adults with DIVA. Because of the paucity of research, studies were not limited to ED populations. Studies, guidelines, or escalation pathways that only included patient populations <18 years, non-human participants, or published language other than English were excluded.

Search strategy and study selection
A comprehensive search was undertaken on 7 May 2020 and rerun on 22 March 2021 (see Table S1 for search strategy). The databases Cochrane Central Register of Controlled Trials (CENTRAL), EMBASE (OVID) and PubMed were searched using controlled vocabulary and text words related to PIVC insertion in patients with DIVA. Hand searches of bibliographies of retrieved publications for further relevant studies were also undertaken. Study authors did not need to be contacted as inclusion eligibility and data were extractable from the published reports.

Outcome measures
The primary outcomes were (i) a description of the available DIVA assessment instruments, CPGs and escalation pathways; (ii) the psychometric quality of assessment instruments, measured using the CONSORT-based Standards for the selection of health Measurement Instruments (COSMIN) checklist; and (iii) methodological quality of available CPGs and escalation pathways, measured according to the Appraisal of Guidelines for Research and Evaluation-II (AGREE-II) instrument criteria.

Data extraction and risk of bias
All references were screened and managed in Covidence systematic review software (Veritas Health Innovation, Melbourne, Australia). Two
study authors (RSP, ES) completed the data extraction form and risk of bias assessment independently, and discrepancies were resolved by discussion and consensus. Where required, consultation with a third, independent review author (JAS) was undertaken to resolve any disagreements. Data were extracted using a standardised data extraction form, created prior to the literature search and included study origin, tool, CPG or pathway, setting for psychometric testing and participants. For DIVA tools, relevant domains of the COSMIN checklist were evaluated using a 4-point rating scale (inadequate, doubtful, adequate and very good), for each relevant domain, depending on the information reported by the study authors. For the CPGs or escalation pathways, each appraiser independently scored the six AGREE-II domains using the 7-point scale, 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.

Synthesis
For each DIVA assessment tool identified, study design, DIVA indicators, psychometric properties, and the lowest COSMIN item ranking are presented. Scaled domain percentages and overall assessments, along with a synthesis of key recommendations and considerations, for each CPG and escalation pathway each are reported.

Results
Overall, 124 records were identified through database searching and an additional six records identified through other sources (Fig. 1).

Characteristics of included studies
We included 24 studies comprising 16 DIVA assessment tools and nine CPGs or escalation pathways (one study included both an escalation pathway and assessment instrument). Most studies were from the USA (37.5%), then Italy (12.5%), UK (12.5%), France (8.3%), Spain (8.3%), the Netherlands (8.3%), and Germany (4.2%). Overall, 29.2% of study populations included emergency patients, with the remainder including hospitalised adult patients (37.5%), or oncology (8.3%), surgical (8.3%), prehospital emergency care (8.3%), and anaesthetic and critical care (4.2%) patients. Two studies did not specify the population.

DIVA assessment instruments
We identified 16 DIVA assessment instruments, described in Table S2. Instruments included peripheral venous grading systems, single-item difficulty of access rating scales, and 3-item, 4-item, 5-item, 6-item, 7-item, 8-item, and 10-item risk factor checklists. Study designs included discussion papers, pilot validation studies, prospective cohort and observational studies and a mixed-methods study. DIVA instruments were most commonly developed and evaluated in emergency settings (n = 7). Most commonly, instruments included vein visibility (88%) and palpability (69%) as key indicators for identifying DIVA. Vein visibility was quantified as ‘not visible’, ‘few visible’, ‘visible with tourniquet’, ‘easily seen’, or in degrees of visibility. Similarly, palpability was quantified as ‘not palpable’, ‘few palpable’, ‘palpable with tourniquet’ or as degrees of palpability. Other common indicators included known history of DIVA (38%), vein diameter (38%),
vascular depletion (31%), number of available veins (31%) and health conditions that affected vein or tissue condition (31%; Table 1).

**Clinical efficacy of assessment instruments**

Overall, six studies reported the clinical efficacy of identifying DIVA or insertion failure (Table S2). The Adult–Difficult Venous Catheterization (A-DICAVE) scale correlated with a clinicians’ ratings of “difficulty” (correlation co-efficient \( r = 0.82 \)) and the actual number of insertion attempts required \( r = 0.50 \) and could accurately discriminate between patients who required >2 attempts versus 1–2 attempts. \cite{25} Similarly, scores on the DIVA Clinical Predictor Tool correlated with number of insertion attempts \( r = 0.32 \). \cite{23} Four studies examined the accuracy of their instruments in identifying patients at high risk of DIVA. \cite{13,35,42,43} The enhanced adult DIVA (EA-DIVA) score (area under the curve [AUC] = 0.94), the adult DIVA (A-DIVA) scale (AUC = 0.89) and the modified A-DIVA scale (AUC = 0.97) all accurately identified patients at high risk of DIVA, with good sensitivity and specificity (Table S2). \cite{13,35,43} The pre-hospital intravenous access assessment was also able to predict successful first-attempt insertion (AUC = 0.78) and >2 min to cannulation (AUC = 0.81), although this finding should be interpreted with caution as the authors used the same sample for both developing and testing the accuracy of the model. \cite{34}

**Quality of DIVA assessment instruments**

The psychometric quality of the DIVA instruments is summarised in Table 2. The majority included sufficient information to evaluate the COSMIN reliability, measurement error and criterion validity domains. \cite{25} Of the seven studies which reported reliability, four \cite{13,35,42,43} were rated as ‘adequate’. \cite{25} Similarly, two out of four studies provided ‘adequate’ information related to measurement error. \cite{39,40} Criterion validity was reported in eight studies, with four meeting the ‘very good’ threshold. \cite{13,35,42,43} Overall, the EA-DIVA, \cite{25} the A-DIVA scale, \cite{43} the modified A-DIVA scale \cite{13} and the A-DICAVE \cite{42} provided promising psychometric properties.

**CPG and escalation pathway recommendations**

The review identified six CPGs pertaining to DIVA and three escalation pathways. All CPGs unanimously recommended the use of vessel visualisation in DIVA patients (see Table S3 for a summary). \cite{27,32,34,36,38} Each escalation pathway included vessel visualisation technology, recommending its use where DIVA was determined \cite{10,11} or after failed insertion attempts. \cite{31} Hallam et al. \cite{11} and Sou et al. \cite{10} suggested the use of infrared or USG technology to aid device insertion, whereas Duran-Gehring et al. recommended escalating to USG after review by the treating physician and alternative insertion site considered. \cite{31} Only one escalation pathway provided a specific recommendation that clinicians evaluate the appropriateness of a PIVC insertion, with

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**TABLE 1. Indicators of difficult intravenous access used by 16 assessment instruments**

<table>
<thead>
<tr>
<th>Item</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vein not visible (± tourniquet)</td>
<td>13</td>
<td>88.0</td>
</tr>
<tr>
<td>Vein not palpable (± tourniquet)</td>
<td>12</td>
<td>69.0</td>
</tr>
<tr>
<td>History of difficult cannulation</td>
<td>6</td>
<td>38.0</td>
</tr>
<tr>
<td>Largest vein diameter &lt;3 mm, small calibre veins</td>
<td>6</td>
<td>38.0</td>
</tr>
<tr>
<td>Vascular depletion (history of chemotherapy, drug abuse, previous venepuncture)</td>
<td>5</td>
<td>31.0</td>
</tr>
<tr>
<td>Limited number of available veins (e.g. because of hemiplegia, spasticity, radical mastectomy, arteriovenous fistula)</td>
<td>5</td>
<td>31.0</td>
</tr>
<tr>
<td>Health conditions/treatments affecting vein/tissue health (e.g. neurovascular disease, coagulative disorder, taking anticoagulants/antiplatelets, chronic conditions, renal failure, diabetes, systemic lupus erythematosus, oedema, cachexia, radiotherapy to upper limbs)</td>
<td>5</td>
<td>31.0</td>
</tr>
<tr>
<td>Obesity/overweight (BMI &gt;25)</td>
<td>4</td>
<td>25.0</td>
</tr>
<tr>
<td>Vein characteristics (e.g. rolling or winding, sclerotic, mobile, tortuous veins, phlebitis)</td>
<td>4</td>
<td>25.0</td>
</tr>
<tr>
<td>Skin appearance (e.g. dark, thick or fragile skin/poor skin integrity)</td>
<td>4</td>
<td>25.0</td>
</tr>
<tr>
<td>Degree of inserter skill required for insertion, perceived difficulty of access</td>
<td>2</td>
<td>12.5</td>
</tr>
<tr>
<td>Emergency surgery indication</td>
<td>1</td>
<td>6.3</td>
</tr>
<tr>
<td>Frequent hospitalisations</td>
<td>1</td>
<td>6.3</td>
</tr>
<tr>
<td>Treatment ≥6 months</td>
<td>1</td>
<td>6.3</td>
</tr>
<tr>
<td>Dark/insufficient ambient lighting</td>
<td>1</td>
<td>6.3</td>
</tr>
<tr>
<td>Risk of extravasation</td>
<td>1</td>
<td>6.3</td>
</tr>
<tr>
<td>Other patient characteristics (e.g. needle phobia, confusion)</td>
<td>1</td>
<td>6.3</td>
</tr>
</tbody>
</table>

BMI, body mass index.

guidance for instead choosing a mid-line, peripherally inserted central catheter or tunnelled central venous catheter. Overall, each escalation pathway recommended vessel visualisation technologies only when used by trained practitioners. Clinical efficacy of CPGs and escalation pathways

No included CPG explored the utility or feasibility of implementing their guidance in clinical practice. Only the escalation pathway developed by Sou and colleagues evaluated clinical outcomes, reporting a 93% success rate, and a significant reduction in median unsuccessful insertion attempts (pre = 2 [2, 4], post = 1 [1], \( P < 0.001 \)) and patient-reported pain (pre = 7 [5, 9], post = 2 [1, 3], \( P < 0.001 \)) after implementation. Methodological quality of CPGs and escalation pathways

Table 3 presents the scaled domain percentages according to the AGREE-II criteria for each CPG and escalation pathway. Overall, ratings for scope, purpose, clarity and presentation were high for most. Stakeholder involvement was mixed; generally relevant professional groups were involved, however, input from patients was infrequently sought, with overall ratings especially low for the escalation pathways. Similarly, while rigour of development for CPGs was high in the majority, this information was infrequently or poorly detailed for each escalation pathway. Details regarding editorial independence were often poorly described, and no CPG or escalation pathway provided information for applicability. Overall, two CPGs and two escalation pathways scored highly (≥5) on the AGREE-II criteria.

Discussion

This systematic review of resources to guide difficult PIVC insertion found variable identification and escalation practices with minimal focus on their implementation. Of the 16 DIVA assessment instruments and nine CPGs or escalation pathways, reported evidence describing the clinical efficacy in routine clinical practice and the quality of these instruments or guidelines was mixed. This paradigm, combined with a lack of recognition of the harmful sequelae of failed PIVC insertion attempts, has resulted in little change in PIVC insertion success rates over time.

Primarily, DIVA assessment instruments relied on vein visibility

<table>
<thead>
<tr>
<th>Instrument</th>
<th>COSMIN</th>
<th>Reliability</th>
<th>Measurement error</th>
<th>Criterion validity</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-DICAVE scale</td>
<td>Adequate</td>
<td>NR</td>
<td>Very good</td>
<td></td>
</tr>
<tr>
<td>A-DIVA scale</td>
<td>NR</td>
<td>NR</td>
<td>Very good</td>
<td></td>
</tr>
<tr>
<td>Adult Venous Assessment Tool</td>
<td>Inadequate</td>
<td>Adequate</td>
<td>NR</td>
<td></td>
</tr>
<tr>
<td>Clinical Evaluation of Peripheral Vein Accessibility</td>
<td>Adequate</td>
<td>NR</td>
<td>Inadequate</td>
<td></td>
</tr>
<tr>
<td>Difficulty of Attempting IV Placement</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td></td>
</tr>
<tr>
<td>Difficult IV Access Criteria</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td></td>
</tr>
<tr>
<td>Difficulty of Attempting IV Placement</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td></td>
</tr>
<tr>
<td>DIVA Clinical Predictor Tool</td>
<td>NR</td>
<td>NR</td>
<td>Inadequate</td>
<td></td>
</tr>
<tr>
<td>DIVA-CD</td>
<td>Adequate</td>
<td>Inadequate</td>
<td>NR</td>
<td></td>
</tr>
<tr>
<td>EA-DIVA scale</td>
<td>NR</td>
<td>NR</td>
<td>Very good</td>
<td></td>
</tr>
<tr>
<td>Modified A-DIVA scale</td>
<td>Adequate</td>
<td>NR</td>
<td>Very good</td>
<td></td>
</tr>
<tr>
<td>Peripheral IV Access Questionnaire</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td></td>
</tr>
<tr>
<td>Peripheral Vein Assessment Tool</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td></td>
</tr>
<tr>
<td>Prehospital IV Access Assessment</td>
<td>NR</td>
<td>NR</td>
<td>Inadequate</td>
<td></td>
</tr>
<tr>
<td>Vein Assessment Tool</td>
<td>Inadequate</td>
<td>Adequate</td>
<td>NR</td>
<td></td>
</tr>
<tr>
<td>Venous International Assessment</td>
<td>Doubtful</td>
<td>Inadequate</td>
<td>Inadequate</td>
<td></td>
</tr>
</tbody>
</table>

A-DICAVE, Adult–Difficult Venous Catheterization; A-DIVA, adult difficult intravenous access; COSMIN, COnsensus-based Standards for the selection of health Measurement Instruments; DIVA, difficult intravenous access; EA-DIVA, enhanced adult difficult intravenous access; IV, intravenous; NR, not reported.

The Only the Guidance regarding With the exception of however it 26
100 78 86 100 13 96
In addition, the 56 50 64 94 0 0
10,11,27,34
This further under-
10,31
The EA-DIVA,
Similarly, speci
35
High-quality
care.
needed to recommend their
dees, further psychometric testing
practice was also lacking,
integration of these was heter-
geometric properties.
and palpability as key indica-
tors.4,11,13,23,29,35,37,39–44
The conceptualisation of these was heter-
oxample, was acknowledge that agreement in
familiar PIVC insertion during develop-
ment of their high-quality care.9,19
High-quality
and early identifica-
tion of DIVA is recommended.10,11,27,34
Assessment of vein quality was not always well quantified, however, and there was no clear threshold for
escalation,42 nor consistent, compre-
hensive guidelines or pathways for
management.11 Guidance regarding
the maximum number of attempts
generally recommended escalation
following ≤2–3 total attempts at
PIVC placement,10,31 and was
broadly consistent with the recent
Infusion Nursing Society (INS)
Guidelines (≤2 attempts prior to
escalation).33 Similarly, specific rec-

demonstrated promising
psychometric properties, particularly
for their accuracy in identifying
DIVA patients.23 In addition, the
A-DICAVE reported promising
clinical efficacy, with moderate to high

tions, further psychometric testing
in inpatient settings is therefore
needed to recommend their
routine use.
Even in the ED – where PIVC use
is ubiquitous and staff have greater
training, escalation to senior staff is
more accessible and USG intrave-
nous access is more readily available – clinical guidelines around PIVC
insertion decisions to aid emergency
clinicians are critical for ensuring
high-quality care.9,19
High-quality

TABLE 3. AGREE-II scaled scores for clinical practice guidelines and escalation pathways

<table>
<thead>
<tr>
<th>Author (year)</th>
<th>Scope and purpose</th>
<th>Stakeholder involvement</th>
<th>Rigour of development</th>
<th>Clarity of presentation</th>
<th>Applicability</th>
<th>Editorial independence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bodenham et al. (2016)</td>
<td>78</td>
<td>50</td>
<td>11</td>
<td>83</td>
<td>17</td>
<td>33</td>
</tr>
<tr>
<td>Chopra et al. (2015)</td>
<td>100</td>
<td>100</td>
<td>78</td>
<td>100</td>
<td>42</td>
<td>67</td>
</tr>
<tr>
<td>Duran-Gehring et al. (2016)</td>
<td>100</td>
<td>44</td>
<td>19</td>
<td>92</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Franco-Sadud et al. (2019)</td>
<td>97</td>
<td>72</td>
<td>75</td>
<td>100</td>
<td>44</td>
<td>92</td>
</tr>
<tr>
<td>Gorski et al. (2021)</td>
<td>100</td>
<td>78</td>
<td>86</td>
<td>100</td>
<td>13</td>
<td>96</td>
</tr>
<tr>
<td>Hallam et al. (2016)</td>
<td>81</td>
<td>50</td>
<td>41</td>
<td>96</td>
<td>11</td>
<td>100</td>
</tr>
<tr>
<td>Lamperti et al. (2012)</td>
<td>69</td>
<td>56</td>
<td>55</td>
<td>81</td>
<td>21</td>
<td>38</td>
</tr>
<tr>
<td>Sou et al. (2017)</td>
<td>100</td>
<td>56</td>
<td>11</td>
<td>92</td>
<td>4</td>
<td>100</td>
</tr>
<tr>
<td>Valdez et al. (2015)</td>
<td>56</td>
<td>50</td>
<td>64</td>
<td>94</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

AGREE-II, Appraisal of Guidelines for Research and Evaluation-II.

and palpability as key indicators.4,11,13,23,29,35,37,39–44
The conceptualisation of these was heter-
oxample, was acknowledge that agreement in
familiar PIVC insertion during develop-
ment of their high-quality care.9,19
High-quality

and palpability as key indicators.4,11,13,23,29,35,37,39–44
The conceptualisation of these was heter-

which has significant implications for successful implementation and evaluation in routine clinical practice.

Patients with DIVA often undergo repeated, failed insertion attempts, increasing their risk of post-insertion complications. Preliminary evidence suggests that DIVA assessment instruments, guidelines and pathways can enhance clinical outcomes by increasing insertion success and reducing post-insertion complications. Although general and ED-specific resources are available to support PIVC insertion in the context of difficult access, it is unclear how these assessment instruments, guidelines, and pathways enhance clinical outcomes and prevent insertion-related adverse events. Specifically, no guideline or pathway provided information about utility (only one study reported clinically relevant outcomes), acceptability to clinicians and consumers in the clinical context, or an evaluation of implementation methods.

Patient experiences of DIVA continue to be a neglected topic within this area. Recognising patient preferences is important, especially as a large proportion of patients describe repeated PIVC insertion attempts as moderately to extremely painful. Some DIVA instruments involved patient assessment of face validity, however, most resources failed to include patients and caregiver preferences in their development, with the Michigan Appropriateness Guide for Intravenous Catheters the only resource to involve a consumer representative during development. PIVC use is pervasive in all hospital settings and particularly in the ED. PIVCs are routinely inserted by novice to expert inserters without a clear model of care, resulting in inconsistent delivery of best care to patients at greatest risk of insertion failure. This is combined with an alarming number of idle or “just in case” PIVCs, raising the question: Are we causing more harm than good, especially in patients with DIVA? More broadly, a crucial step in preventing complications associated with DIVA may instead be to first consider if PIVC access is even the most appropriate mode of treatment delivery. Although DIVA prediction instruments and pragmatic insertion decision-making algorithms are necessary, literature pertaining to the decision to use a PIVC and the appropriateness of alternative routes in different settings remains a knowledge gap. Clearer direction from CPGs on who needs a PIVC in the first place is critical.

This systematic review is not without limitations. We used a broad search strategy that encompassed numerous databases and grey literature, as well as hand-searching of reference lists. Although we expanded our search to include escalation pathways in addition to CPGs, it is possible some relevant studies were missed because of variations in terminology or because of excluding papers not in English. The expanded scope of the present study to include studies outside of the emergency setting also impacts the specificity of current findings for use in the ED. The lack of discussion within CPGs regarding implementation, or evaluation of escalation pathways and DIVA assessment instruments in clinical practice, limits the scope of this review to explore or meta-analyse their use and efficacy in clinical practice. Consequently, this reduces the generalisability and utility in improving first attempt insertion success in patients with DIVA in practice. A key strength of the review was the rigorous methodology.

Conclusions

There is limited international consensus and standardisation of resources to identify and manage patients with or at-risk of difficult PIVC insertion, however, the adoption of CPGs, escalation pathways or DIVA assessment instruments for patients with DIVA may improve clinical outcomes. Combined, the included resources demonstrated consensus of recommended use of USG PIVC insertion in patients with DIVA. Future research should evaluate the impact of implementing DIVA resources in clinical practice to improve patient care.

Acknowledgements

This research was funded by a National Health and Medical Research Council (NHMRC) Partnership Project Grant (APP1180193). Open access publishing facilitated by The University of Queensland, as part of the Wiley - The University of Queensland agreement via the Council of Australian University Librarians.

Competing interests

JAS reports grant funding from Griffith University, Children’s Hospital Foundation and investigator-initiated research and educational grants provided to Griffith University by vascular access product manufacturers (Baxter, Becton Dickinson), unrelated to this project. MC reports grant funding from Griffith University, Children’s Hospital Foundation, National Health and Medical Research Council (NHMRC), Royal Brisbane and Women’s Hospital Foundation, Cancer Council Queensland, Australasian College for Infection Prevention and Control, and investigator-initiated research and educational grants and speaker fees provided to Griffith University by vascular access product manufacturers (Becton Dickinson), unrelated to this project. AU reports fellowships and grants by the NHMRC, employment by Griffith University, grants by the Children’s Hospital Foundation, Royal Brisbane and Women’s Hospital Foundation, Emergency Medicine Foundation and the Australian College of Critical Care Nursing, and investigator-initiated research grants and speaker fees provided to Griffith University from 3M, Cardinal Health and Becton Dickinson. TMK reports grant funding from Children’s Hospital Foundation, Griffith University, NHMRC, Emergency Medicine Foundation and investigator-initiated research grants and speaker fees provided to Griffith University from vascular access product manufacturers 3M Medical, Access Scientific, BD-Bard, Medical Specialties Australia, Smiths Medical, Vygon. GK reports investigator-initiated grant funding from the Gold Coast
Hospital Foundation, NHMRC and Emergency Medicine Foundation. NM reports investigator-initiated research grants and speaker fees provided to Griffith University from vascular access product manufacturers (3M, BD-Bard, Cardinal Health, Elouquest Healthcare), unrelated to this project. CMR reports investigator-initiated research grants and speaker fees provided to Griffith University or University of Queensland from vascular access product manufacturers (3M, BD-Bard; Cardinal Health, Elouquest Healthcare), unrelated to this project.

**Data availability statement**

The data that support the findings of the present study are available from the corresponding author upon reasonable request.

**References**

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

Table S1. Summary of search terms used for the electronic database search.
Table S2. Assessment tools summary information.
Table S3. Clinical practice guidelines and escalation pathways summary information.