**Development, diagnostic sensitivity and prognostic accuracy of the Adult-Difficult Venous Catheterization scale for emergency departments**

**Contribution to emergency nursing practice**

- The current state of scientific knowledge is that no easily applied instrument is available for emergency nurses to reliably detect difficult peripheral intravenous access.
- The main result of this research is the development and testing of the prognostic accuracy of A-DICAVE, an easily used and reliable difficult peripheral intravenous access detection instrument for use by emergency nurses.
- The key implication of this research for emergency nursing practice is that the A-DICAVE, by reliably measuring venous access early on, can benefit both patients and health professionals.

**Abstract**

**Introduction:** Difficulty in accessing peripheral veins in emergency departments increases patient discomfort and impedes patient diagnosis. The objective of this study was to develop and test the prognostic accuracy of an easily applied scale to measure difficult venous access (DVA) to peripheral veins in emergency departments, called the Adult-Difficult Venous Catheterization scale (A-DICAVE).

**Methods:** This prospective observational study was conducted between December 2015 and January 2016 in adults from the hospital catchment area attending the emergency department. The scientific literature was reviewed to locate the main studies on DVA instruments. Using the Delphi technique, five experts reached a consensus regarding a 3-item scale scored from 0 to 5. Concurrent validity and predictive validity were analysed using a numerical rating scale to assess DVA (scored from 0 to 10) and the number of access attempts, respectively. To determine diagnostic discrimination in terms of sensitivity and specificity, an optimal cutoff value was determined using a receiver operating characteristic (ROC) curve. Internal consistency and inter-observer reliability for three independent observers were analysed using Cronbach's alpha and Cohen's kappa, respectively.

**Results:** Recruited were 392 participants to analyse the diagnostic and prognostic sensitivity of the A-DICAVE instrument and 42 participants for the inter-observer agreement analysis. Mean (SD) difficulty of access was 1.31 (1.61). The concurrent and predictive validity scores pointed to positive relationships with the numerical rating scale ($r=0.82$; $p<0.001$) and the number of access attempts ($r=0.5$; $p<0.001$), respectively. The odds ratio (OR) for 1-2 access attempts versus >2 access attempts in relation to the A-DICAVE score was 2.752; 95% CI: 1.857-4.077; $p<0.0001$). Sensitivity and specificity values for the A-DICAVE scale were good, at 93.75% and 78.99%, respectively, as were internal consistency (Cronbach's alpha 0.81) and inter-observer reliability (Cohen's kappa 0.75).

**Discussion:** The A-DICAVE scale is a valid and reliable instrument for predicting DVA in emergency departments.

**Key words:** Peripheral intravenous catheterization. Difficult venous access. Nursing care. Emergency department.

## Introduction

Achieving peripheral intravenous access in emergency department patients is often difficult,[1] requiring several attempts or an alternative approach. Accessing a vein may be difficult when anatomical landmarks cannot be identified because of obesity, oedema or anatomical variations, when visible veins have been altered by previous intravenous punctures and when the number of available access sites is limited.[2,3] Difficult venous access (DVA) is commonly defined as the failure by an experienced nurse to access a vein in two attempts using conventional approaches.[4] Catheter insertion involving numerous punctures can cause pain and discomfort for patients, delay diagnosis and treatment and increase the workload for health professionals. While several authors[5-7] have attempted to define specific characteristics of DVA, their definitions are usually based on specific pathologies or conditions. Potential cases of DVA are typically evaluated by a nurse viewing or palpating veins and, although subjective, this is currently the most widely used approach.[8]

Several authors[9-11] have studied DVA evaluation in paediatric patients, with Yen et al.[9] developing a specific instrument called the Difficult Intravenous Access (DIVA) scale. Instruments have also

been developed to measure DVA in adults.[12-15] Loon et al.[16] developed the Adult Difficult Intravenous Access (A-DIVA) scale specifically for surgical patients, associating five variables with first-time access difficulty: visibility, palpability, a history of difficulty, an unplanned surgery indication, and vein diameter of less than 2 mm.

Identifying DVA at the outset of emergency care reduces patient pain and discomfort and facilitates diagnosis and treatment; furthermore, suitably informed patients will have realistic expectations regarding their DVA situation, given that patient trust and cooperation have been shown to be enhanced when procedures are explained beforehand.[9,10] Early DVA detection also facilitates decision-making regarding the use of catheterization support technologies for especially complex DVA cases.[17] Ultrasound-guided catheterization, for instance, is increasingly used in emergency departments for patients with DVA.[18,19]

Optimal DVA management begins when the triage nurse evaluates the need for intravenous access, considering factors such as condition severity and chronicity, the need for hydration, sedation or other medication, the need for blood sampling and the availability of support resources and technologies to facilitate catheter insertion.[10] Success often depends on the experience and training of nurses[20] or the availability of a specialist DVA team.[21]

As far as we are aware, no rapid and easy to use objective numerical scale to quantify DVA exists as yet for patients attended to in emergency departments. Such a scale would reduce pain and discomfort for patients, speed up diagnosis and treatment and ameliorate the workload for health professionals. It would also facilitate studies and clinical trials aimed at comparing approaches aimed at facilitating catheterization.

The objective of this study was to develop and test the prognostic accuracy of a simple scale, called the Adult-Difficult Venous Catheterization scale (A-DICAVE), to measure DVA in adults attending an emergency department.

## Material and Methods

### *Study design*

Prospective observational study.

### *Setting and sample*

This study was carried out in a level I community hospital between December 2015 and January 2016. Recruitment was consecutive and convenient. Included were adults from the hospital catchment area attending the emergency department and requiring peripheral intravenous access, and excluded were adults with altered cognitive faculties or states of consciousness.

Considering a 25% rate of DVA among study participants, a confidence interval (CI) of 95%, a design effect of 1 and a margin of error of 5%, the minimum sample size necessary to validate the A-DICAVE scale and set a cutoff value was determined to be 289 patients, raised to 303 participants to take into account a 5% attrition rate. In parallel, 42 randomly selected consecutive cases were used to analyse agreement between the findings of three independent observers.

***Protection of human subjects***

This research was approved by the Research Ethics Committee of the Dr Josep Trueta University Hospital of Girona (protocol number 2015.098). Informed consent was obtained from all participants, who were assured that their data privacy rights would be respected. The researchers also adhered to the Code of Good Practice in Research for their hospital, developed on the basis of international and national research practice standards.

***Development of the A-DICAVE scale***

To create the A-DICAVE scale, the scientific literature was reviewed to locate the main studies on DVA instruments (Table 1). Items that reflected characteristics and pathologies not supported by sufficient evidence were excluded. The final list of items, adequately supported by the existing evidence,[12,15,16,22] was endorsed in three Delphi rounds by five nurses with over 15 years' emergency department experience each, all expert trainers in traditional and ultrasound-guided venous puncture. The experts agreed on *vein visibility, vein palpability* and *access difficulty history* as the minimum necessary items for the scale, with visibility and palpability to be rated by the nurse and access difficulty history to be rated on the basis of a previously recorded history of DVA or the patient's affirmative response to the question: Has it previously been difficult to access any of your veins? The final score for the 3-item A-DICAVE scale was the overall sum, ranging from 0 (no DVA) to 5 (maximum DVA), with values for the item *access difficulty history* treated as ordinal data (Figure 1). Before commencing the study, the scale was piloted in 10 patients, with the items scored by two different nurses to ensure correct interpretation of the scale and consensus regarding final scores.

***Concurrent validity and predictive validity***

Concurrent validity was assessed by analysing correlation in terms of Spearman's rho for the A-DICAVE and 10-point numerical rating scales.

Predictive validity was assessed, as in other studies,[2,12,15,16,23,24] by the number of catheter insertion attempts, with >2 punctures rated as DVA, as indicated by the widely accepted definition of difficulty[11] and the recommendations of the Infusion Nurses Society.[25] Although some studies have defined difficulty on the basis of a single failed attempt,[15,16] the five experts who participated in this study opted for the more frequently used definition of two failed attempts.[7,22-24,26]

The study variables were as follows: technique success; the number of catheter insertion attempts; the overall A-DICAVE score (vein visibility, vein palpability and access difficulty history); and a 10-point numerical rating scale (0=no DVA to 10=maximum DVA) as used in other studies performed in emergency departments.[12,27] Salleras et al.,[27] in a study of 78 patients for whom catheterization was only possible using ultrasound, reported a mean (SD) difficulty score of 8 points (1.71; range 2-10; 7 points in the 25th percentile and 9 points in the 75th percentile). Lapostolle et al.,[12] in their study of 671 patients assessed using a visual analogue scale, reported, after the first catheterization attempt, a median difficulty score of 3 (range 2-5) for successful cases and of 6 (range 3-9) for unsuccessful cases ($p<0.0001$).

***Sensitivity and specificity***

To validate the A-DICAVE scale, an optimal cutoff value was determined using a receiver operating characteristic (ROC) curve. Diagnostic discrimination sensitivity and specificity values were analysed using the Epidat® 4.2 program.

***Reliability testing***

Inter-observer reliability and internal consistency for the three independent observers were analysed using Cohen's kappa and Cronbach's alpha, respectively.

***Procedure***

A triage nurse evaluated patients before venous puncture, applying a tourniquet to both arms and administering the A-DICAVE and numerical rating scales (both arms were evaluated, as difficulty may exist in only one arm in some people). The triage nurse recorded this data in a specially designed data collection form, informed the patient about the study and asked for their written

informed consent. Consenting patients were taken to an examination room for venous puncture by the nurse in charge, who afterwards recorded the number of attempts and the final outcome in the data collection form. The actual number of attempts was decided on the basis of the professional criteria of the examination room nurse.

***Statistical analysis***

Numerical variables were expressed as mean and standard deviation (SD) and median and interquartile range (IQR). Spearman's rho (r) was used to analyse correlations between A-DICAVE scores and the number of catheter insertion attempts and logistic regression was performed to dichotomize the A-DICAVE score according to 1-2 attempts and >2 attempts. Statistical analyses were performed using SPSS v21.

**Results**

Recruited were 392 participants to analyse the diagnostic and prognostic sensitivity of the A-DICAVE instrument and 42 participants for the inter-observer agreement analysis. Figure 2 shows the sampling and A-DICAVE application flowchart.

A-DICAVE mean (SD) and median (IQR) scores were 1.31 (1.61) and 0.50 (2). Patient distribution according to A-DICAVE scores and the number of catheter insertion attempts are shown in Table 2. Catheter insertion was achieved in 100% of cases.

***Concurrent validity***

Mean (SD) and median (IQR) numerical rating scale scores were 2.70 (2.82) and 2.00 (1.62), respectively. According to the concurrent validity criterion, the A-DICAVE and numerical rating scales were positively correlated ($r=0.82$; $p<0.001$).

***Predictive validity***

The Spearman correlation value indicated a moderately positive relationship between A-DICAVE and the number of access attempts ($r=0.5$; $p<0.001$), i.e., higher scores (indicating greater difficulty) were associated with more catheter insertion attempts. A univariate logistic regression analysis was performed that dichotomized the A-DICAVE score according to 1-2 attempts and >2 attempts, resulting in an OR of 2.752 (95% CI:1.857-4.077; $p<0.0001$). The OR values for the individual items were as follows: vein visibility 6.1 (95% CI: 2.7-13.4; $p<0.0001$), vein palpability

13.3 (95% CI: 5.1-34.7; p<0.0001) and access difficulty history 7.7 (95% CI: 2.6-22.9; p<0.0001) (Table 3).

### *Sensitivity and specificity*

The ROC cutoff value (Figure 3) indicating optimal sensitivity and specificity was 3, for an area under the curve of 0.91 (upper and lower limits 0.02 and <0.001, respectively; CI: 0.866-0.952), confirming that >2 punctures was a poor result. The A-DICAVE scale could thus be dichotomized into easy catheterization (0-2 points) and difficult catheterization (3-5 points), for a mean (SD) of 1.05 (0.23) and 1.72 (0.98) catheter insertion attempts (p<0.001), respectively.

Diagnostic discrimination was reflected by sensitivity and specificity values of 93.75% and 78.99%, respectively, while negative and positive predictive values were 99.6% and 15.96%, respectively.

### *Reliability testing*

Cronbach's alpha for the A-DICAVE items was 0.81, indicating good internal consistency. For the dichotomized A-DICAVE scale, Cronbach's alpha was 0.91, while substantial agreement was indicated by a value of 0.75 (p<0.001; CI: 0.53-0.97) for Cohen's kappa as a measure of inter-observer reliability. Table 4 summarizes evaluation results for the three observers.

## Discussion

Catheter insertion success overall was 100%, a rate that compares well to other studies reporting 80% to 99% success rates.[22,28] Our first-attempt success rate was 85%, higher than the 83%, 74%, 76% and 46% reported by Loon et al.,[16] Lapostolle et al.,[12] Minville et al.[29] and Costantino et al.,[5] respectively.

The positive correlation between A-DICAVE scores for DVA and the number of catheter insertion attempts reflects results in the literature.[12] Since DVA refers to the number of punctures required to achieve catheterization,[4] the A-DICAVE score is corroborated by actual difficulty, i.e., the higher the score, the greater the risk of insertion failure. Our results indicate that the risk of having to make >2 attempts at catheterization increases 2.75 times for each additional point in the A-DICAVE scale.

For the numerical rating scale to assess DVA, divided into easy and difficult categories (0-7 and 8-10 points, respectively, based on results obtained in a previous study[27]), the mean overall score was 2.69, while, for patients with DVA, the mean score was 8. This instrument is similar to the difficulty scale used by Lapostolle et al.,[12] which, like our study, reflected an association between DVA and the number of puncture attempts. In that study, first-attempt success was achieved at 3 points and otherwise at 6 points; the difference with our result is explained by the fact that the cutoff used in Lapostolle et al.[12] was based on just a single insertion attempt.

A quarter of our sample (24%) was found to have DVA (3-5 points), a percentage similar to that reported by Loon et al.,[16] bearing in mind that, in their study, difficulty was classified in three groups, with 26% of their sample presenting with moderate difficulty (2-3 points) or high difficulty (4-5 points).

The A-DICAVE scale was capable of discriminating according to puncture difficulty and showed good sensitivity and specificity. While the negative predictive value (patients correctly diagnosed without DVA) was 99.6%, the positive predictive value (patients correctly diagnosed with DVA) was only 15.96%; this low value is explained by the small number of patients in our sample (4%) requiring >2 punctures.

As for the concurrent validity criterion, the A-DICAVE scale positively correlated with difficulty scales used in other studies.[12,27]

Cronbach's alpha indicated good internal consistency for the three A-DICAVE items, with each item individually reflecting DVA and number of attempts. Regarding vein visibility and vein palpability, 98.9% of patients had visibility difficulties (veins not visible or barely visible) and 100% of patients had palpability difficulties (veins not palpable or barely palpable). While Loon et al.[16] reported non-visible and non-palpable vein rates of 49% and 53%, respectively, those lower percentages were based on a single access attempt (not two as in our study). Regarding the third item (*access difficulty history*), 81.9% of our patients with DVA had a previous history of difficulty, similar to the 84%-88% reported by Panebianco et al.[7]

Cohen's kappa measuring inter-observer reliability pointed to good agreement between the three independent observers in their evaluation of 42 randomly selected patients – a finding similar to that reported by Webster et al.[30]

Our simple but valid A-DICAVE scale can effectively predict possible difficulties with catheterization, which is a task usually performed by nurses before attempting venous puncture. The fact that the scale is numerical and objective also facilitates pre-selection of a suitable catheter calibre and a better puncture technique. Although several authors[2,5,6,12,31] have studied factors or pathologies that may affect DVA, insufficient evidence is available for these to be taken into account in a DVA instrument; this, in turn, suggests a need for further research to analyse risk factors associated with DVA. While evaluations of vein visibility and palpability may be subjective and imprecise, as pointed out by Walsh et al.,[8] their evaluation can undoubtedly be systematized using a numerical instrument. Vein visibility and palpability have been shown to be important but also access difficulty history, which has been included in the A-DICAVE.

While the A-DICAVE opens the way to new research aimed at analysing new techniques aimed at tackling DVA, it also remains necessary to continue studying other factors that may contribute to DVA and to include them in systems for assessing DVA. Systematic recording of DVA would also help calculate the additional nursing workload resulting from DVA.

**Limitations**

While our single-centre results can be extrapolated to similar populations, they cannot be extrapolated to all emergency departments. Another limitation is possible outcome bias, since variable evaluation was subjective and depended on each nurse's experience. Furthermore, factors such as advanced age, intravenous drug abuse and dialysis treatment that might contribute to DVA would need to be considered in further studies. Finally, it was not possible to use a validated instrument for the concurrent validity criterion given that no such validated scale existed.

**Implications for emergency nurses**

The A-DICAVE scale can potentially improve emergency nurse routines by enabling DVA to be identified early on so that the problem can be tackled from the outset using support technologies such as ultrasound-guided catheterization. Early DVA detection can ameliorate nurse workloads by reducing the number of failed catheterization attempts. Furthermore, early DVA detection

leads to realistic expectations in patients, who also benefit from the lesser likelihood of pain and discomfort and speedier diagnosis and treatment.

**Conclusions**

The A-DICAVE scale, which yields similar results when used by different healthcare staff, is a validated easily used and reliable instrument for predicting DVA, with scores that proportionally reflect access difficulty in terms of the number of catherization attempts.

**References**


1. Leidel B, Kirchhoff C, Bogner V, et al. Is the Intraosseous Route Fast and Efficacious Compared to Conventional Central Venous Catheterization in Adult Patients under Resuscitation in the Emergency Department? A prospective observational pilot study. Patient Saf Surg. 2009;3(1):24. doi:10.1186/1754-9493-3-24

2. Gregg SC, Murthi SB, Sisley AC, Stein DM, Scalea TM. Ultrasound-Guided Peripheral Intravenous Access in the Intensive Care Unit. J Crit Care. 2010;25(3):514-519. doi:10.1016/j.jcrc.2009.09.003

3. Carr PJ, Rippey JCR, Budgeon CA, Cooke ML, Higgins N, Rickard CM. Insertion of Peripheral Intravenous Cannulae in the Emergency Department: Factors Associated with First-time Insertion Success. J Vasc Access. 2016;17(2):182-190. doi:10.5301/jva.5000487

4. González Casares N. Vía Venosa Difícil: Estrategias. Emergencias. 2004;16:201-204.

5. Costantino TG, Parikh AK, Satz W a, Fojtik JP. Ultrasonography-Guided Peripheral Intravenous Access Versus Traditional Approaches in Patients with Difficult Intravenous Access. Ann Emerg Med. 2005;46(5):456-461. doi:10.1016/j.annemergmed.2004.12.026

6. Chinnock B, Thornton S, Hendey GW. Predictors of Success in Nurse-Performed Ultrasound-Guided Cannulation. J Emerg Med. 2007;33(4):401-405. doi:10.1016/j.jemermed.2007.02.027

7. Panebianco NL, Fredette JM, Szyld D, Sagalyn EB, Pines JM, Dean AJ. What you see (Sonographically) Is What you get: Vein and Patient Characteristics Associated With Successful Ultrasound-Guided Peripheral Intravenous Placement in Patients with Difficult Access. Acad Emerg Med. 2009;16(12):1298-1303. doi:10.1111/j.1553-2712.2009.00520.x

8. Walsh G. Difficult Peripheral Venous Access: Recognizing and Managing the Patient at Risk. J Assoc Vasc Access. 2008;13(4):198-203. doi:10.2309/java.13-4-7

9. Yen K, Riegert A, Gorelick M. Derivation of the DIVA score: a clinical prediction rule for the identification of children with difficult intravenous access. Pediatr Emerg Care. 2008;24:143-147.

10. Kuensting L, Deboer S, Holleran R, Shultz BL, Steinmann RA, Venella J. Difficult Venous Access in Children: Taking Control. J Emerg Nurs. 2009;35(5):419-424. doi:10.1016/j.jen.2009.01.014

11. Riker M, Kennedy C, Yen K, Dowd M. Validation and Refinement of the Difficult Intravenous Access Score: a Clinical Prediction Rule for Identifying Children with Difficult Intravenous Access. Acad Emerg Med. 2011;18:1129-1134. doi:10.1111/j.1553-2712.2011.01205.x.

12. Lapostolle F, Catineau J, Garrigue B, et al. Prospective Evaluation of Peripheral Venous Access Difficulty in Emergency Care. Intensive Care Med. 2007;33(8):1452-1457. doi:10.1007/s00134-007-0634-y

13. Blaivas M, Lyon M. The Effect of Ultrasound Guidance on the Perceived Difficulty of Emergency Nurse-obtained Peripheral IV Access. J Emerg Med. 2006;31(4):407-410. doi:10.1016/j.jemermed.2006.04.014

14. White A, Lopez F, Stone P. Developing and Sustaining an Ultrasound-Guided Peripheral Intravenous Access Program for Emergency Nurses. Adv Emerg Nurs J. 2010;32(2):173-188. doi:10.1097/TME.0b013e3181dbca70

15. Sebbane M, Claret P-G, Lefebvre S, et al. Predicting Peripheral Venous Access Difficulty in the Emergency Department using Body Mass Index and a Clinical Evaluation of Venous Accessibility. J Emerg Med. 2013;44(2):299-305. doi:10.1016/j.jemermed.2012.07.051

16. Van Loon FH, Puijn LA, Houterman S, Bouwman AR. 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). Medicine (Baltimore). 2016;96(16). doi:10.1097/MD.0000000000003428.

17. Crowley M, Brim C, Proehl J, et al. Emergency Nursing Resource: Difficult Intravenous Access. J Emerg Nurs. 2012;38(4):335-343. doi:10.1016/j.jen.2012.05.010

18. Feinsmith S, Huebinger R, Pitts M, Baran E, Haas S. Outcomes of a Simplified Ultrasound-Guided Intravenous Training Course for Emergency Nurses. J Emerg Nurs. 2018;44(2):169-175.e2. doi:10.1016/j.jen.2017.10.001

19. Edwards C, Jones J. Development and Implementation of an Ultrasound-Guided Peripheral Intravenous Catheter Program for Emergency Nurses. J Emerg Nurs. 2018;44(1):33-36. doi:10.1016/j.jen.2017.07.009

20. Rippey JC, Carr PJ, Cooke M, Higgins N, Rickard CM. Predicting and Preventing Peripheral Intravenous Cannula Insertion Failure in the Emergency Department: Clinician 'gestalt' wins again. EMA - Emerg Med Australas. 2016;28(6):658-665. doi:10.1111/1742-6723.12695

21. Whalen M, Maliszewski B, Sheinfeld R, Gardner H, Baptiste D. Outcomes of an Innovative Evidence-Based Practice Project: Building a Difficult-Access Team in the Emergency Department. J Emerg Nurs. 2018;44(5):478-482. doi:10.1016/j.jen.2018.03.011

22. Fields JM, Dean AJ, Todman RW, et al. The Effect of Vessel Depth, Diameter, and Location on Ultrasound-Guided Peripheral Intravenous Catheter Longevity. Am J Emerg Med. 2012;30(7):1134-1140. doi:10.1016/j.ajem.2011.07.027

23. Bauman M, Braude D, Crandall C. Ultrasound-Guidance vs. Standard Technique in Difficult Vascular Access Patients by ED Technicians. Am J Emerg Med. 2009;27(2):135-140. doi:10.1016/j.ajem.2008.02.005

24. Schoenfeld E, Boniface K, Shokoohi H. ED Technicians can Successfully Place Ultrasound-Guided Intravenous Catheters in Patients with Poor Vascular Access. Am J Emerg Med. 2011;29(5):496-501. doi:10.1016/j.ajem.2009.11.021

25. Infusion Nurses Society. Vascular Access Site Preparation and Device. Infusion Nursing Standards of Practice. Vol 34.; 2011. www.journalofinfusionnursing.com.

26. Stein J, George B, River G, Hebig A, McDermott D. Ultrasonographically Guided Peripheral Intravenous Cannulation in Emergency Department Patients with Difficult Intravenous Access: a Randomized Trial. Ann Emerg Med. 2009;54(1):33-40. doi:10.1016/j.annemergmed.2008.07.048

27. Salleras-Duran L, Fuentes-Pumarola C, Bosch-Borràs N, Punset-Font X, Sampol-Granes FX. Ultrasound-Guided Peripheral Venous Catheterization in Emergency Services. J Emerg Nurs. 2016;42(4):438-443. doi:10.1016/j.jen.2015.11.005.

28. Witting MD, Schenkel SM, Lawner BJ, Euerle BD. Effects of Vein Width and Depth on Ultrasound-Guided Peripheral Intravenous Success Rates. J Emerg Med. 2010;39(1):70-75. doi:10.1016/j.jemermed.2009.01.003

29. Minville V, Pianezza A, Asehnoune K, Cabardis S, Smail N. Prehospital Intravenous Line Placement Assessment in the French Emergency System: a Prospective Study. Eur J Anaesthesiol 2006, 23: 594-597. 10.1017/S0265021506000202.

30. Webster J, Morris HL, Robinsson K, Sanderson U. Development and validation of a vein assessment tool. Aust J Adv Nurs. 2007;24(4):5-7.

31. Van Loon FHJ, van Hooff LWE, de Boer HD, et al. The Modified A-DIVA Scale as a Predictive Tool for Prospective Identification of Adult Patients at Risk of a Difficult Intravenous Access: A Multicenter Validation Study. J Clin Med. 2019;8(2):144. doi:10.3390/jcm8020144

**Conflicts of interest.** The authors declare no conflicts of interest in relation to this article.

**Funding.** This research did not receive any specific grant from funding agencies in the public, commercial or not-for-profit sectors.

**Table 1.** Main DVA instruments analysed.

| Author | Year | Sample (n) | Study type | Study scope | Instrument | Results |
|---|---|---|---|---|---|---|
| Yen et al.[9] | 2008 | 615 | Prospective descriptive | Emergency Paediatric | DIVA scale with 4 items: evaluation of palpated veins, evaluation of visible veins, history of prematurity, child's age | The area under the receiver operating characteristic curve was 0.67. Subjects with a DIVA score of 4 or more were more than 50% likely to have failed intravenous placement on first attempt |
| Kuensting et al.[10] | 2009 | - | Expert consensus | Paediatric | DIVA scale and other parameters | Standards of practice and treatment algorithms are needed to ensure that children with peripheral DVA are managed effectively |
| Riker et al.[11] | 2011 | 366 | Prospective observational cross-sectional | Paediatric | Refined and validated DIVA scale | A three-variable rule (vein palpability, vein visibility, and patient age) was evaluated and found to possess discriminating ability (AUC:0.72, 95% CI:0.67 to 0.78) |
| Lapostolle et al.[12] | 2006 | 671 | Prospective observational | Prehospital emergency Adults | Visual analogue scale (easy to difficult) | The median difficulty score assessed on the visual analogue scale after the first attempt was 3 (2–5) in cases of successful cannulation and 6 (3–9) in unsuccessful cases ($p < 0.0001$) |
| Blaivas and Lion[13] | 2006 | 321 | Observational prospective | Emergency Adults | Gradual classification: very easy, easy, hard, very hard | 258 (80%) of the patients rated as very hard sticks before Ultrasound, 59 as hard, 3 as easy, and none as very easy. |
| White et al.[14] | 2010 | - | Implementation programme | Emergency Adults | Five-point visual scale: very difficult to very easy | Developing a program to train emergency nurses in ultrasound guided venous cannulation is viable, easy, and safe. |
| Sebbane et al.[15] | 2011 | 595 | Prospective observational | Emergency Adults | Scoring system: good/ favourable, poor/unfavourable, very poor/very unfavourable | Independent risk factors were: BMI≥30 (OR:1.98, 95% CI:1.09–3.60), BMI<18.5 (OR:2.24; 95% CI:1.07–4.66), and an unfavourable (OR:1.66, 95% CI:1.02–2.69), and very unfavourable clinical assessment of PV accessibility |
| Loon et al.[16] | 2016 | 1104 | Prospective observational | Surgery Adults | A-DIVA with 5 variables: visibility, palpability, difficulty history, unplanned surgery indication, vein diameter <2 mm | Variables were associated with a failed first attempt of peripheral intravenous cannulation: palpability of the target vein (OR:4.94, 95% CI:2.85–8.56; p<0.001), visibility of the target vein (OR:3.63, 95% CI:2.09–6.32; p<0.001), a history of difficult peripheral intravenous cannulation (OR:3.86, 95% CI:2.39–6.25; p<0.001), an unplanned indication for surgery (OR:4.86, 95% CI:2.92–8.07; p<0.001), and the vein diameter of at most 2 millimetres (OR:3.37, 95% CI:2.12–5.36; p<0.001) |

**Table 2.** Patient distribution (n=392) by A-DICAVE scores and catheter insertion attempts.

| **Distribution by A-DICAVE total score (n, %)** | | | | | | |
|---|---|---|---|---|---|---|
| **A-DICAVE total** | **0** | **1** | **2** | **3** | **4** | **5** |
| | 196 (50) | 47 (12) | 55 (14) | 48 (12.2) | 19 (4.8) | 27 (6.9) |
| **Distribution by A-DICAVE item scores (n, %)** | | | | | | |
| **Vein visibility** | **Visible** | | **Barely visible** | | **Not visible** | |
| | 221 (56.4) | | 116 (29.6) | | 55 (14) | |
| **Vein palpability** | **Palpable** | | **Barely palpable** | | **Not palpable** | |
| | 242 (61.7) | | 113 (28.8) | | 37 (9.4) | |
| **Access difficulty history** | | **Yes** | **No** | | | |
| | | 94 (24) | 298 (76) | | | |
| **Distribution by number of insertion attempts (n, %)** | | | | | | |
| **Attempts** | **1** | **2** | **3** | **4** | **5** | **6** |
| | 334 (85.2) | 42 (10.7) | 11 (2.8) | 3 (0.8) | 1 (0.3) | 1 (0.3) |

**Table 3.** Regression analysis output. 1-2 attempts versus >2 attempts with the overall A-DICAVE and 1-2 attempts versus >2 attempts for the different A-DICAVE items.

| | B | Standard error | Wald | gl | Sig. | Exp(B) | 95% CI by EXP(B) Upper | Lower |
|---|---|---|---|---|---|---|---|---|
| A-DICAVE | 1.012 | .201 | 25.468 | 1 | .000 | 2.752 | 1.857 | 4.077 |
| Constant | -5.846 | .814 | 51.611 | 1 | .000 | .003 | | |
| Vein visibility | 1.808 | .402 | 20.258 | 1 | .000 | 6.100 | 2.776 | 13.407 |
| Constant | -5.076 | .663 | 58.666 | 1 | .000 | .006 | | |
| Vein palpability | 2.590 | .490 | 27.979 | 1 | .000 | 13.325 | 5.104 | 34.786 |
| Constant | -5.960 | .835 | 51.004 | 1 | .000 | .003 | | |
| Access difficulty history | 2.050 | .554 | 13.714 | 1 | .000 | 7.766 | 2.625 | 22.980 |
| Constant | -4.071 | .451 | 81.464 | 1 | .000 | .017 | | |

**Table 4.** A-DICAVE scores for observers 1, 2 and 3 (n=42 patients)

| A-DICAVE score | Observer scores (n, %) | | |
|---|---|---|---|
| | **Observer 1** | **Observer 2** | **Observer 3** |
| 0 | 18 (42.9) | 19 (45.2) | 17 (40.5) |
| 1 | 5 (11.9) | 6 (14.3) | 11 (26.2) |
| 2 | 9 (21.4) | 10 (23.8) | 6 (14.3) |
| 3 | 4 (9.5) | 4 (9.5) | 3 (7.1) |
| 4 | 5 (11.9) | 0 | 1 (2.4) |
| 5 | 1 (2.4) | 3 (7.1) | 4 (9.5) |
| **Difficulty according to A-DICAVE overall score (n, %)** | | | |
| Easy (≤2) | 32 (76.2) | 35 (83.3) | 34 (81) |
| Difficult (>2) | 10 (23.8) | 7 (16.7) | 8 (19) |
| **Vein visibility (n, %)** | | | |
| Visible | 22 (52.4) | 25 (59.5) | 22 (52.4) |
| Barely visible | 15 (35.7) | 14 (33.3) | 15 (35.7) |
| Not visible | 5 (11.9) | 3 (7.1) | 5 (11.9) |
| **Vein palpability (n, %)** | | | |
| Palpable | 24 (57.1) | 24 (57.1) | 27 (64.3) |
| Barely palpable | 14 (33.3) | 15 (35.7) | 11 (26.2) |
| Not palpable | 4 (9.5) | 3 (7.1) | 4 (9.5) |
| **Access difficulty history (n, %)** | | | |
| Yes | 13 (31) | 13 (31) | 13 (31) |
| No | 29 (69) | 29 (69) | 29 (69) |

**Figure 1.** A-DICAVE scale.

| **Adult-Difficult Venous Catheterization (A-DICAVE) scale** |
|---|
| **Vein visibility** |
| **0 = visible (a vein suitable for puncture is visible)**<br>**1 = barely visible (a visible vein is tortuous and thin, but may be accessible with a small-calibre catheter (22G or inferior)**<br>**2 = not visible (no vein suitable for puncture is visible)** |
| **Vein palpability** |
| **0 = palpable (a vein suitable for puncture is palpable)**<br>**1 = barely palpable (a palpable vein is tortuous and thin, but may be accessible with a small-calibre catheter (22G or inferior)**<br>**2 = not palpable (no vein suitable for puncture is palpable)** |
| **Access difficulty history** |
| **0 = no (there is no previous report or history of access difficulty)**<br>**1 = yes (the patient has a previous history of access difficulty)** |

**Figure 2.** Sample selection and A-DICAVE application flowchart.

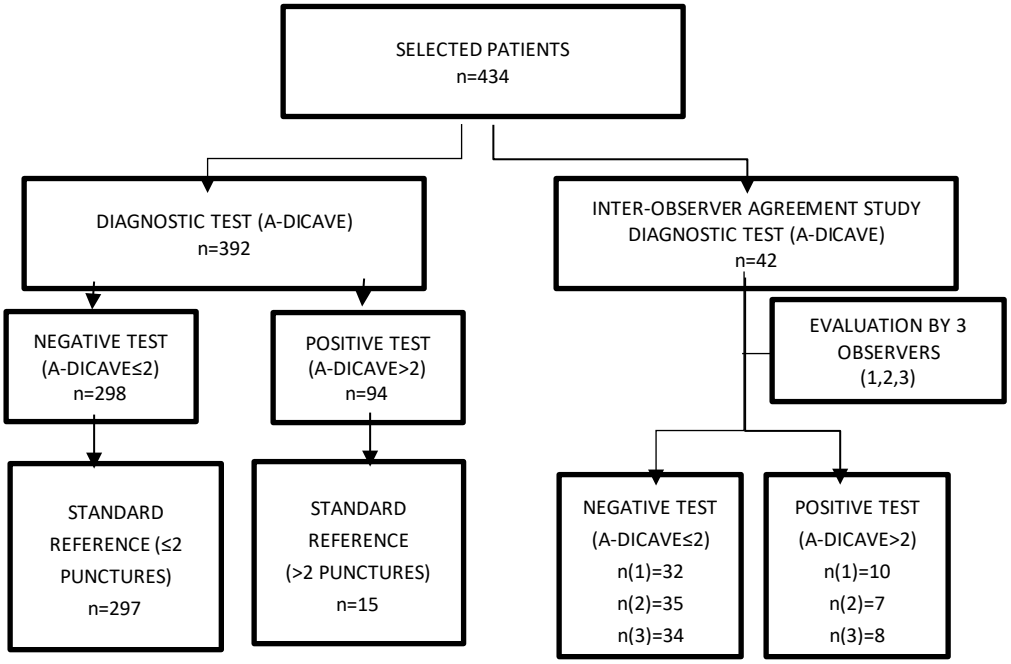


**Figure 3.** ROC curve