BMJ Open

Association between peripheral venous catheter failure and care complexity factors in emergency department: a cross-sectional study

Andrea Urbina,[1,2] Maria-Eulàlia Juvé-Udina,[3,4] Jordi Adamuz ,[1,2] Maribel González-Samartino,[1,2] Emilio Jiménez-Martínez,[2,5] Pilar Delgado-Hito,[2,4] Marta Romero-García[2,4]

To cite: Urbina A, Juvé-Udina M-E, Adamuz J, *et al*. Association between peripheral venous catheter failure and care complexity factors in emergency department: a cross-sectional study. *BMJ Open* 2024;**14**:e090101. doi:10.1136/bmjopen-2024-090101

► Prepublication history and additional supplemental material for this paper are available online. To view these files, please visit the journal online (https://doi.org/10.1136/bmjopen-2024-090101).

Received 17 June 2024
Accepted 02 October 2024

For numbered affiliations see end of article.

Correspondence to
Dr Jordi Adamuz;
jadamuz@bellvitgehospital.cat

ABSTRACT

Objective The objective was to determine the prevalence of peripheral venous catheter (PVC) failure and its association with care complexity individual factors (CCIFs) in emergency department (ED) patients.

Design A cross-sectional, descriptive-correlational study was performed.

Methods All patients with a PVC inserted in the ED of a tertiary hospital were included. The period of study was from June 2021 to June 2022. The main outcomes were PVC failure (phlebitis, extravasation/infiltration, dysfunction/occlusion and dislodgement/involuntary withdrawal) and 26 CCIFs categorised into 5 domains (psycho-emotional, mental-cognitive, sociocultural, developmental and comorbidity/complications). Other secondary variables were also collected, such as level of triage or nursing care plan. All data were collected retrospectively from the electronic health records. A descriptive and inferential analysis was performed.

Results A total of 35 968 patients with one or more PVC inserted during their ED visit were included in the study. The prevalence of PVC failure was 0.9% (n=316). The statistically significant CCIFs associated with PVC failure were: incontinence, haemodynamic instability, transmissible infection, vascular fragility, anxiety and fear, impaired adaptation, consciousness disorders, lack of caregiver support and agitation. In addition, we identified that patients with a higher number of CCIFs were more frequently experienced PVC failure.

Conclusion This study identified a prevalence of PVC failure in the ED of around 1%. The most prevalent complication was dysfunction, followed by extravasation and dislodgement. In addition, PVC failure was associated with comorbidity/complications, psycho-emotional and mental-cognitive CCIFs domains.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ The study was conducted in a high-complexity hospital.
⇒ This cross-sectional study included a large sample of patients treated in the emergency department (ED).
⇒ Patients were only followed up during their stay in the ED, which could have impacted the prevalence of peripheral venous catheter failure.
⇒ All data were collected retrospectively from electronic health records.
⇒ Catheter dwell time or drugs administered have not been considered in this study.

INTRODUCTION

The insertion of a peripheral venous catheter (PVC) is one of the most common invasive procedures performed by healthcare providers, being an indispensable tool in medical practice for the administration of fluids, blood derivatives, electrolytes or drugs, and other important clinical interventions.[1 2] The use of a PVC may compromise patient safety, causing adverse effects such as phlebitis, occlusion or extravasation. There are currently high rates of these catheter-derived complications that affect millions of patients each year worldwide.[3] Previous studies show that PVC failure is associated with length of hospital stay, mortality and the cost of hospitalisation.[4 5]

Non-standardised practices reported among healthcare professionals, among others, may play a significant role in the occurrence of these complications. One of the causes of this variability could be the poor training and the low levels of clinical guidelines implemented, that could have an impact in the prevention and the prior identification of PVC failure.[6]

The use of a PVC is a fundamental part of emergency healthcare. Over half of all emergency department (ED) patients will require a PVC during their visit.[5] The evidence identified that the prevalence of unnecessary PVC ranges from 27% to 32% in ED.[7–9] Additionally, in a recent systematic review, it was found that PVC failure due to infiltration and

extravasation were higher in EDs compared with other healthcare settings (25.2% vs 12.3%).[10] Although the success rates of the first insertion in the ED have been reported to be about 80%.[11 12] Other studies have shown that ED was also a risk factor for other complications, such as suboptimal dressings[13] or phlebitis.[14] It is known that complex patients with multiple chronic conditions and psychosocial issues have more frequent interactions with healthcare systems, are more vulnerable to complications and are at higher risk for poor health outcomes.[15] In addition, the number of older patients visiting the ED is increasing rapidly and, as a result, patients are becoming more fragile and complex.[16]

There is currently evidence on the association of PVC failure with factors such as catheter gauge, insertion site, catheter dwell time and drugs administered.[14 17 18] Other studies have discussed patient-related factors such as age, sex or their chronic diseases.[19–21] However, evidence regarding other sociocultural or emotional factors in the patient associated with PVC failure is scarce. In this context, the concept of care complexity plays a fundamental role by considering aspects related to the patient without limiting itself only to therapeutic aspects.[22] In 2010, Juvé-Udina defined the care complexity individual factors (CCIFs) as a set of specific characteristics in each person related to the different determining axes. These may have complicate care delivery and contribute to adverse events.[23]

Previous studies carried out in public hospitals of Catalonia found that several CCIFs were associated with adverse events (pressure ulcers, falls and aspiration pneumonia),[24 25] in-hospital mortality,[25] hospital readmission[26] and revisit to the ED at 30 days.[27] In addition, recently a study also associated PVC failure with CCIF; however, this study was conducted in inpatient wards, without considering patients admitted in ED.[28]

Given the abundant use of PVCs in the ED, it is likely that many patients are suffering PVC-related complications. Therefore, the risk of PVC complications must be considered to improve patient outcomes. In order to help create strategies to reduce healthcare-acquired complications and strengthen safety culture, knowledge of the prevalence of PVC failure in the ED and its relationship with CCIF is essential.

METHODS

Objective, study design and sample population

The aim of this study was to determine the prevalence of PVC failure and its association with CCIFs and other clinical and sociodemographic variables in patients admitted to the ED. This cross-sectional, descriptive-correlational study was performed to evaluate the association between PVC failure and CCIFs. This monocentric study was carried from 1 June 2021 to 30 June 2022. The setting of the study was the Bellvitge University Hospital, a tertiary care centre located in the southern metropolitan area of Barcelona, Spain. It is a referral high-tech hospital for more than 200 000 inhabitants. This facility has an ED equipped with 5 modules and 120 treatment rooms, and it attends approximately 118 000 patients annually. In addition, this department handles urgent cases of any specialty, except paediatrics and obstetrics.[29]

A consecutive sampling method was used. Systematic selection of all patients admitted to the ED during the inclusion period was conducted. The inclusion criteria of the study were patients with a complete nursing care plan in the electronic health records (EHR). Patients who did not have a PVC registered and all those under 16 years of age were excluded.

Data collection

Data were collected retrospectively from the EHR. The main outcomes were PVC failure and CCIFs. These data were recorded in the EHR using Architecture, Terminology, Interface, Information, Nursing and Knowledge (ATIC) terminology by the ED nurses responsible for each patient, and refer to the patient's assessment, identified diagnoses and nursing interventions. For this study, we obtained this information from the clinical data warehouse of the Catalan Health Institute. Sociodemographic variables were collected from the Minimum Basic Data Set of the ED.[30] The information from both sources was linked in this database through the patient episode numbers. All data were pseudonymised independently by the nursing knowledge management and information systems department using a unique identification number. In this way, the confidential data of the participants was preserved.

Measurements

The main variables of the study were PVC failure and 26 CCIFs. Both variables were identified and recorded in real time by the nurses in the nursing assessment form of EHR when the patient was attended to the ED.

PVC failure

The PVC failure was identified by nurses using ATIC terminology and were categorised into four main groups: phlebitis (phlebitis and signs of infection), extravasation (extravasation and infiltration), occlusion (by clots or other mechanical occlusion) and dysfunction (involuntary or accidental withdrawal, catheter dislodgement, dysfunction or leakage of fluid). Data regarding PVC failure were collected from the electronic nurse records, in which registered nurses reported any of the following nurse diagnoses during patient admission: catheter-associated phlebitis (code: 10001284); extravasation (code: 10002222); occlusion (code: 10005988) or dysfunction (code: 10005388); and dislodgement (code: 10017289) or involuntary withdrawal (code: 10010464/10010495/10010496), according to ATIC terminology.

Care complexity individual factors (CCIFs)

CCIFs are a group of patient characteristics related to different health dimensions that may complicate care

delivery and contribute to poor health outcomes. CCIFs were identified by ED nurses and were classified into five domains: (1) comorbidity/complications, (2) developmental, (3) psycho-emotional, (4) mental-cognitive and (5) sociocultural. Patients were considered to have CCIF if they presented with at least one defined characteristic, as identified in a previous study.[23] These CCIFs were collected from the nursing assessment e-charts as structured data based on the Architecture, Terminology, Interface, Knowledge terminology.[31] The CCIFs included in this study are summarised in online supplemental file.

Clinical and sociodemographic variables

Haemodynamic instability was obtained from the early warning system named VIDA (the Catalan acronym for Surveillance and Identification of Acute Deterioration). This nursing surveillance improvement programme has evolved into an early warning score system that is used on a daily basis to assist clinical decision-making. The VIDA Score automatically classifies patients into five groups according to patient progress data: no risk (level 0), low risk (level 1), moderate risk (level 2), high risk (impending complication if not stabilised) (level 3) and manifested complication initial status (level 4). For the purposes of this study, the VIDA Score was classified as mild (levels 1–2) or high (levels 3–4) risk. Patients were classified according to the highest VIDA Score obtained during their visit. Patient progress data were extracted from anonymised EHRs and included: respiratory rate, oxygen saturation, temperature, mental status (level of awareness: 1=aware and orientated, >1=disturbed mental status), heart rate and systolic and diastolic blood pressure.[24]

Other clinical and sociodemographic variables such as age, sex, nursing care plan and triage level were also collected. The nursing care plan is an instrument for standardising clinical practice that includes nursing interventions and their programming, nursing diagnoses and clinical variables of the patients attended.[32] On the other hand, triage level is the process that allows the patient to be assigned a level of prioritisation in clinical care. Nowadays, there are different validated triage scales, Spanish Triage System (SET) is the tool used in the hospital setting. SET System is based on the five levels of triage: 1—resuscitation, 2—emergency, 3—urgency, 4—less urgent and 5—non-urgent.[33]

Validity and reliability

CCIFs were collected according to the classification created in 2010 by Juvé-Udina *et al*. Through a participatory action research study involving more than 400 nurses from 8 public hospitals, CCIFs were identified and classified into a total of 5 domains. Each domain is structured into factors and specifications. These specifications were part of the coded and structured data in the initial and ongoing nursing assessment sections of the EHR, as described in the ATIC. This classification has been used in other studies to reveal associations between CCIFs and other unfavourable patient outcomes,[27] and the predictive ability of this classification has already been demonstrated.[24–26]

ATIC terminology has been used since 2020 in ED records, although this terminology has been used in hospitalisation settings of Catalan Institute of Health since 2007, the major public healthcare provider in Catalonia (Spain). All nurses in the ED received training process, and they were provided on-site mentorship in clinical practice and methodology before implantation. In addition, superuser nurses are responsible for supporting the training process of all staff and provide support on the use of the information systems, in clinical analysis and discussions to improve nursing care provision.[32]

Patient and public involvement

None.

Statistical analysis

IBM SPSS V.25.0 statistical software was used. We reported descriptive statistics for clinical and demographic variables in the study. Qualitative variables (nominal, ordinal and dichotomous) were described using absolute frequencies and percentages; and quantitative variables were expressed as median and IQR. The χ^2 test was used for the comparison of qualitative variables and the Student's t-test or Mann-Whitney U test for continuous variables, depending on whether the data followed a normal distribution. The normality of data was evaluated using the Kolmogorov-Smirnov test. Inferential analysis was used to identify significant relationships between catheter failure and care complexity factors. The OR and CIs were calculated and a 95% CI was established for all cases. All statistical analyses were performed using two-tailed tests with an alpha error of 0.05, and a p value of less than 0.05 was considered significant.

RESULTS

During the study period, 51 412 adult patients were admitted to an ED with a completed nursing health record. Of these, 35 968 (70%) patients with one or more PVC inserted during their ED visit were included. Table 1 shows the clinical and sociodemographic characteristics of the patients included in the study. The median age was 70 years (IQR 53.1–81.0) and 54.3% were male patients. The median of length of stay was 12 hours and triage level was ≤3 in more than 85% of cases (this level means patients require more urgent care). The main reasons for ED visits were: dyspnoea, malaise, COVID-19 infection, abdominal pain, chest pain and heart rhythm disorders.

We observed that 80% (n=28 827) of patients had at least one CCIF. Table 2 presents the prevalence of CCIFs organised by domains of complexity. The most prevalent CCIFs were uncontrolled pain (32.8%), extreme age (39.5%), anxiety and fear (16%) and consciousness disorders (14.9%).

Table 1 Patients' demographic and clinical characteristics (n=35 968)

Demographic and clinical characteristics	N (%)	
Age (median (IQR))	70.0 (53.1–81.0)	
Stay (median (IQR))	12 (7.4–21.9)	
Sex		
Male	19 515	(54.3)
Female	16 453	(45.7)
Triage level		
Level 1	806	(2.2)
Level 2	10 261	(28.5)
Level 3	19 557	(54.4)
Level 4	3752	(10.4)
Level 5	1283	(3.6)
No triage	309	(0.9)
Main medical diagnoses		
COVID-19	1851	(5.1)
Abdominal pain	790	(2.2)
Chest pain	694	(1.9)
Syncope and collapse	673	(1.9)
Cerebral infarction	516	(1.4)
Urinary tract infection	484	(1.3)
Main nursing care plans		
Consult for dyspnoea	3589	(10)
General malaise/constitutional syndrome	2826	(7.9)
COVID-19 infection	2493	(6.9)
Abdominal pain	2428	(6.8)
Consultation for chest pain	2344	(6.5)
Consultation for heart rhythm and/or driving disorders	1443	(4.0)

Table 2 Care complexity individual factors of adults in emergency department (n=35 968)

Care complexity individual factors	N (%)	
Comorbidity and complications	22 414	(62.3)
Uncontrolled pain	11 793	(32.8)
Haemodynamic instability	4791	(13.3)
Incontinence	4078	(11.3)
Transmissible infection	2368	(6.6)
Anatomical and functional disorders	2281	(6.3)
Extreme weight	1899	(5.3)
Postural limitation	1691	(4.7)
High risk of haemorrhage	1645	(4.6)
Vascular fragility	1620	(4.5)
Communication disorders	1148	(3.2)
Oedema	708	(2.0)
Involuntary movements	270	(0.8)
Dehydration	45	(0.1)
Developmental	14 223	(39.5)
Extreme age	14 223	(39.5)
Psycho-emotional	6145	(17.1)
Anxiety and fear	5750	(16.0)
Impaired adaptation	576	(1.6)
Aggressiveness	150	(0.4)
Mental-cognitive	5500	(15.3)
Consciousness disorders	5353	(14.9)
Agitation	294	(0.8)
Impaired cognitive functions	83	(0.2)
Perception of reality disorders	49	(0.1)
Sociocultural	423	(1.2)
Language limitation	286	(0.8)
Lack of caregiver support	55	(0.2)
Belief conflict	57	(0.2)
Social exclusion	35	(0.1)
Illiteracy	10	(0.0)

Among patients with a PVC, 0.9% (n=316) had some complication. The reasons for the PVC failure charted by the ED nurses were: dysfunction/occlusion 29% (n=92), extravasation/infiltration 26.3% (n=83), dislodgement/involuntary withdrawal 26.3% (n=83) and phlebitis 18.4% (n=58).

The association of CCIFs with PVC failure is summarised in table 3. The CCIFs associated with PVC failure were: incontinence (OR: 1.85; 95% CI: 1.39 to 2.45; p<0.05), haemodynamic instability (OR: 3.06; 95% CI: 2.41 to 3.88; p<0.05), transmissible infection (OR: 1.61; 95% CI: 1.11 to 2.32; p<0.05), vascular fragility (OR: 2.94; 95% CI: 2.09 to 4.15; p<0.05), fear and/or anxiety (OR: 1.45; 95% CI: 1.10 to 1.89; p<0.05), impaired adaptation (OR: 3.57; 95% CI: 2.17 to 5.86; p<0.05), consciousness disorders (OR: 2.76; 95% CI: 2.18 to 3.50; p<0.05), lack of caregiver support (OR: 4.28; 95% CI: 1.04 to 17.63; p<0.05) and agitation (OR: 4.07; 95% CI: 2.15 to 7.72; p<0.05). The median number of CCIFs was higher in patients with PVC failure than those without PVC failure (2 vs 1; p value=0.001). Moreover, table 4 shows the association of other clinical factors with PVC failure. The length of stay in the ED showed a statistically significant relationship with PVC failure.

Finally, figure 1 shows that the prevalence of PVC failure showed an increasing trend in ED patients with a higher number of CCIFs (0.61% in patients with 0–1 CCIF, 0.89% in patients with 2–3 CCIFs, 1.78% in patients with 4–5 CCIFs, 2.58% in patients with 6–7 CCIFs and 6.5% in patients with >8 CCIFs).

DISCUSSION

The prevalence of PVC failure in the ED was around 1%. The presence of a higher number of CCIFs was associated

Table 3 Association between peripheral venous catheter failure and care complexity individual factors

Care complexity individual factors	N (%) N=35 968		PVC failure Yes N=316 N (%)		No N=35 652 N (%)		OR (CI)	P value
CCIF (median (IQR))	1	(1–2)	2	(1–4)	1	(1–2)	1.33 (1.25 to 1.40)	<0.001
Comorbidity and complications	22 414	(62.3)	232	(73.4)	22 182	(62.2)	1.68 (1.31 to 2.16)	<0.001
Uncontrolled pain	11 793	(32.8)	116	(36.7)	11 677	(32.8)	1.19 (0.95 to 1.50)	0.136
Haemodynamic instability	4791	(13.3)	100	(31.6)	4691	(13.2)	3.06 (2.41 to 3.88)	<0.001
Incontinence	4078	(11.3)	60	(19.0)	4018	(11.3)	1.85 (1.39 to 2.45)	<0.001
Transmissible infection	2368	(6.6)	32	(10.1)	2336	(6.6)	1.61 (1.11 to 2.32)	0.011
Anatomical and functional disorders	2281	(6.3)	23	(7.3)	2258	(6.3)	1.16 (0.76 to 1.78)	0.493
Extreme weight	1899	(5.3)	21	(6.6)	1878	(5.3)	1.28 (0.82 to 2.00)	0.277
Postural limitation	1691	(4.7)	21	(6.6)	1670	(4.7)	1.45 (0.93 to 2.26)	0.103
High risk of haemorrhage	1645	(4.6)	18	(5.7)	1627	(4.6)	1.26 (0.78 to 2.04)	0.338
Vascular fragility	1620	(4.5)	38	(12.0)	1582	(4.4)	2.94 (2.09 to 4.15)	<0.001
Communication disorders	1148	(3.2)	13	(4.1)	1135	(3.2)	1.31 (0.75 to 2.28)	0.350
Oedema	708	(2.0)	7	(2.2)	701	(2.0)	1.13 (0.53 to 2.40)	0.751
Involuntary movements	270	(0.8)	3	(0.9)	267	(0.7)	1.27 (0.41 to 3.99)	0.682
Dehydration	45	(0.1)	1	(0.3)	44	(0.1)	2.57 (0.35 to 18.71)	0.352
Developmental	14 223	(39.5)	141	(44.6)	14 082	(39.5)	1.23 (0.99 to 1.54)	0.064
Extreme age (≥75 years old)	14 223	(39.5)	141	(44.6)	14 082	(39.5)	1.23 (0.99 to 1.54)	0.064
Psycho-emotional	6145	(17.1)	78	(24.7)	6067	(17.0)	1.60 (1.24 to 2.07)	<0.001
Anxiety and fear	5750	(16.0)	68	(21.5)	5682	(15.9)	1.45 (1.10 to 1.89)	0.007
Impaired adaptation	576	(1.6)	17	(5.4)	559	(1.6)	3.57 (2.17 to 5.86)	<0.001
Aggressiveness	150	(0.4)	2	(0.6)	148	(0.4)	1.53 (0.38 to 6.19)	0.553
Mental-cognitive	5500	(15.3)	102	(32.3)	5398	(15.1)	2.67 (2.11 to 3.39)	<0.001
Consciousness disorders	5353	(14.9)	102	(32.3)	5251	(14.7)	2.76 (2.18 to 3.50)	<0.001
Agitation	294	(0.8)	10	(3.2)	284	(0.8)	4.07 (2.15 to 7.72)	<0.001
Impaired cognitive functions	83	(0.2)	1	(0.3)	82	(0.2)	1.38 (0.19 to 9.92)	0.751
Perception of reality disorders	49	(0.1)	0	(0.0)	49	(0.1)	–	–
Sociocultural	423	(1.2)	3	(0.9)	420	(1.2)	0.80 (0.26 to 2.52)	0.708
Language limitation	286	(0.8)	1	(0.3)	285	(0.8)	0.39 (0.06 to 2.82)	0.353
Lack of caregiver support	55	(0.2)	2	(0.6)	53	(0.1)	4.28 (1.04 to 17.63)	0.044
Belief conflict	57	(0.2)	0	(0.0)	57	(0.2)	–	–
Social exclusion	35	(0.1)	0	(0.0)	35	(0.1)	–	–
Illiteracy	10	(0.0)	0	(0.0)	10	(0.0)	–	–

" - " There was no individual with catheter failure in this group.
CCIF, care complexity individual factor; PVC, peripheral venous catheter.

with PVC failure. Logistic regression identified the CCIFs significantly associated with PVC failure were incontinence, haemodynamic instability, transmissible infection, vascular fragility, anxiety and fear, impaired adaptation, consciousness disorders, lack of caregiver support and agitation. To date, there is the first study that evaluated CCIFs in the ED[27]; however, there have been other studies carried out in other departments (hospitalisation units).[24–26 28 34] These previous inquires have found associations between CCIFs and other patient health outcomes such as in-hospital mortality, adverse events or hospital readmission. The results of the current study showed that 80% of the patients had CCIFs and that the mean number of CCIFs was approximately 2 per patient, consistent with previous studies.[24–26 34]

In relation to the number of patients with a PVC, the study showed that more than two-thirds of patients with a registered nursing care plan required a PVC, according to previous studies carried out in EDs.[8 35 36] The prevalence of PVC failure was lower than other reports in this

Table 4 Association between peripheral venous catheter failure and characteristics of emergency department patients

Characteristics	n=35 968 N (%)		PVC failure (n=316) n (%)		Not PVC failure (n=35 652) n (%)		OR (CI)	P value
Age (median (IQR))	70 (53.1–81.0)		73.0 (61.2–83.7)		70.0 (53.0–81.0)		1.01 (1.01 to 1.02)	<0.001
Length of stay (hours) (median (IQR))	12 (7.4–21.9)		28.8 (19.9–45.3)		11.9 (7.4–21.6)		1.04 (1.04 to 1.05)	<0.001
Sex								
Male	19 515	(54.3)	158	(50.0)	19 357	(54.3)	0.84 (0.68 to 1.05)	0.128
Female	16 453	(45.7)	158	(50.0)	16 295	(45.7)	1.19 (0.95 to 1.48)	0.128
Triage level								
Level 1	806	(2.2)	0	(0.0)	806	(2.3)	–	–
Level 2	10 261	(28.5)	94	(29.7)	10 167	(28.5)	1.06 (0.83 to 1.35)	0.630
Level 3	19 557	(54.4)	172	(54.4)	19 385	(54.4)	1.00 (0.80 to 1.25)	0.984
Level 4	3752	(10.4)	36	(11.4)	3716	(10.4)	1.11 (0.78 to 1.57)	0.575
Level 5	1283	(3.6)	13	(4.1)	1270	(3.6)	1.16 (0.67 to 2.03)	0.599
Main medical diagnoses								
COVID-19	1851	(5.1)	12	(3.8)	1839	(5.2)	0.73 (0.41 to 1.30)	0.278
Abdominal pain	790	(2.2)	6	(1.9)	784	(2.2)	0.86 (0.38 to 1.94)	0.717
Chest pain	694	(1.9)	1	(0.3)	693	(1.9)	0.16 (0.02 to 1.14)	0.068
Syncope and collapse	673	(1.9)	3	(0.9)	670	(1.9)	0.50 (0.16 to 1.56)	0.234
Cerebral infarction	516	(1.4)	5	(1.6)	511	(1.4)	1.11 (0.46 to 2.69)	0.825
Urinary tract infection	484	(1.3)	9	(2.8)	475	(1.3)	2.17 (1.11 to 4.24)	0.023
Main nursing care plans								
Consult for dyspnoea	3589	(10)	7	(2.2)	3582	(10.0)	0.20 (0.09 to 0.43)	<0.001
General malaise/ constitutional syndrome	2826	(7.9)	33	(10.4)	2793	(7.8)	1.37 (0.96 to 1.97)	0.087
COVID-19 infection	2493	(6.9)	22	(7.0)	2471	(6.9)	1.01 (0.65 to 1.55)	0.983
Abdominal pain	2428	(6.8)	26	(8.2)	2402	(6.7)	1.24 (0.83 to 1.86)	0.294
Consultation for chest pain	2344	(6.5)	9	(2.8)	2335	(6.5)	0.42 (0.22 to 0.81)	0.010
Consultation for heart rhythm and/or driving disorders	1443	(4.0)	14	(4.4)	1429	(4.0)	1.11 (0.65 to 1.90)	0.704

" - "There was no individual with catheter failure in this group.
PVC, peripheral venous catheter.

same department.[10 19] This difference could be explained by different criteria from the data collection and the PVC complications. In this sense, in our study all data have been obtained from EHC, and possibly the number of PVC complications has been underestimated. Accordingly, previous studies in other settings reported variable rates,[13 21 37] with values ranging from less than 1%[38] to more than 50% of PVC failure.[14] In addition, there is great variability when measuring and recording these complications. For example, in relation to phlebitis, at least 71 different phlebitis scales exist, with highly disparate criteria and minimal testing of validity.[39] On the other hand, several studies have classified the complications of PVC in a similar way to the current study[40–42]; however,

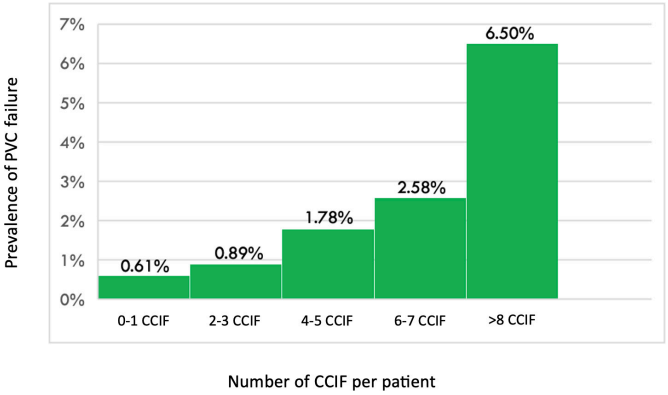

Figure 1 Prevalence of peripheral venous catheter (PVC) failure according to the number of care complexity individual factor (CCIF).

many of them only considered phlebitis and infectious complications, without considering other causes of PVC failure.[20 43 44] In those studies where several PVC complications were considered, the highest rates were usually extravasation or phlebitis.[5 10 21 45] In our study, the most prevalent cause was dysfunction/occlusion, followed by dislodgement and extravasation, and lastly, phlebitis. Phlebitis often takes hours or days to develop[46]; therefore, it is possible that the difference in the proportion of PVC failure in previous research is due to the patient follow-up period. Thus, the patient's shorter ED dwell time may explain these results.

In relation to sociodemographic variables, we observed a relationship between PVC failure and age, consistent with previous studies.[19] However, no statistically significant differences were found in relation to sex, although some studies have reported an association with female sex.[21 28 47] The length of patient stay in the ED was related to PVC failure. Patients who spend the longest time in the ED are those who have higher PVC dwell time, these results are consistent with studies that have associated the catheter dwell time with the risk of complications.[20] Our study found no association between the triage level and PVC failure, although another study found differences in risk of PVC failure and the different levels of triage.[19] The triage level assigned in ED categorises the urgency of patients based on the reason for the consultation or severity, and determining their waiting time, but it does not reflect the care complexity. Therefore, within each triage level, there are heterogeneous patients with different CCIFs, which might explain our findings.

Regarding CCIFs and PVC failure, we observed the association with several care complexity factors. First, in the comorbidity/complications domain was associated the haemodynamic instability, incontinence, transmissible infection and vascular fragility factors. In relation to this last complexity factor, 4.5% of patients who visited the ED presented it. This indicates that a relatively high proportion of patients can have venous tortuosity or fragility, that could hinder the PVC insertion. Similarly, a recent study showed that the prevalence of patients with difficult access in ED was 8.9%.[48] These results are in line with studies that have related the number of attempts to catheter insertion with the complications reported subsequently, thus confirming that difficult intravenous access is associated with more complications.[14 37] Patients who are haemodynamically instability often require higher gauche catheters and higher levels of intravenous drug administration, which can contribute to PVC failure.[14 17] Similarly, patients with transmissible infections required the administration of one or more intravenous antibiotics that can be associated with PVC failure.[18 45 49] Other studies confirmed that age is an important factor to consider.[19] Although the developmental domain was not associated with PVC failure, elders presented a higher frequency of PVC failure. The psycho-emotional domain was also associated with PVC failure, specifically the complexity factors of fear or anxiety and impaired adaptation. There is little evidence related to these factors and PVC failure. However, other studies show that fear and anxiety were associated with other unfavourable health outcomes, both in hospitalisation units and in EDs.[24–27] In the mental-cognitive domain, consciousness disorders and agitation were found to be predictors of PVC failure. This relationship could be related to patient movement and catheter fixation and integrity. In recent years, it has been demonstrated that optimal fixations or reinforced dressings reduce complications, reducing movement. This causes less irritation of the endovascular tissue and reduces entry of bacteria into the wounded skin, among other benefits.[13 50] Conversely, accidental or involuntary dislodgement has been one of the most prevalent causes of PVC failure.[5 10] Finally, in relation to the sociocultural domain, the lack of caregiver support was related to the PVC failure, as shows in previous studies.[28] Also, this CCIF was associated with other adverse events, such as pressure ulcer, falls or aspiration pneumonia.[25] Specifically, in the ED, the figure of the caregiver or companion plays a fundamental role in improving communication between the professional and patient, as they actively participate in the care process and play a crucial role in decision-making.[51] However, the benefits of caregivers in the ED remain underexplored and more evidence is needed.

In summary, the CCIFs associated with PVC failure were incontinence, haemodynamic instability, transmissible infection, vascular fragility, fear and/or anxiety, impaired adaptation, consciousness disorders, lack of caregiver support and agitation. Nevertheless, the evidence shows that in order to understand PVC failure must be considered other factors: (1) catheter factors, such as material, calibre or type of dressing used to fix it[13 50]; (2) clinical factors, such as days of catheter dwell, insertion site, length of stay or drug administration[44 49]; and also, (3) patient characteristics, such as age and vascular fragility.[28]

Limitations

This was an observational analysis with a large number of patients included in a referral hospital in Barcelona. In this study, we evaluated CCIFs that could be associated

with PVC failure. Even so, there were some limitations to the current study. First of all, this study did not consider the complexity factor 'major chronic disease' because it was not possible to collect this data from the EHR. However, there is already evidence regarding the relationship between chronic diseases and catheter complications.[20] Second, the prevalence of PVC failure may have been under-reported because the length of stay of patients in ED is relatively short. Patients are often transferred to inpatient units or other services, so a patient may have PVC failure that was recorded by a nurse in another department. We should take into account that EHRs in ED were only implemented a few years ago, which may have impact in the compliance of nursing records. In this sense, we relied on compliance in completing the EHR; however, since EHR are completed voluntary, some caution is required regarding interpretation. Finally, a cross-sectional design of our study limiting the ability to determine causal inferences, and we did not analyse other variables such as calibre catheter, catheter dwell time or drugs administered. Future research should be conducted using a longitudinal design to analyse the variables independently associated with PVC failure and thus provide more robust findings.

CONCLUSIONS

The CCIFs associated with PVC failure were: incontinence, haemodynamic instability, transmissible infection, vascular fragility, anxiety and fear, impaired adaptation, consciousness disorders, lack of caregiver support and agitation. Therefore, PVC failure was associated with several CCIFs-related comorbidity and complications, psycho-emotional and mental-cognitive domains. The prevalence of PVC failure increased as patients had a higher number of CCIFs. Therefore, complications derived from PVC are common and compromise patient safety. Knowing the causes associated with them could help to avoid unfavourable PVC-related health outcomes. Consequently, the early identification of PVC failure would help to stratify patients and implement preventive strategies.

Author affiliations
[1]Nursing Knowledge Management and Information Systems Department, Nursing Research Group (IDIBELL), Bellvitge University Hospital, L'Hospitalet de Llobregat, Catalunya, Spain
[2]Nursing Faculty, University of Barcelona, Barcelona, Spain
[3]Catalan Institute of Health, Barcelona, Catalunya, Spain
[4]Nursing Research Group (IDIBELL), Bellvitge Institute for Biomedical Research, Barcelona, Spain
[5]Infectious Disease Department. Nursing Research Group (IDIBELL), Bellvitge University Hospital, L'Hospitalet de Llobregat, Catalunya, Spain

Acknowledgements We thank the CERCA Programme/Generalitat de Catalunya for institutional support.

Contributors AU, JA and MRG conceived the study, designed the project and secured research funding. JA, MEJU and PD-H supervised the conduct of the study and the collection of data. AU, JA and MGS recruited participating centres and patients and managed data, including quality control. AU, JA and EJM provided statistical advice on study design and analysed the data. AU and JA wrote the manuscript and EJM, MEJU, MGS, MRG and PDH contributed substantially to its review. AU is responsible for the overall content as guarantor and accepts full responsibility for the finished work and/or the conduct of the study, had access to the data and controlled the decision to publish.

Funding This study is part of the project 'Individual Factors of Care Complexity, Care Intensity and Patient Health Outcomes in Emergency Department', financed by the Official College of Nurses of Barcelona as part of the Nurse Research Projects Grants (PR-542/2022) and by the Research Committee of the Bellvitge University Hospital (PR051-22). AU is the recipient of a research grant from Official College of Nurses of Barcelona and Research Committee of the Bellvitge University Hospital. This study also financed by the Agència de Gestió d'Ajuts Universitaris i de Recerca (2021SGR00929) whom M-EJ-U and JA are the recipient grant.

Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval This study involves human participants. The study was carried out in accordance with current laws and regulations and was approved by the institutional review board of Bellvitge University Hospital (Ref. PR051/22). All data were pseudonymised independently by an individual outside the research team, who assigned a numerical code to each patient episode in an Excel database. In this way, the confidential data of the participants was preserved. All data were recruited retrospectively of electronic health records.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement All data relevant to the study are included in the article or uploaded as online supplemental information. Not applicable.

ORCID iD
Jordi Adamuz http://orcid.org/0000-0002-5480-0981

REFERENCES

1 Webster J, Osborne S, Rickard CM, *et al*. *Clinically-indicated replacement versus routine replacement of peripheral venous catheters*. John Wiley and Sons Ltd, 2019.
2 Robert HE, Jeffrey K, John K, *et al*. n.d. Accepted but Unacceptable: Peripheral IV Catheter Failure. *J Infus Nurs*42:151–64.
3 Marsh N, Larsen EN, Ullman AJ, *et al*. Peripheral intravenous catheter infection and failure: A systematic review and meta-analysis. *Int J Nurs Stud* 2024;151:S0020-7489(23)00238-9.
4 Vendramim P, Avelar AFM, Rickard CM, *et al*. The RESPECT trial-Replacement of peripheral intravenous catheters according to clinical reasons or every 96 hours: A randomized, controlled, non-inferiority trial. *Int J Nurs Stud* 2020;107:S0020-7489(19)30311-6.
5 Alexandrou E, Ray-Barruel G, Carr PJ, *et al*. Use of Short Peripheral Intravenous Catheters: Characteristics, Management, and Outcomes Worldwide. *J Hosp Med* 2018;13:10.
6 Zingg W, Barton A, Bitmead J, *et al*. Best practice in the use of peripheral venous catheters: A scoping review and expert consensus. *Infect Prev Pract* 2023;5:100271.
7 Guihard B, Rouyer F, Serrano D, *et al*. Appropriateness and Complications of Peripheral Venous Catheters Placed in an Emergency Department. *J Emerg Med* 2018;54:281–6.

8 Gledstone-Brown L, McHugh D. Review article: Idle “just-in-case” peripheral intravenous cannulas in the emergency department: Is something wrong? *Emerg Med Australas* 2018;30:309–26.
9 Evison H, Sweeny A, Ranse J, *et al*. Idle peripheral intravenous cannulation: an observational cohort study of pre-hospital and emergency department practices. *Scand J Trauma Resusc Emerg Med* 2021;29:126.
10 Marsh N, Webster J, Ullman AJ, *et al*. Peripheral Intravenous Catheter Non-Infectious Complications in Adults: A Systematic Review and Meta-Analysis. *J Adv Nurs* 2020;76:3346–62.
11 Carr PJ, Rippey JCR, Cooke ML, *et al*. Factors associated with peripheral intravenous cannulation first-time insertion success in the emergency department. A multicentre prospective cohort analysis of patient, clinician and product characteristics. *BMJ Open* 2019;9:e022278.
12 Carr PJ, Rippey JCR, Budgeon CA, *et al*. Inserción de cánulas intravenosas periféricas en el departamento de emergencias: factores asociados con el éxito de la primera inserción. *J Vasc Access* 2016;17:182–90.
13 Corley A, Ullman AJ, Mihala G. Peripheral intravenous catheter dressing and securement practice is associated with site complications and suboptimal dressing integrity: A secondary analysis of 40,637 catheters. *Int J Nurs Stud* 2019;100:S0020-7489(19)30216-0.
14 Chen YM, Fan XW, Liu MH, *et al*. Risk factors for peripheral venous catheter failure: A prospective cohort study of 5345 patients. *J Vasc Access* 2022;23:911–21.
15 Hong CS, Atlas SJ, Ashburner JM, *et al*. Evaluating a Model to Predict Primary Care Physician-Defined Complexity in a Large Academic Primary Care Practice-Based Research Network. *J Gen Intern Med* 2015;30:1741–7.
16 Clegg A, Young J, Iliffe S. Frailty in elderly people. *Lancet* 2013;381:752–62.
17 Kache S, Patel S, Chen NW, *et al*. Doomed peripheral intravenous catheters: Bad Outcomes are similar for emergency department and inpatient placed catheters: A retrospective medical record review. *J Vasc Access* 2022;23:50–6.
18 Gras E, Jean A, Rocher V, *et al*. Incidence of and risk factors for local complications of peripheral venous catheters in patients older than 70 years: Empirical research quantitative. *J Clin Nurs* 2023;32:5000–9.
19 Carr PJ, Rippey JCR, Cooke ML, *et al*. From insertion to removal: A multicenter survival analysis of an admitted cohort with peripheral intravenous catheters inserted in the emergency department. *Infect Control Hosp Epidemiol* 2018;39:1216–21.
20 Atay S, Sen S, Cukurlu D. Phlebitis-related peripheral venous catheterization and the associated risk factors. *Niger J Clin Pract* 2018;21:827–31.
21 Marsh N, Larsen EN, Takashima M. Peripheral intravenous catheter failure: A secondary analysis of risks from 11,830 catheters. *Int J Nurs Stud* 2021;124:S0020-7489(21)00242-X.
22 Guarinoni MG, Motta PC, Petrucci C, *et al*. Complexity of care: a concept analysis. *Ig* 2014;26:226–36.
23 Juvé-Udina ME. Intensidad de cuidados enfermeros: ¿cargas de trabajo o complejidad individual. n.d. Available: https://www.academia.edu/20754559/Intensidad_de_cuidados_enfermeros_cargas_de_trabajo_o_complejidad_individual
24 Adamuz J, González-Samartino M, Jiménez-Martínez E, *et al*. Risk of acute deterioration and care complexity individual factors associated with health outcomes in hospitalised patients with COVID-19: a multicentre cohort study. *BMJ Open* 2021;11:e041726.
25 Adamuz J, Juvé-Udina M-E, González-Samartino M, *et al*. Care complexity individual factors associated with adverse events and in-hospital mortality. *PLoS One* 2020;15:e0236370.
26 Adamuz J, González-Samartino M, Jiménez-Martínez E, *et al*. Care Complexity Individual Factors Associated With Hospital Readmission: A Retrospective Cohort Study. *J Nurs Scholarsh* 2018;50:411–21.
27 Urbina A, Juvé-Udina ME, Romero-García M, *et al*. Care complexity factors associated with revisits to an emergency department. Factores de complejidad de cuidados asociados a la reconsulta en un servicio de urgencias. *Emerg* 2023;35:245–51.
28 Jiménez-Martínez E, Adamuz J, González-Samartino M, *et al*. Peripheral intravenous catheter failure, nurse staffing levels and care complexity individual factors: A retrospective multicentre cohort study. *PLoS One* 2024;19:e0303152.
29 Bellvitge university hospital. n.d. Available: https://bellvitgehospital.cat/es
30 Government of Catalonia. Department of Health. CMBD regulations and manual. Barcelona: Catalan Health Service, Available: https://catsalut.gencat.cat/ca/proveidors-professionals/registres-catalegs/registres/cmbd/normativa-manual/
31 ATIC care. n.d. Available: http://aticcare.peoplewalking.com/
32 Juvé-Udina M-E, Adamuz J. *Nursing knowledge tools and strategies to improve patient outcomes and the work environment. Mentoring in nursing through narrative stories across the world*. Cham: Springer International Publishing, 2023:211–22.Available: https://doi.org/10.1007/978-3-031-25204-4_29
33 Font-Cabrera C, Juvé-Udina ME, Adamuz J, *et al*. Activity, triage levels and impact of the pandemic on hospital emergency departments: A multicentre cross-sectional study. *J Adv Nurs* 2024.
34 Asensio Flores S, Juvé-Udina M-E, Soldevila Cases R, *et al*. n.d. Factores individuales de complejidad de cuidados en pacientes ingresados en unidades de cardiología y cirugía cardiaca. *Enferm Cardiol*:28–33.
35 Willis M, Colonetti E, Bakir A, *et al*. Prospective observational study of peripheral intravenous cannula utilisation and frequency of intravenous fluid delivery in the emergency department-Convenience or necessity? *PLoS One* 2024;19:e0305276.
36 Shokoohi H, Boniface KS, Kulie P, *et al*. The Utility and Survivorship of Peripheral Intravenous Catheters Inserted in the Emergency Department. *Ann Emerg Med* 2019;74:381–90.
37 Larsen EN, Marsh N, O’Brien C, *et al*. Inherent and modifiable risk factors for peripheral venous catheter failure during cancer treatment: a prospective cohort study. *Support Care Cancer* 2021;29:1487–96.
38 Gregg SC, Murthi SB, Sisley AC, *et al*. Ultrasound-guided peripheral intravenous access in the intensive care unit. *J Crit Care* 2010;25:514–9.
39 Ray-Barruel G, Polit DF, Murfield JE, *et al*. Infusion phlebitis assessment measures: a systematic review. *J Eval Clin Pract* 2014;20:191–202.
40 Simin D, Milutinović D, Turkulov V, *et al*. Incidence, severity and risk factors of peripheral intravenous cannula-induced complications: An observational prospective study. *J Clin Nurs* 2019;28:1585–99.
41 Liu C, Chen L, Kong D, *et al*. Incidence, risk factors and medical cost of peripheral intravenous catheter-related complications in hospitalised adult patients. *J Vasc Access* 2022;23:57–66.
42 Privitera D, Geraneo A, Li Veli G, *et al*. Complications related to short peripheral intravenous catheters in patients with acute stroke: a prospective, observational, single-cohort study. *Intern Emerg Med* 2024;19:1605–13.
43 Arias-Fernández L, Suérez-Mier B, Martínez-Ortega M del C, *et al*. Incidencia y factores de riesgo de flebitis asociadas a catéteres venosos periféricos. *Enferm Clín* 2017;27:79–86.
44 Lv L, Zhang J. The incidence and risk of infusion phlebitis with peripheral intravenous catheters: A meta-analysis. *J Vasc Access* 2020;21:342–9.
45 Johann DA, Danski MTR, Vayego SA, *et al*. Risk factors for complications in peripheral intravenous catheters in adults: secondary analysis of a randomized controlled trial. *Rev Lat Am Enferm* 2016;24:e2833.
46 Higginson R, Parry A. Phlebitis: treatment, care and prevention. *Nurs Times* 2011;107:18–21.
47 Wallis MC, McGrail M, Webster J, *et al*. Risk factors for peripheral intravenous catheter failure: a multivariate analysis of data from a randomized controlled trial. *Infect Control Hosp Epidemiol* 2014;35:63–8.
48 Davis EM, Feinsmith S, Amick AE, *et al*. Difficult intravenous access in the emergency department: Performance and impact of ultrasound-guided IV insertion performed by nurses. *Am J Emerg Med* 2021;46:539–44.
49 Larsen EN, Marsh N, Mihala G, *et al*. Intravenous antimicrobial administration through peripheral venous catheters - establishing risk profiles from an analysis of 5252 devices. *Int J Antimicrob Agents* 2022;59:S0924-8579(22)00046-2.
50 Marsh N, Webster J, Mihala G, *et al*. Devices and dressings to secure peripheral venous catheters to prevent complications. *Cochrane Database Syst Rev* 2015;2015:CD011070.
51 Cooper S, Stevenson F. Communicating decisions about care with patients and companions in emergency department consultations. *Health Expect* 2022;25:1766–75.