Intravenous access placement and fluid administration appropriateness in the emergency department

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Abstract

The aim of this study is to assess practice and effectiveness of Peripheral Venous Catheter (PVC) insertion and intravenous fluid administration in the Emergency Department (ED). A prospective study was conducted at a single primary ED in Brescia, Italy. 455 participants were included in the analysis. PVC were placed in 88 % of patients, 18 gauge catheters were the most frequently used (63%). In 360 patients PVC placement required one attempt. In 99 % of patients PVCs were used at least once. Fluid administration was considered appropriate in 23 patients. Out of 402 PVC placements, 244 were not necessary (in 225 patients PVCs were used only for blood samples withdrawal, and in 16 patients they were used for blood samples withdrawal, and inappropriate fluid administration). We concluded that a large number of PVC placements in the ED was potentially avoidable, and, when PVCs were used for IV fluid administration, the indication was often inappropriate. Physicians should carefully assess the real need of PVC placement in patients admitted to the ED and critically assess some issues of everyday practice, like PVC placement or IV fluids prescription, with evaluation of cost savings.

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Introduction

The Peripheral Venous Catheter (PVC) insertion is one of the most basic, yet important, components of modern medical practice, both in and out of hospital. Although this procedure has become of routine use only in recent years, the first documented attempts to gain a peripheral IV access can be found in the XVII century, during the Galilean revolution.[1]

Peripheral intravenous catheterization is one of the simplest and most frequently performed medical procedures,[2] although no currently accepted guidelines for PVC insertion are available.[3] Some studies reported that the prevalence of PVC placement in the ED was 15-26 % among all patients admitted to the ED. At the same time, it was observed that 35 to 50% of those catheters were never used during the ED stay.[4-6] This suggests that "preventive catheterization" in the ED could be an inappropriate and potentially harmful procedure.

PVCs are mainly used for repeated blood sampling, IV administration of fluids and/or medications including chemotherapeutic agents, nutritional support, transfusion of blood or blood products, or use of radiologic contrast agents.[7] The New South Wales Health department guidelines state that PVC placement is indicated if PVC is needed, alternatives have been considered, and the benefits outweigh the risks.[8] Despite this evidence, no international guidelines have been approved yet, and it is still difficult to assess the appropriateness of PVC placement.

PVC placement is usually considered a safe procedure, although a number of complications have been described such as phlebitis, extravasation of fluids, catheter misplacement, and local oedema. Moreover, systemic complications, such as sepsis, deep venous thrombosis, vascular or nerve lesions and rarer complications including septic discitis, gas embolism and pneumocephalus may be associated to this procedure.[9,10] Adverse events related to PVC insertion have been reported to be as frequent as 39%,[11] with phlebitis being the most frequent one (1,5-80%).[12,13] Among all intravascular devices, PVCs proved to be safer than midline, peripherally inserted central catheter (PICC), central venous catheter (CVC), or tunnelled catheters[3] when blood infections are considered.

Only a few studies have analysed the economic impact of venous catheterization in the Emergency Department (ED), and no study has ever assessed the economic impact of inappropriate PVC placement in the ED. Cost analysis regarding PVC is usually done

in comparison to other intravenous devices. Periard *et al.* have compared PVC and PICC in admitted patients, computing a total cost of 237 US$ for PVCs, and 690$ for PICCs; this difference was mainly due to PICC components being more expensive, and the need for angiography for placement.[14] A study by Tandale *et al.* in a paediatric population showed that PVC placement is a time consuming procedure; in some cases IV access placement could take up to 60 minutes.[15]

PVCs are the first choice intravenous device in the ED setting.[16,17] PVCs allow rapid access to venous circulation and quick drug administration, and they are frequently placed during blood draws. However, choosing PVC placement over less invasive procedures such as venipuncture does not carry a clear clinical indication.[3,18]

For these reasons, we decided to assess the use of PVC placement and its appropriateness in the ED setting for adult patients. In addition, we recorded the use of IV fluid administration and the prevalence of unnecessary or avoidable peripheral venous catheterizations, according to the National Institute for Health and Care Excellence (NICE) proposed criteria.[7]

Materials and Methods

We prospectively collected data regarding peripheral venous catheterization and fluid administration, during a 6 months period (March 1st 2017 - August 31st 2017).

All patients admitted to the Emergency Department of Spedali Civili in Brescia, Italy, are assigned a triage tag (red, yellow, green, white), and are re-directed to one of three different areas: non-urgent visits area, open space medical ward, or resuscitation room.

All consecutive adult patients admitted to the "open space" area during 6 hours shifts from 8 a.m. to 6 p.m (for a total of 120 hours) were enrolled into the study.

Exclusion criteria were the following: patients younger than 18 years of age, and the presence of a previously placed PVCs (in another hospital or during out-of-hospital care); in addition, patients admitted to the resuscitation room and to the non-urgent visits area were not included into the study. Data collection was performed by an emergency medicine resident (E.C.) and a medical student (S.B.), previously trained by a full professor in internal medicine, via the Airtable spreadsheet-database hybrid and the use of smartphones or tablets (Table 1). All collected data were then quality checked by two authors (ML.M and E.C.)

Because of the lack of predefined criteria for appropriate PVC placement, we considered PVC insertion as adequate when used for appropriate intravenous fluid or drug administration. In all the other instances, (*i.e.* intravenous catheter inserted but not used, intravenous catheter inserted but used for blood draws only, intravenous catheter inserted but used for inappropriate intravenous fluid administration), we considered it as not appropriate. We analysed the number of catheters that were placed but not used, those that could have been avoided in favour of the butterfly needle for blood sample draws, and those that could have been avoided in favour of oral fluid administration.

The study was approved by the hospital Research and Ethics Committee and informed consent was obtained prior to enrollment.

Statistical analysis

Descriptive analyses of the variables were expressed as mean and standard deviation or frequencies expressed in absolute numbers and percentages. Continuous variables were analyzed by ANOVA, categorical data were compared using the χ^2 test or the Kruskal Wallis test as appropriate; $p<0.05$ was considered statistically significant.

Results

Five-hundred-seventy-one consecutive patients were considered. According to the exclusion criteria, 116 patients (20,3%) were excluded: 6 patients were younger than 18 years of age, while 3 patients had a previously placed PVC at the time of arrival. In addition, for 107 patients, data regarding their whole ED stay were incomplete; in the end, 455 patients were prospectively enrolled into the study (247 males and 208 females).

The median age was 61 years (range 18-97); 83.4% of patients were 40 years or older, 56.2% were 60 years or older, 38.4% were

Table 1. Data collected in the study (airtable spreadsheet-database).

Collected data
Database ID
Coded ID
Time and date of triage
Triage tag
Gender
Mode of arrival
Age
PVC placement room
Ultrasound guided procedure (yes/no)
Qualifications of the personnel placing the PVC
PVC gauge
Attempts to place
Site of PVC insertion
Time, date, and purpose of IV use
Administered drugs
"A priori" evaluation of IV fluids appropriateness
Time and mode of discharge from the ED
Notes

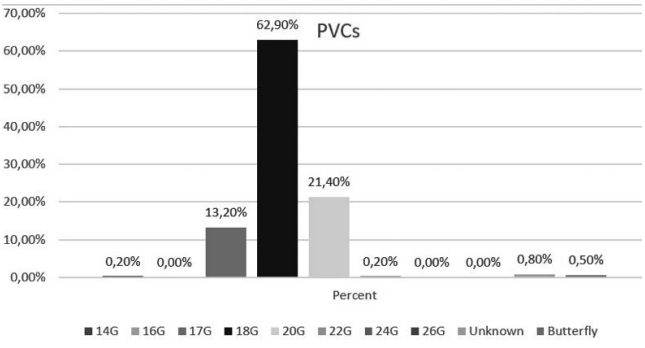

Figure 1. PVCs placements.

70 years or older. More than 75% were "walk-in" patients, while 22,4% were brought in by an ambulance.

At the end of their ED stay, 225 patients (50%), were admitted to medical wards of the Spedali Civili, while 202 (44%) were discharged, 18 patients (3,95%) were admitted to the ER observation unit, 9 (1,97%) refused admission, and 1 patient was transferred to another hospital.

PVC placement

A total of 402 PVCs were placed (88,3% of patients). The intravenous access insertion was performed by nurses in 98,5% of cases (396), and in 4 patients by a physician. The most used PVCs were 18G (62,9%), 20G (21,4%), and 17G (13,2%) (Figure 1). The 14G and 22G catheters were used only in one patient each. The butterfly needle was used for blood draws without PVC insertion in only two patients. When the number of successful insertions was assessed, we observed that in 360 patients (89,6%) peripheral vein catheterization was obtained immediately, while it required two attempts in 28 patients, three attempts in 8 patients, and four attempts in one patient. In only one patient 6 attempts were needed, and the PVC was finally placed with ultrasound assistance. The whole procedure was performed by nurses.

Regarding the site of insertion, the cubital fossa was the most used site (259 times), followed by the forearm (82 patients), hand (54 patients), the foot (4 patients), and in one patient the PVC was inserted in the external jugular vein.

PVC use

Out of 402 placed PVCs, 399 (99,2%) were used at least once, while in three patients it was unused (no blood was drawn, nor fluid or drugs were given). PVCs were used in most cases (n=383, 95% of patients) for blood samples withdrawal. In 53 patients intravenous fluids and in 166 patients intravenous drugs were administered (50% for analgesia). In 7 patients contrast medium during CT scans was injected, and in 2 patients blood units were transfused. Overall, PVCs were used 611 times.

Effectiveness of PVC placement

Overall, 3 PVCs were placed but never used, 225 were used for blood sample draws only, and 16 were used for blood sample draws and inappropriate fluid administration (according to the NICE criteria[7] reported in Table 2). In total, 244 PVCs out of 402 (60,7%) could have been avoided. We further analysed these data for each specific triage tag: 73 out of 120 among green tags were inappropriate (60,8%), 148 out of 244 among yellow ones (60,7%), 19 out of 33 for red ones (57%); in this last group of 19 patients with a red triage tag, 3 were discharged, and 16 were admitted after just having blood draws performed, without intravenous therapy.

Fluid administration

Fluids were administered in 53 patients (13,2%). Intravenous fluid administration appropriateness was assessed using the NICE criteria reported in Table 2.[7] The most frequent criterion for fluid administration was fluid resuscitation (9 patients). Based on these criteria, fluid administration was appropriate in 23 patients out of 53 (43,4%).

Discussion

This study showed that PVC placement was not strictly necessary in a significant number of patients (60,7% of all placed catheters), based on proposed criteria.[7,8] Moreover, in a small but significant number o patients, PVCs were placed but never used during the ED stay. According to the accepted guidelines, PVCs may be placed preventively in an ED setting only if the physician or the nurse may forecast the need for IV therapy or contrast medium injection. The rationale behind "preventive PVC placement" is that using a butterfly needle for blood sample withdrawal and then placing a PVC for fluids or drugs administration would expose patients to two invasive and painful repeated venepunctures, thus increasing the total risk of complications.[9-12] However, the ineffective use of PVCs observed in this study is higher than the one reported in other studies[4-6,16-19] and it could be due to the fact that clear guidelines regarding PVC placement in an ED setting are lacking. Our results also showed that the most frequent site of insertion was not ideal in most cases, being the cubital vein on the cubital fossa. If a PVC is used for fluid/drug infusion or contrast medium administration, cubital vein placement could expose patients to the need of a second catheterization, because of the high risk of PVC displacement or malfunction due to arm movements.

Despite the worldwide awareness of the importance of correct catheterization, no clear universal indications to the use of PVCs were available to nurses and medical staff in the ED at the time of the study.[20-22] In a few patients only (10.4 %) more than one catheterization attempt was needed. A recent study has identified that some patients related factors (older age and non-palpable vein) are independently associated with reduced odds of first-time of catheterization, while other clinician related factors (number of insertions and pre-insertion confidence), increased the rate of success.[21] The effectiveness of ultrasound-guided insertions could not be evaluated in this study, since it usually is the last resort for locating a peripheral vein, when the clinician has already failed with previous insertion attempts.[21]

Furthermore, our data showed that when PVCs were used for IV fluid administration, the indication was inappropriate in some cases, frequently overlooking the possibility to administer fluids per oral route. Fifty-three patients were given intravenous fluids, but 30 of them (56,6%) lacked all the "a priori" defined criteria for intravenous therapy appropriateness. It should be noted that in these patients oral therapy would have been possible, avoiding the risks of intravenous catheterization related complications.

Deciding the optimal dose, composition, and intravenous fluid infusion rate is a complex matter. Despite this, the evaluation, prescription, and monitoring of intravenous fluids in the ED is often

Table 2. Use of PVC according to the NICE proposed criteria.7

Appropriateness criteria	No. of patients
Fluid resuscitation	9
Vomit and signs of dehydration	2
Severe nausea	0
Electrolyte imbalance	2
Dysphagia	2
Fasting for procedures	2
Dementia	2
Reduced GCS	4
Delirium	0
Need for blood transfusion	0
TOTAL	23

left to unexperienced personnel: junior doctors or inadequately trained nurses.[23-25] Inadequate fluid management is a frequent event, and it may significantly increase morbidity, mortality, hospitalization, and costs.

Despite the need for fluid prescription guidelines in all acute situations, the majority of randomized controlled trials on IV therapy refers to intensive care or intraoperative fluid management. Many recommendations are based on basic principles, therefore all healthcare professionals involved in the prescription and administration of fluids should know the correct indications to guarantee patient's safety.[7] One could argue that preventive PVC placement could be useful if the patient's condition suddenly got worse. It should be noted, however, that, according to the protocol design, all patients were admitted to the open-space area, and none of the enrolled patients was admitted to an ICU; in case of immediate need, the medical and nurse staff is usually able to quickly gain an intravenous access, and, in emergency situations, additional tools could be used, like intraosseus drills.

From an economics point of view, it should be noted that the cost of a PVC is about twice the one of a butterfly needle. In our hospital, at the time of the study, the cost of a PVC is 0.6 € and the cost of a butterfly needle is 0.25 €. Based on our results, since 244 PVCs placed in a 120 hours period could have been avoided, it could be estimated that in a year span, about 17.000 PVCs could be spared, and, even if replaced with a butterfly needle for blood sample draws, this could lead to a 6000 € saving, showing the potential for an economic advantage. It should also be noted that these numbers could be even greater if the costs for complications management were added (such as infections).

Limitations

Our study was performed in a single center. Practices could be different in other EDs and thus lead to slightly different results.[26]

The number of patients is relatively small since we enrolled only those patients who entered the open space, and not all consecutive patients admitted to the ED during the selected period. The rationale behind this choice is that these patients require a more accurate evaluation regarding intravenous access placement. Patients with a direct access to the resuscitation room were excluded, considering that in most cases they need immediate intravenous access by definition for emergency treatment. It also seemed reasonable to exclude the patients who entered the "non-urgent area", since they usually present normal vital signs, and rarely require intravenous therapy. Pediatric patients were not included since PVC placement, according to literature, is less frequent, and the need for intravenous access is already more carefully assessed.[27]

Furthermore, the study was conducted over a short period of time, and patients were not enrolled during nightshifts. This limitation is due to the availability of the medical staff/student responsible for data collection. However, it is unlikely that the decision to use a butterfly needle rather than PVC would have been different from nighttime to daytime, since the nurse and medical personnel cover all the shifts, and the most important diagnostic services are available 24 hours, 7 days a week in the Spedali Civili of Brescia. Nevertheless, the results of our study are consistent with the literature.[28,29] Another limitation is that we did not follow patients after discharge or after admission to a medical/surgical ward and subsequently, the incidence of possible complications related to the catheterization were not recorded.

Conclusions

Our study results show that a significant amount PVC placements in and ED are potentially avoidable. These results support the hypothesis that the decision to place a PVC is not always made upon "a priori" standardized criteria, but it is more often made out of clinicians' (both nurses and physicians) habit or experience, and may represent an idle "just in case" placement.[26]

Modern medicine relies on new tools, procedures, diagnostic tests and therapies, and, especially in rich countries, these are prescribed without carefully weighing costs and benefits. Physicians should carefully assess the real needs of patients before prescriptions and reassess some critical issues of everyday practice, like PVC placement or intravenous fluids administration in the ED. This could imply some, albeit small, economic advantage.

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