The Utility and Survivorship of Peripheral Intravenous Catheters Inserted in the Emergency Department

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Study objective: We compare the use and survivorship rate of peripheral intravenous catheters placed in the emergency department (ED) by insertion method.

Methods: We analyzed a prospective cohort of ED patients who received a peripheral intravenous catheter in the ED by ultrasonographically guided or landmark insertion. Research assistants recorded the uses of the ED-inserted catheters during the ED visit and hospitalization. Among subjects admitted, research assistants tracked catheter survivorship for 72 hours or hospital discharge, whichever came first. Research assistants documented reason for catheter removal and whether it was replaced during hospitalization. Premature removal was defined as catheters that were replaced because of mechanical failure, complication, or discomfort. We used multivariate binomial regression to estimate the relative risk of insertion method on premature removal and a Kaplan-Meier curve to compare survivorship duration by insertion method.

Results: A cohort of 1,174 patients with a mean age of 45 years and 63% female predominance was analyzed. Catheter use was 73% and 78% in the ED and hospital for the administration of fluids, medications, or contrast agents (and 96% if blood drawn for testing was included). Peripheral intravenous use did not differ significantly in the ED or hospital by insertion method. For 330 patients who were admitted, 132 of 182 patients (73%) in the ultrasonographically guided group and 117 of 148 (79%) in the landmark group had 72-hour catheter survival. Premature removal was not significantly more likely to occur if the catheter was inserted by the ultrasonographically guided method compared with the landmark one (relative risk 1.26; 95% confidence interval 0.88 to 1.80).

Conclusion: ED-inserted peripheral intravenous catheters were frequently used in the ED and hospital. Peripheral intravenous use and hospital survivorship of ED-inserted peripheral intravenous catheters were similar by insertion method. [Ann Emerg Med. 2019;■:1-10.]

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INTRODUCTION

Background

Peripheral intravenous catheter placement is a common practice in the emergency department (ED). The catheters are used for multiple purposes, including drawing blood and administering fluids, medications, and contrast agents. In anticipation of diagnostic testing and treatments needed and to expedite ED care, nursing or other staff may insert a catheter in a patient before a physician order. For patients who are admitted, peripheral catheters inserted in the ED continue to be used during the hospital stay. Current Centers for Disease Control and Prevention guidelines state that peripheral catheters do not need to be replaced more frequently than every 72 to 96 hours.[1] Considering the risk of thrombosis, infection, and mechanical complications, as well as the discomfort and anxiety patients can experience from peripheral intravenous catheter insertion, it is important to evaluate catheters' use and survivorship.[2]

Studies that have examined the use of peripheral intravenous catheters in the ED have reported that between 46% and 85% are used for medication administration, intravenous fluids, and drawing of laboratory samples for analysis.[3-7] The variation in catheter use among studies is likely due to how use is defined and differences in the composition of the study samples. Some studies do not include catheter uses that could be replaced by other means such as blood drawing or therapies that can be administered orally. Most studies do not report the percentage of all patients who have a peripheral intravenous catheter inserted in the ED. Higher patient acuity is associated with higher peripheral catheter insertion and use rates.[7,8] Finally, several studies have reported the percentage of peripheral

Editor's Capsule Summary

What is already known on this topic

Most peripheral intravenous lines placed in the emergency department (ED) are used in the inpatient setting when the patient is admitted.

What question this study addressed

For patients who are admitted to the hospital, does placing a peripheral intravenous line by the ultrasonographically guided or landmark method influence line survivorship?

What this study adds to our knowledge

In this secondary analysis of a randomized trial, for 330 admitted inpatients, 72-hour survivorship of peripheral intravenous lines was similar irrespective of whether lines were placed in the ED by ultrasonography (73%) or landmark method (79%).

How this is relevant to clinical practice

For ED patients who are admitted, hospital survivorship of peripheral intravenous lines appears independent of the placement method.

intravenous catheters used in the ED according to catheters inserted by emergency medical services staff.[3,4]

Importance

Relatively little is known about the survivorship of peripheral intravenous catheters among ED patients who are admitted. The few studies that have reported peripheral catheter survivorship are based on small samples of ED patients with difficult intravenous access who had ultrasonographically guided catheters inserted.[9,10] To our knowledge, no study to date has reported survivorship in a broad ED patient population that includes patients with easy and difficult intravenous access or those whose catheters were inserted with a traditional landmark approach in the ED.

Goals of This Investigation

The purpose of this study was to compare by insertion method the use of ED-inserted peripheral intravenous catheters in the ED and hospital, and 72-hour survivorship among patients admitted. Our investigation was a secondary analysis of data collected as part of a randomized controlled trial that evaluated the initial success rate of peripheral intravenous catheter insertion using a landmark or ultrasonographically guided approach among patients with easy, moderately difficult, or difficult intravenous access.[11] We hypothesized that there would be no significant difference in peripheral intravenous catheter use or survivorship by insertion method.

MATERIALS AND METHODS

Study Design

This prospective cohort study was designed and nested within a randomized controlled trial that we conducted and described previously.[11] For this study, the research assistants reviewed the charts of patients enrolled in the randomized controlled trial after ED or hospital discharge and documented the different uses of the peripheral intravenous lines by the ED staff. In addition, among the subjects admitted to the hospital, the research assistants prospectively documented the survivorship status of the ED-inserted peripheral catheters by checking the catheters of each admitted subject daily up to 72 hours postadmission. The university's institutional review board approved the study protocol and all patients provided written informed consent. The article was written in accordance with Strengthening the Reporting of Observational Studies in Epidemiology guidelines.[12]

Setting and Selection of Participants

The study was conducted in an urban, tertiary hospital with an annual ED census of approximately 71,000 visits. On average, 25% of patients are admitted to the hospital. At this ED, peripheral intravenous cannulation is the primary responsibility of the ED technicians. Since 2008, attending emergency physicians with ultrasonographic expertise have trained the ED technicians to perform ultrasonographically guided intravenous insertion.[13,14]

Eligible participants for the randomized controlled trial were adult ED patients for whom the ED technician decided that a peripheral intravenous catheter inserted in their upper extremity (excluding the hand) was needed, according to the orders placed by the treating physicians (eg, intravenous fluids, medications). Patients were excluded if they were considered high acuity (all Emergency Severity Index triage level 1 patients plus triage level 2 for whom the care team deemed it unsafe to delay intravenous placement).[15] Patients were randomized to an ultrasonographically guided or landmark method with equal probability, stratified by operator and difficulty of intravenous access. If the first attempt was unsuccessful, subjects were randomized a second time. If the second attempt failed, the insertion method used for subsequent attempts was left to the technician's discretion.

Because there is no validated method of classifying difficulty of intravenous access for adults, the ED technicians used a combination of visibility and palpability of the veins.[16,17] The ED technicians classified subjects as having difficult intravenous access if they could not see or palpate a vein in either upper extremity. Subjects were classified as having moderately difficult intravenous access if the ED technician could see or palpate at least one vein but thought it might be difficult to insert the catheter with a landmark approach. Subjects with easy access were those with at least one vein that the ED technician could visualize or palpate and that he or she judged could be used to easily insert the catheter with a landmark approach.[11]

In the parent trial, a total of 1,662 subjects were screened for the study and 1,189 met the eligibility criteria and were enrolled (Figure 1). The intravenous lines were placed by 33 ED technicians, who enrolled a median of 26 subjects each. For this study, the examination of peripheral catheter use was based on 1,174 of the 1,189 subjects enrolled in the parent study. Fifteen subjects were excluded from this analysis because the peripheral cannulation was not successful and the subjects were ultimately treated with a different type of catheter (1 received an external jugular intravenous line and 2 received central lines) or none at all (n=12). The survivorship analysis is based on the 330 enrolled subjects admitted to the hospital with an ED catheter inserted by the landmark or ultrasonographically guided approach.

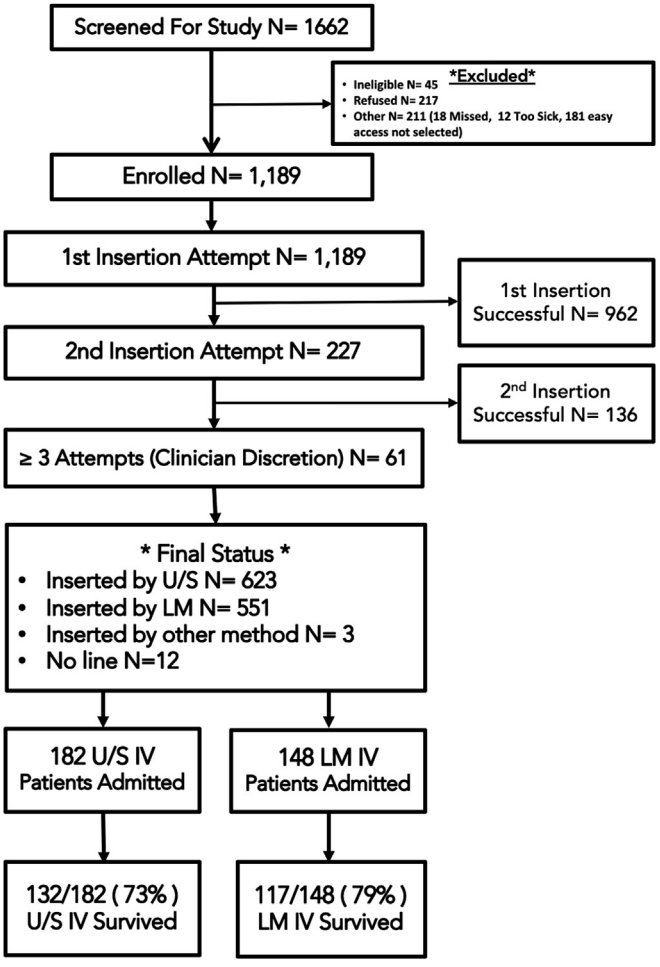

Figure 1. Flow diagram of study cohort. *LM*, Landmark; *U/S*, ultrasonography; *IV*, intravenous.

Data Collection and Processing

After enrollment, the research assistants interviewed subjects to obtain weight, height, and specific comorbidities or treatments that had been previously associated with difficult intravenous access in the literature (ie, intravenous drug use, sickle cell disease, diabetes, past or present chemotherapy, end-stage renal disease or dialysis, living in a nursing home, or frequent hospitalizations or blood drawing).[7,18,19] Subjects were also asked whether other clinicians had ever used ultrasonography to place a catheter in their arm.[18] After this brief interview, the research assistants observed the insertion of the peripheral intravenous catheter by the ED technician. For the first 2 insertion attempts, the research assistant prospectively documented the method of attempt, whether it was successful, the needle gauge (18, 20, or 22) and catheter length (standard length of 1 1/4 inches versus long length of 1 7/8 inches), the anatomic placement of the catheter (forearm, antecubital, or above elbow), and any complications that occurred. If more than 2 attempts were performed, the ED technicians documented only the method of final attempt; they did not document catheter gauge, length, or insertion location.

Trained research assistants documented the use and survivorship of the ED-inserted catheters and were blinded to this study's hypotheses. Neither form that the research assistants used to document catheter use or survivorship included information on catheter insertion method. After ED discharge of the patients, the research assistants reviewed the electronic medical record and documented the different uses of the peripheral catheter by ED staff, using a standardized form. The research assistants documented 4 different types of use: administration of continuous solutions, administration of medications, administration of contrast agents, and drawing of blood.

As part of the study protocol, the ED technician attached a tag to the catheter once successfully inserted in the ED and noted the date so that for subjects admitted to the hospital, the research assistants could easily determine whether the ED-inserted catheter was still in place when they followed up with subjects on the hospital floor. For up

to 3 days after patient admission or hospital discharge, whichever occurred first, the research assistant would locate the subject on the inpatient floor and determine the status of the ED-inserted catheter. We chose a 72-hour follow-up period because our hospital protocol is to replace the peripheral intravenous catheters after 72 hours, regardless of clinical indication.

Using a standardized form, the research assistants recorded the date and time that the intravenous catheter was checked, the date and time of catheter removal, reason for catheter removal (eg, infiltration, infection, fell out, subject discharged, no longer needed), and whether the peripheral catheter was replaced. For all ED-inserted catheters removed, the research assistants asked the nurse on duty why the catheter had been removed. If the nurse did not know, they reviewed the documentation in the electronic medical record, and if there was no documentation, they asked the subject. For 22 of the 330 cases, the research assistants reviewed the catheter removal circumstances with the two physician authors (H.S. and K.B.) who were blinded to insertion method. In all but 2 of these cases, the physicians were able to identify the reason for removal.

Outcome Measures

The main outcomes were the proportion of the ED-inserted peripheral intravenous cannulas that were used during the ED visit, and the premature removal of the catheter within the first 72 hours of hospital admission, until death or hospital discharge, whichever occurred first. Peripheral intravenous catheters were defined as used if the catheter delivered medications, fluids, or contrast agents or was used to draw blood. We included blood drawing in our definition because we were measuring catheter use rather than evaluating the appropriateness of catheter insertion.

Premature removal was defined as a catheter that was removed because it either stopped working (eg, fell out, dislodged) or a complication occurred (infiltrated, became infected, or was painful) and the catheter was replaced within the 72-hour follow-up period. Routine removal of the catheter because of completion of care and patient discharge before 72 hours was not considered premature removal. In only 2 cases were the research assistants and physician authors unable to determine the reason for catheter removal. We classified both of these cases as having a prematurely removed catheter because the line was replaced.

Secondary outcomes included the proportion of the ED-inserted peripheral intravenous cannulas that were used during the hospital visit, the number of different purposes of the peripheral catheter, and the duration it remained in place in the hospital.

Primary Data Analysis

The analysis compares peripheral intravenous catheter use and survivorship by insertion method. It was conducted according to the final insertion method; it was not an intention-to-treat analysis because it was not possible to measure the main outcomes until after the catheter was successfully inserted in the ED. This study was planned at the initial design of the randomized controlled trial, but the sample size was determined by the main outcome of the randomized controlled trial and not by the outcomes of this study. Given the sample size we achieved, a post hoc power estimation revealed that we had adequate power (ie, 80%) to detect a difference in use in the ED between the 2 methods of 5% or greater and a 15% difference or greater in the proportion of peripheral intravenous catheters prematurely removed between the 2 insertion methods.

First, we compared the distribution of the patient and catheter characteristics for the overall and admitted samples by insertion method. Second, we compared the proportion of subjects whose catheters were used in the ED and hospital and the number of different purposes the catheter was used for by insertion method. Third, we examined the relationship between patient and catheter characteristics and premature catheter removal among the subjects who were admitted. For all the above categoric comparisons, we evaluated the relationship between the patient and catheter characteristics and the different outcomes according to the relative risk and 95% confidence interval (CI). For all comparisons involving a continuous predictor, we evaluated the relationship between the predictor and the outcome by the risk difference and 95% CI.

We also modeled premature catheter removal as a function of selected patient and catheter characteristics, using a generalized estimating equation model that adjusted for the correlation among subjects treated by the same ED technician. We included basic demographic variables, including age and sex, as well as clinical and treatment characteristics that we hypothesized would influence catheter survivorship. We hypothesized that clinical characteristics related to difficulty of insertion might influence catheter survivorship. We measured difficulty of insertion in different ways, including history of an ultrasonographically inserted catheter, presence of specific comorbidities previously associated with difficulty of insertion, whether more than one attempt was required to insert the catheter, and difficulty of intravenous access as judged by the ED technician. Because history of an ultrasonographically guided inserted catheter, number of insertion attempts, and difficulty of intravenous access were all strongly correlated and were also correlated to the final insertion method as measured by a χ^2 test statistic, we

included only the final insertion method in the final model. We were unable to evaluate the influence of needle length, needle gauge, and vein used because these variables lacked significant variation by final insertion method. For example, no catheters were inserted with a long needle by the landmark method; they were all inserted with the ultrasonographically guided method.

The 2 treatment characteristics that we hypothesized might influence catheter survivorship were the number of different uses of the catheter in the ED and in the hospital. Because these 2 variables were highly correlated according to a χ^2 test statistic, we included only the number of different uses in the hospital in the final model because the outcome was catheter survivorship in the hospital.

Effect modification was considered, but because of the small number of predictors included in the final model and because there was no a priori reason to suspect an interaction effect, we did not formally test for interaction.

We report the relative risk ratio and 95% CI of the variables included in the final model. For the multivariate regression analysis, results were considered statistically significant if the 95% CI did not include 1.0. We assessed the fit of the final model by comparing it with a fuller model that also included history of an ultrasonographically guided catheter and number of insertion attempts, using a likelihood ratio test that compares the fit of the 2 models.

Finally, to evaluate whether the timing of premature catheter removal varied by insertion method, we plotted a Kaplan-Meier curve and compared the survival distributions of the catheters inserted by landmark versus ultrasonography during a 72-hour follow-up period, using a log-rank test.

RESULTS

The study sample included 1,174 patients with a mean age of 45 years. The majority of subjects were women (63%; N=740) and more than one third were obese (37%; N=434) (Table 1). Approximately three quarters of the study sample (72%; N=845) was characterized as having an Emergency Severity Index level 3 and 28% (N=330) were admitted. There were no deaths in the admitted patient group. For slightly more than half of the overall sample (623/1,174) and admitted sample (182/330), ultrasonography was the final insertion method. In the overall sample, subjects with an ultrasonographically guided intravenous catheter were slightly more likely to have a history of a medical condition associated with insertion difficulty (relative risk 1.15; 95% CI 1.03 to 1.28). There were also significant differences in the catheter characteristics of the overall and admitted samples by insertion method. ED technicians were significantly more likely to use a long needle and to insert the catheter above the elbow compared with the antecubital fossa, using ultrasonography rather than a landmark approach (Table 1).

The majority (1,123/1,174; 96%; 95% CI 94% to 97%) of the ED-inserted catheters were used in the ED and in admitted patients (318/330; 96%; 95% CI 94% to 98%) (Table 2). The most common purposes of the ED-inserted catheter in the ED and hospital were for blood drawing (≥90%), followed by medication administration (54% in the ED and 66% in the hospital). The least common use of the ED-inserted peripheral intravenous catheter was to administer a contrast agent (17% and 9% in ED and hospital, respectively). The majority of the time, the ED-inserted catheters were used for 2 or more purposes (66% and 72% in the ED and hospital, respectively). There were no significant differences in the type or number of purposes by insertion method.

Among the 330 subjects admitted, the percentage of subjects whose catheter was prematurely removed was 25% (N=81) (Table 3). The 72-hour premature removal was 50 of 182 (27%; 95% CI 21% to 35%) in the ultrasonographically guided group and 31 of 148 (21%; 95% CI 15% to 28%) in the landmark group, for a relative risk of 1.26 (95% CI 0.88 to 1.80). The most common reasons for premature removal during the 72-hour follow-up period were patient discomfort or catheter dysfunction (N=41), infiltration (N=24), and dislodgement (N=14). There were no inhospital deaths among these patients on 72-hour follow-up.

Premature removal was significantly associated with the number of uses of the catheter in the hospital (Tables 3 and 4). With each additional type of use of the catheter in the hospital, the relative risk of premature removal increased by approximately 36% (relative risk 1.36; 95% CI 1.16 to 1.58) (Table 4). Premature removal of the catheter occurred most frequently during the first 24 hours of hospitalization (Table 3). However, there was no significant difference in the timing of premature removal by insertion method (Figure 2) (*P* value of log-rank test=.44).

LIMITATIONS

The results of this study must be considered in the context of the following limitations. First, it was performed in a single academic ED that relies on technicians to place peripheral intravenous lines, and it may be challenging to extrapolate to other centers with different policies.

Second, we were unable to determine how representative our study sample was of all patients who receive a

Table 1. Patient and catheter characteristics for total and admitted samples by peripheral intravenous catheter insertion method.

	Overall			Admitted		
Patient Characteristics	**Ultrasonographically Guided, N = 623**	**Landmark, N = 551**	**Relative Risk (95% CI)**	**Ultrasound, N = 182**	**Landmark, N = 148**	**Relative Risk (95% CI)**
Mean age, y*	46	45	1.52 (−0.40 to 3.44)	53	52	0.24 (−3.41 to 3.89)
Female sex	392 (63)	347 (63)	1.00 (0.90 to 1.12)	101 (55)	78 (53)	0.95 (0.78 to 1.16)
Emergency Severity Index score						
2	100 (16)	98 (18)	1 [Reference]	53 (29)	36 (25)	1 [Reference]
3	437 (72)	385 (72)	1.05 (0.90 to 1.23)	111 (62)	98 (67)	0.89 (0.72 to 1.10)
4–5	71 (12)	68 (10)	0.90 (0.74 to 1.10)	18 (9)	14 (8)	1.06 (0.75 to 1.50)
Mean body mass index, kg/m^2*	29.33	28.87	0.46 (−0.47 to 1.38)	29.40	28.95	0.45 (−1.36 to 2.26)
Presence of comorbidities	275 (44)	203 (37)	1.15 (1.03 to 1.28)†	111 (61)	80 (54)	1.13 (0.92 to 1.38)
Previous ultrasonographically guided IV insertion	151 (24)	60 (11)	1.46 (1.32 to 1.63)†	63 (35)	27 (18)	1.41 (1.17 to 1.70)†
Admitted to hospital	182 (29)	153 (28)	1.03 (0.92 to 1.16)	182 (100)	148 (100)	1.03 (0.92 to 1.16)
Difficulty of IV access						
Easy	263 (42)	323 (59)	1 [Reference]	50 (27)	82 (56)	1 [Reference]
Moderately difficult	210 (34)	179 (32)	1.20 (1.06 to 1.37)†	65 (36)	42 (28)	1.60 (1.23 to 2.09)†
Difficult	150 (24)	49 (9)	1.68 (1.49 to 1.89)†	67 (37)	24 (16)	1.94 (1.51 to 2.50)†
Needle length, in‡						
Standard (1 1/4)	326 (52)	518 (94)	1 [Reference]	67 (37)	139 (94)	1 [Reference]
Long (1 7/8)	248 (40)	4 (1)	0.03 (0.01 to 0.07)†	97 (53)	0 (0)	3.07 (2.53 to 3.74)†
Missing	49 (8)	29 (5)	1.53 (1.24 to 1.89)†	18 (10)	9 (6)	2.05 (1.47 to 2.86)†
Needle gauge‡						
18	158 (25)	64 (12)	1 [Reference]	58 (32)	24 (16)	1 [Reference]
20–22	416 (67)	458 (83)	0.67 (0.60 to 0.75)†	106 (58)	115 (78)	0.68 (0.56 to 0.82)†
Missing	49 (8)	29 (5)	0.88 (0.73 to 1.07)	18 (10)	9 (6)	0.94 (0.70 to 1.27)
Vein used‡						
Antecubital	398 (64)	423 (77)	1 [Reference]	89 (49)	108 (73)	1 [Reference]
Above elbow	67 (11)	6 (1)	1.89 (1.72 to 2.09)†	33 (18)	1 (1)	2.15 (1.82 to 2.53)†
Forearm	109 (17)	94 (17)	1.11 (0.96 to 1.28)	42 (23)	30 (20)	1.29 (1.01 to 1.66)†
Missing	49 (8)	28 (5)	1.31 (1.09 to 1.58)†	18 (10)	9 (6)	1.48 (1.08 to 2.01)†
>1 attempt	121 (19)	91 (17)	1.09 (0.96 to 1.25)	49 (27)	22 (15)	1.34 (1.11 to 1.63)†

The reference group is in parentheses for categoric variables.
*The estimate is statistically significant because the 95% CI does not include 1 for the relative risk ratio or it does not include 0 for mean difference for a continuous predictor.
†Mean difference and 95% CI of the difference.
‡We did not collect detailed catheter information on final catheter insertions that were not randomized. Thus, there were 76 subjects for whom we did not record needle length, needle gauge, or vein used.

peripheral catheter in our ED. Our electronic medical record does not reliably capture all catheters inserted by providers during the ED visit, so we were unable to compare the entire population of patients who received a catheter with the study sample. Our findings cannot be extended to patients with Emergency Severity Index scores 1 and 2. The exclusion of the highest-acuity patients may have led to an underestimate of the percentage of peripheral intravenous catheters that are used for various purposes. However, it is also true that once a catheter is inserted, it can influence the decision to use it, which may have biased our estimate toward higher use rates. We measured the types of catheter use but not how many different times a catheter was used.

Third, our analysis of premature removal was constrained by the lack of variation among some of the clinical factors by insertion method, which precluded our ability to evaluate the influence of these factors on catheter survivorship. It is also possible that premature removal is more frequent with the ultrasonographically guided or

Table 2. Peripheral intravenous catheter use of total sample by insertion method.

	Total, N=1,174	Ultrasonographically Guided, N=623	Landmark, N=551	Relative Risk (95% CI)
Catheter use in ED				
Catheter used in ED	1,123 (96)	591 (95)	532 (97)	0.84 (0.67–1.04)
Purposes of catheter use in ED*				
Blood drawing	1,049 (90)	563 (90)	486 (89)	1.10 (0.91–1.33)
Medications	633 (54)	346 (55)	287 (45)	1.06 (0.95–1.19)
Continuous solutions	485 (41)	258 (53)	227 (47)	1.00 (0.90–1.12)
Contrast agents	199 (17)	108 (17)	91 (17)	1.03 (0.89–1.18)
Catheter used only for blood drawing	313 (27)	159 (26)	154 (28)	0.94 (0.83–1.07)
No. of types of catheter use				
0	51 (4)	32 (5)	19 (4)	1 [Reference]
1	352 (30)	173 (28)	179 (32)	0.78 (0.62–1.00)
2	367 (31)	190 (31)	177 (32)	1.29 (0.89–1.88)
3	334 (29)	190 (30)	144 (26)	0.91 (0.72–1.14)
4	70 (6)	38 (6)	32 (6)	0.87 (0.64–1.17)
ED-inserted catheter use in hospital	**Total, N=330**	**Ultrasonographically guided, N=182**	**Landmark, N=148**	
Catheter used in hospital	318 (96)	178 (98)	140 (95)	1.68 (0.75–3.76)
Purposes of catheter use in hospital*				
Continuous solutions	120 (36)	65 (36)	55 (37)	0.97 (0.79–1.19)
Medications	219 (66)	116 (64)	103 (70)	1.16 (0.89–1.51)
Blood drawing	308 (93)	173 (95)	135 (91)	1.37 (0.82–2.29)
Contrast agents	30 (9)	21 (12)	9 (6)	1.30 (1.00–1.69)
Catheter used only for blood drawing	73 (22)	43 (24)	30 (20)	1.09 (0.87–1.36)
No. of types of catheter use				
0	12 (4)	4 (2)	8 (5)	1 [Reference]
1	79 (24)	47 (26)	32 (22)	1.78 (0.79–4.05)
2	136 (41)	76 (42)	60 (41)	1.68 (0.74–3.78)
3	86 (26)	44 (24)	42 (28)	1.53 (0.67–3.51)
4	17 (5)	11 (6)	6 (4)	1.94 (0.81–4.65)

*Does not add to 100% because catheters were used for more than one purpose.

landmark method, but the difference is smaller than we were able to detect (<15%) with our sample size.

DISCUSSION

We examined the use and 72-hour survivorship of peripheral intravenous catheters inserted in the ED with a landmark or ultrasonographically guided approach. We found that the ED-inserted catheters were used frequently in the ED and hospital and commonly for more than one purpose. One quarter of the ED-inserted catheters were prematurely removed during the first 72 hours of hospital admission, most often because they were painful or stopped working. The only factor associated with premature removal was the number of purposes of catheter use in the hospital.

In our study, less than 5% of inserted catheters were never used, and 27% of catheters were used for blood drawing alone. Approximately three quarters of catheters in the ED were used for administration of fluids, medications, and contrast agents. Past studies have reported that between 46% and 85% of peripheral intravenous catheters are used during the ED visit.[3-6] The variation in the use of peripheral catheters is likely due to a variety of reasons. Henderson et al[3] reported that 46% of catheters were used, but they measured only medications and fluids, not contrast agents. Vandenbos et al[6] reported that 66% of catheters were used, but this was based on appropriate use

Table 3. Unadjusted relationship of patient and catheter characteristics to premature peripheral intravenous catheter removal status among admitted patients (N=330).

	Prematurely Removed		
	Yes, N=81	**No, N=249**	**Relative Risk (95% CI)**
Patient characteristics			
Mean age, y	51	53	−1.77 (−5.98 to 2.44)
Female sex (male sex)	43 (53)	136 (55)	0.95 (0.65 to 1.39)
Body mass index, kg/m^2			
<18.5–24.9 (underweight to normal weight)	37 (46)	81 (33)	1 [Reference]
25–29.9 (overweight)	16 (20)	68 (27)	0.61 (0.36 to 1.12)
≥30 (obese)	28 (35)	100 (40)	0.69 (0.46 to 1.06)
Presence of a comorbidity (none)	49 (60)	142 (57)	1.11 (0.75 to 1.63)
Difficulty of IV access			
Easy	32 (39)	100 (40)	1 [Reference]
Moderately difficult	21 (26)	86 (35)	0.81 (0.50 to 1.32)
Difficult	28 (35)	63 (25)	1.27 (0.82 to 1.95)
Catheter characteristics			
Inserted by ultrasonography	50 (62)	132 (53)	1.31 (0.89 to 1.94)
Inserted by LM	31 (38)	117 (47)	1 [Reference]
Long needle length (standard)*	28 (37)	69 (30)	1.27 (0.85 to 1.89)
20/22 needle gauge (18 gauge)*	54 (72)	167 (73)	0.95 (0.62 to 1.48)
Location of vein used			
Forearm	20 (25)	52 (21)	1 [Reference]
Antecubital	49 (61)	148 (60)	0.90 (0.57 to 1.40)
Above elbow	6 (7)	28 (11)	0.64 (0.28 to 1.44)
Contrast agent used in ED	18 (22)	43 (17)	1.26 (0.81 to 1.96)
Mean No. of different types of uses in ED	1.99	2.00	−0.02 (−0.29 to 0.26)
Mean No. of different types of uses in hospital	2.35	1.96	0.39 (0.16 to 0.62)†
Day of catheter removal			
1	39 (48)	46 (18)	1 [Reference]
2	29 (36)	106 (43)	0.47 (0.31 to 0.70)
3	13 (16)	41 (16)	0.52 (0.31 to 0.89)†
Still remaining	0 (0)	56 (23)	0.02 (0.00 to 0.30)†
Reason for removal before 72 h			
Catheter still in place	0 (0)	68 (27)	NA
Infiltration	24 (30)	5 (2)	
Infection	0 (0)	0 (0)	
Fell out and replaced	14 (17)	0 (0)	
Uncomfortable/not working and replaced	41 (51)	0 (0)	
Unknown, but catheter replaced	2 (2)	0 (0)	
Patient discharged	0 (0)	172 (69)	
No longer needed	0 (0)	4 (2)	

NA, Not applicable.
The reference group is in parentheses for categoric variables.
*Catheter information not collected on subjects with greater than 2 insertion attempts (N=27).
†The estimate is statistically significant because the 95% CI does not include 1 for the relative risk ratio or it does not include 0 for mean difference for a continuous predictor.

Table 4. Results of multivariate generalized estimating equation model of premature removal by patient and clinical characteristics among admitted subjects.

Characteristic	Relative Risk (95% CI), N=329*
Age (continuous)	0.99 (0.98–1.01)
Male sex (female sex)	0.96 (0.61–1.50)
Body mass index (continuous)	0.99 (0.96–1.02)
Presence of comorbidities (no)*	1.20 (0.82–1.76)
Ultrasonographically guided catheter insertion (landmark)	1.26 (0.88–1.80)
Contrast agent used in ED (no)	1.31 (0.96–1.79)
No. of IV use types in hospital (ordinal)	1.36 (1.16–1.58)†

The reference group is in parentheses.
*Missing data on one subject.
†The estimate is statistically significant because the 95% CI does not include 1 for the relative risk ratio.

of peripheral intravenous catheters rather than any use. Finally, Limm et al[5] reported that 50% of catheters were used in the ED, according to a review of peripheral intravenous catheters documented in the electronic medical record. This did not include the use of intravenous lines solely to obtain blood samples for analysis, and so their overall rate of 50% of intravenous lines' being used for drug administration and intravenous fluids may be similar to our findings of 66% of intravenous lines' being used for drug administration and intravenous fluids in the ED. Identification of the catheters through the electronic medical record may have led to selection bias because only 15% of their patients had a catheter inserted in the ED according to the electronic medical record.

All of the studies mentioned above did not include blood drawing as a purpose of peripheral intravenous

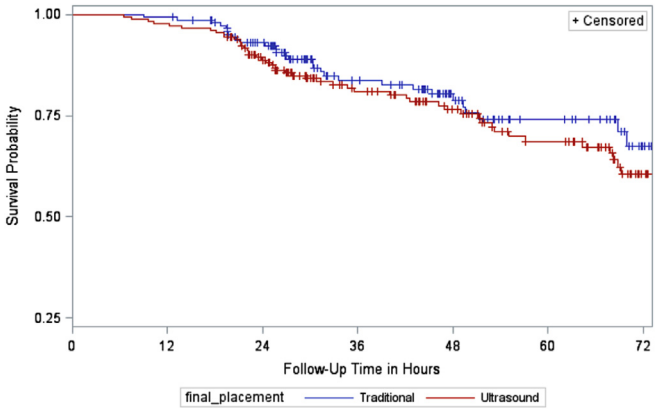

Figure 2. Peripheral catheter survival time in the hospital by insertion method (P=.44, no significant difference in the survival rates by the insertion method).

catheter insertion. However, it is common practice for ED providers to place a catheter in patients when a blood sample is needed to avoid a second needle puncture if subsequent intravenous treatment is anticipated. In our study, 27% of the ED-inserted catheters were used only for blood drawing in our ED. A chart review study of ED-inserted catheters in an Australian ED reported that only 18% of peripheral intravenous catheters were used for a blood drawing.[20] In both studies, the majority of the catheters (>65%) were used for 2 or more purposes.

Among the patients in our study who were admitted, the ED-inserted catheters continued to be used in the hospital for blood drawing and the administration of medications and fluids. Vandenbos et al[6] also found that a high percentage of ED-inserted catheters (80%) was used during the hospital stay. In contrast, among a small sample of ED patients whose catheters were not used in an Australian ED and who were admitted (N=62), 56% of catheters were subsequently used in the hospital.[5]

The premature removal rate of our ED-inserted catheters (25%) is consistent with that of other follow-up studies of ED-inserted catheters (32% to 44%),[9,10] as well as hospital-inserted catheters (30% to 35%).[21,22] The 2 studies that reported survivorship of ED-inserted catheters[9,10] were based on ED patients with difficult intravenous access who had their catheters inserted with an ultrasonographically guided approach. In contrast, the follow-up of peripheral intravenous catheters inserted in the hospital relied on catheters placed with a traditional landmark approach.[21,22] To our knowledge, our study is the first to include both insertion methods. In our heterogeneous sample of patients with various difficulty of intravenous access, we did not find a large difference in catheter survivorship in the first 72 hours of hospitalization between catheters placed by the landmark technique and those placed by ultrasonographic guidance. Given that the ultrasonographically guided catheters were successfully inserted more frequently in patients with difficult intravenous access, our results suggest that insertion method does not influence catheter survivorship.

Relatively few factors were associated with premature catheter removal in our study sample. As did Marsh et al,[21] we found that the more frequently the peripheral intravenous catheter was used in the hospital, the greater the odds it would fail.

In conclusion, peripheral intravenous catheters inserted in the ED are frequently used for multiple diagnostic and treatment applications in the ED and the hospital. In a cohort of ED patients with various levels of difficulty of intravenous access, there were no large differences observed in the survivorship of peripheral intravenous catheters

inserted with a landmark or ultrasonographically guided approach during the first 72 hours of hospital admission.

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