Original Contribution

Standard-length catheters vs long catheters in ultrasound-guided peripheral vein cannulation

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Abstract

Purpose: Ultrasound (US) is a useful tool for peripheral vein cannulation in patients with difficult venous access. However, few data about the survival of US-guided peripheral catheters in acute care setting exist. Some studies showed that the survival rate of standard-length catheters (SC) is poor especially in obese patients. The use of longer than normal catheters could provide a solution to low survival rate. The aim of the present study was to compare US-guided peripheral SCs vs US-guided peripheral long catheters inserted with Seldinger technique (LC) in acute hospitalized patients with difficult venous access.

Methods: This was a prospective, randomized controlled trial. A total of 100 consecutively admitted subjects in an urban High Dependency Unit were randomized to obtain US-guided intravenous access using either SC or LC after 3 failed blind attempts. Primary outcome was catheter failure rate.

Results: Success rate was 86% in the SC groups and 84% in the LC group (P = .77). Time requested to positioning venous access resulted to be shorter for SC as opposed to LC (9.5 vs 16.8 minutes, respectively; P = .001). Catheter failure was observed in 45% of patients in the SC group and in 14% of patients in the LC group (relative risk, 3.2; P < .001).

Conclusions: Both SC and LC US-guided cannulations have a high success rate in patients with difficult venous access. Notwithstanding a higher time to cannulation, LC US-guided procedure is associated with a lower risk of catheter failure compared with SC US-guided procedure.

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1. Introduction

Peripheral venous cannulation is a common procedure in hospitalized patients, but approximately 20% of intravenous insertions are unsuccessful [1]. Variables influencing catheter insertion failure are obesity, intravenous drug abuse (IVDA), chronic medical conditions, and hospital length of stay. Central line placement is a frequently used alternative in patients lacking accessible peripheral venous

sites. However, central line is associated with several short-term and long-term complications [2]. Avoiding central line placement and removing central line that is no longer essential reduce the bloodstream infection risk [3].

Ultrasound (US) may be useful for peripheral vein cannulation in patients with difficult venous access, allowing to identify peripheral vessels and guide the procedure. Ultrasound-guided peripheral vein cannulation is successful in more than 90% of cases [4]. Compared with blind technique, US-guided technique showed a higher success rate [5]. Furthermore, US guidance reduces time to cannulation and improves patient satisfaction with fewer skin punctures

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and fewer immediate complications [6]. Perceived difficulty of emergency nurse significantly decreased [7].

Despite the fact that US-guided cannulation seems to be an effective alternative to central line placement, few data about the survival of US-guided peripheral catheters in acute care setting exist. Standard-length (3-5 cm) catheters positioned in deep brachial or basilic vein are frequently complicated by infiltration or dislodgment. Keyes et al [4] observed that peripheral line was infiltrated or fell out within 1 hour of cannulation in 8% of patients. In a recent study, the authors found out that the survival rate of intravenous catheters after 96 hours was only 56%, with a median survival rate of 26 hours [8]. Use of longer than normal catheters may provide a solution to high failure rate. Ultrasound-guided insertion of a 15-cm catheter appeared fast, safe, and well tolerated [9]. Evidence on effectiveness of different-length US-guided peripheral catheters for patients with difficult venous access in acute care setting is lacking.

The aim of the present study was to compare US-guided peripheral standard-length catheters (SC) vs US-guided peripheral long catheters inserted with Seldinger technique (LC) in acute hospitalized patients with difficult venous access, with particular regard to failure rate (primary end point).

2. Methods

2.1. Study design

This was a prospective, randomized study. The institutional review board approved the study protocol, and patients gave informed consent before entering the study.

2.2. Study setting and population

The study was conducted in the High Dependency Unit of San Giovanni Bosco Hospital, Torino, Italy. Our center treats patients coming from emergency department, medical ward, surgical ward, and intensive care unit, requiring monitoring and subintensive care.

Inclusion criterion was failure of 3 peripheral intravenous attempts through standard blind insertion techniques in subjects missing of peripheral access, subjects with non-functioning peripheral access, or subjects with unnecessary central venous access. Exclusion criterion was the need for central venous access. The need for removal or insertion of central venous access was defined by the treating physician.

The procedures were performed by nurses, attending physicians, or resident physicians. All the operators received a suitable training on US-guided vein cannulation.

2.3. Study protocol

A commercially available US machine (Philips-ATL, HDI 1500; Philips Medical Systems, Solingen, Germany) with 10.5-MHz linear array probe was used.

After randomization and informed consent, each patient arm was examined to locate basilic, brachial, and cephalic veins and check for compressibility. The vessel and arm selection for cannulation was left at the discretion of the operators performing the procedure in consideration of anatomical criteria (venous diameter and depth). Each procedure was performed with a 2-operator technique. The first operator held the probe in place, whereas the second operator performed the cannulation. A short-axis approach was used, with the probe centered on the target vessel and the needle directed under dynamic guidance into the target lumen.

Cannulation of SC was performed using a 20-gauge intravenous catheter, 5 cm in length (Optiva; Medex Medical Ltd, Rossendale, UK). Cannulation of LC was performed using a 20-gauge guidewire catheter, 12 cm in length, inserted with Seldinger technique (Arrow International, Reading, PA). For both techniques, a tourniquet was placed on the patient's arm and removed after vessel puncture. In SC cannulation, the skin was prepared with 2% chlorhexidine, and the operators used nonsterile gloves. In LC cannulation, the procedure was performed with aseptic technique including sterile gloves, sterile probe dressing, and sterile sheet and was preceded by anesthesia with 1% lidocaine.

For both procedures, success was confirmed by both aspirating the blood after catheter positioning and sonographic catheter visualization into the vessel using a long-axis approach. Three attempts (defined as percutaneous sticks) were accepted. A 8.5×11.5-cm sterile, transparent, semipermeable dressing (Tegaderm, 3M, St Paul, MN) was placed to secure the line. Using 2-0 silk suture, LCs were fixed to the skin.

The catheters were flushed with 0.9% 10 mL sodium chloride twice a day, unless continuous infusion. The percutaneous entry sites were examined for the presence of dislocation, infiltration, or phlebitis and were cared for twice a day by nurse personnel. Catheters were removed when they were no longer essential, in the presence of accidental dislocation, and when signs of infiltration, phlebitis, or occlusion appeared. Compressive US examination was performed to evaluate vessel patency before catheter removal.

Patient's age, sex, body mass index, admitting diagnosis, risk factors for difficult venous access, and hospital division from which the patient came from were recorded. For each procedure, the time to cannulation (between skin preparation and blood aspiration from catheter) and the number of percutaneous sticks were recorded.

2.4. Outcome measures

Primary end point was catheter failure rate.

Secondary end points were successful cannulation, time to cannulation, number of percutaneous sticks, occlusion and/or thrombophlebitis rate, dislocation and/or infiltration rate, and thrombosis rate.

2.5. Data analysis

Data were analyzed using Epiinfo statistical software (Centers for Disease Control and Prevention, Atlanta, GA) and R version 2.11.1 (R Development Core Team: http://www.R-project.org).

Results in the 2 groups were evaluated using 2-tailed χ^2 test, unpaired Student t test, or Fisher exact test, when appropriate. Comparisons of median values were made using the Mann-Whitney test.

A priori power analysis, based on a previous retrospective analysis of our patients, showed that a sample size of 80 patients would allow detecting a 30% difference in catheter survival rate between the 2 groups, with a 80% power at the 5% 2-sided level of significance.

Catheter failure was assessed by means of a survival mode with univariate analysis using Kaplan-Meier methods to describe catheter survival over time.

A 2-tailed level of significance $P = .05$ was considered significant for all comparisons.

3. Results

A total of 100 consecutive patients with difficult venous access according to inclusion criteria were enrolled from May 2009 to March 2010. In this time, 612 patients were admitted to our center. Rate of subjects with difficult venous access was 16.3%. No patient refused to participate in the study.

Patient characteristics are similar for both the groups except for obesity rate (Table 1).

The basilic vein was cannulated in 79% of patients, the brachial vein in 14% of patients, and the cephalic vein in 7% of patients. Right arm was preferred in 55% of cases.

Success rate was 86% in the SC groups and 84% in the LC group ($P = .77$; Table 2). Time requested to positioning venous access was shorter in SC as opposed to LC (9.5 vs 16.8 minutes, respectively; $P = .001$; Fig. 1).

Table 1 Subject characteristics by group

	SC	LC	
Sex			
Male	23 (46%)	23 (46%)	P = NS
Female	27 (54%)	27 (54%)	P = NS
Age (y), mean (±SD)	67.7 (±15.8)	70.3 (±12.9)	P = NS
Reason for difficulty			
Obesity	16 (32%)	21 (42%)	P = .03
IVDA	2 (4%)	1 (2%)	P = NS
Anasarca	9 (18%)	7 (14%)	P = NS
Hospital provenience			
ED	24 (48%)	30 (60%)	P = NS
ICU	13 (26%)	8 (16%)	P = NS
Medical ward	10 (20%)	7 (14%)	P = NS
Surgical ward	3 (6%)	5 (10%)	P = NS

ED indicates emergency department; ICU, intensive care unit; NS, not significant.

Table 2 US-guided peripheral vein cannulation procedure data, by group

	SC	LC	
Overall success	42/50 (84%)	43/50 (86%)	$P = .77$
Total time (min), mean (±SD)	9.5 (±8.9)	16.8 (±11.1)	$P < .001$
No. of percutaneous sticks, mean (±SD)	1.9 (±1.11)	2.2 (±1.4)	$P = .17$
Catheter survival (d)			$P = .002$
Mean (±SD)	3.5 (±4.23)	6.19 (±5.1)	
Median (range)	3.5 (1-5.5)	5 (2-7.5)	
Catheter failure	18 (45%)	6 (14%)	RR, 3.2 (95% CI, 1.4-7.3) $P < .001$
Dislocation and/or infiltration	17 (42.5%)	1 (2.3%)	RR, 18.7 (95% CI, 2.0-134.2) $P < .0001$
Occlusion and/or thrombophlebitis	1 (2.5%)	5 (11.4%)	RR, 0.22 (95% CI, 0.02-1.8) $P = .12$
Thrombosis	5 (12.5%)	9 (20.9%)	RR, 0.59 (95% CI, 0.2-1.6) $P = .30$
Thrombosis (no./1000 catheter-days)	29.9/1000	34.6/1000	

CI indicates confidence interval.

No difference in percutaneous sticks numbers was observed in the SC group compared with the LC group (1.9 vs 2.2, $P = .17$). Catheter failure was observed in 45% of patients in the SC group and in 14% of patients in the LC group (relative risk [RR], 3.2; $P < .001$). Fig. 2 shows Kaplan-Meier survival curves for both groups. Complications rate with regard to catheter failure, dislocation/ infiltration, occlusion, and thrombosis are summarized in Table 2. No clinical embolic events were recorded among the patients with catheter thrombosis.

4. Discussion

Ultrasound is a useful tool for peripheral vein cannulation in patients with difficult venous access. However, SC cannulation may be associated with a high premature failure due to dislocation, especially in obese patients and subjects with diffuse edema. The use of long catheters placed with Seldinger technique could reduce the displacement risk and, more generally, the catheter failure risk. In this study, we have compared SC with longer catheters inserted with Seldinger technique to evaluate the failure risk.

In our population, difficult venous access rate was similar to that seen in other studies. Jacobson and Winslow [1] find out that approximately one fourth of the intravenous
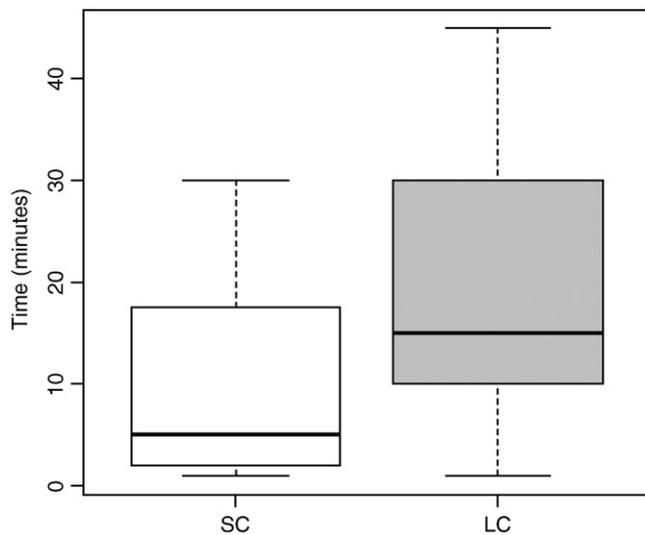
Fig. 1 Box plot of time required to catheter positioning. The central line represents the median value, the box boundaries represent the 25th and 75th percentiles, and the whiskers represent the minimum and the maximum values. Procedure time was significantly shorter in patients randomized to SC ($P = .001$).

insertions in hospitalized patients were unsuccessful. In our study, difficult venous access rate was 16.3%. Obesity, history of IVDA, and chronic medical conditions are known risk factors. In our population, more than half of patients were obese or diffusely edematous. Patients were enrolled consecutively limiting selection bias.

Basilic vein was the chosen vein in most of patients. Cephalic and brachial veins were cannulated only in 21% of patients. In effect, basilic vein offers some advantages
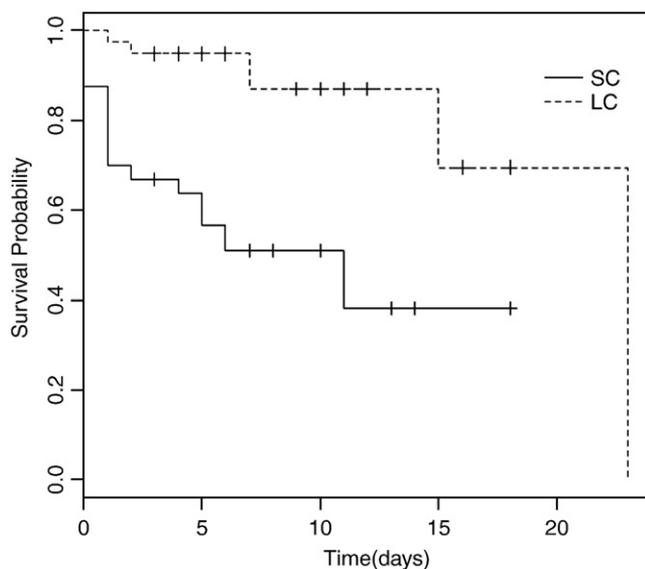

Fig. 2 Kaplan-Meier survival probability comparing patients with SC to those who received LC. The curves are significantly different (log-rank test; $P = .000165$).

compared with the other arm veins. Basilic vein shows a larger diameter compared with cephalic vein and a larger distance from arterial and nervous structures compared with brachial vein. For these reasons, the procedure could be more successful and the complications could be fewer. In a single study, basilic vein appeared to have higher success rate than the other veins [10].

A 2-operator technique was used for vein cannulation. We think that 2-operator technique is easier to learn than 1-operator technique, although a single study showed no differences in success rate between the 2 techniques [11]. A short-axis approach was chosen for ultrasonographic guidance. In a prospective randomized study, short axis was faster than long axis in obtaining vascular access [12]. Procedures were performed by experienced and inexperienced operators. Inexperienced operators underwent suitable training consistent of theoretical and practical teaching, and an experienced operator was always present for any procedure.

Seldinger technique for US-guided peripheral cannulation has been previously used [13,14]. Different approaches with a modified Seldinger technique were recently proposed. Mills and coworkers [9] used a 15-cm catheter inserted over a guide placed through a standard-length catheter. Mahler et al [15] used a 20-gauge catheter with integral wire. For both approaches, the modified Seldinger technique was safe and successful. In the present study, a 20-gauge, 12-cm catheter was placed with traditional Seldinger technique. Because we have considered this technique mostly invasive, sterile approach was preferred to nonsterile approach.

Success rate of the procedure was high for both the catheters, without significant differences. Success rate in this study appears comparable with the success rate in previous studies. Bauman et al [6], Stein et al [16], Costantino et al [5], and Keyes et al [4], recorded a success rate of 80%, 86%, 97%, and 91%, respectively. Cannulation of SC was faster and required fewer percutaneous sticks and needle redirections.

The catheter failure rate was significantly higher for SC than LC, supporting the hypothesis of our study. Regarding catheter failure reasons, SC appears to have a higher rate of infiltration and dislocation, whereas occlusion and thrombophlebitis rate was similar for both groups. Our conclusions were similar to those of another study. Dargin et al [8] showed that 47% of US-guided 6.35-cm length catheters failed within 24 hours and that infiltration, followed by dislocation, was the most common cause.

In our study, main survival was 3.5 days for SC and 6.19 days for LC. Despite the suggestion of Centers for Disease Control and Prevention guidelines that catheter removal should be performed within 96 hours from positioning, we have chosen to leave in place the catheters beyond this time till complications appeared or till the catheters were no longer essential [17]. In fact, for patients with difficult venous access, the same guidelines suggest the catheter be used for longer period, although the patient and the insertion sites should be closely monitored.

Finally, the presence of thrombosis was evaluated with compressive US before catheter removal. We observed a similar thrombosis rate for both groups, 12.9 % in SC group and 20% in LC group. Most cases of thrombosis were pericatheter; only 6 of 14 thrombotic events resulted in catheter occlusion, and no embolic events were recorded.

5. Limitations

Our study is subject to a number of limitations. First, we did not record vein depth and diameter. Both the measures are related to the procedure's success rate. Panebianco et al [18] observed that increasing vessel diameter was associated with a higher likelihood of success and that beyond a threshold depth of 16 mm, there was no successful cannulation with SCs. Furthermore, procedures were performed by experienced and inexperienced operators entailing hypothetical provider-related differences. Despite the presence of inexperienced operators, success rate was high. However, the relation between sonographic experience and success rate was not evaluated.

Infectious risk was not considered in our study. Peripheral venous catheter bloodstream infection rate appears to be low, although studies focusing specifically on this feature are lacking [19,20]. A single study compared peripheral intravenous lines placed under US guidance with traditionally placed intravenous lines. No differences have been shown between these approaches [21].

6. Conclusion

Both SC and LC US-guided cannulations have a high success rate in patients with difficult venous access. Notwithstanding a higher time to cannulation, LC US-guided procedure is associated with a lower risk of catheter failure compared with SC US-guided procedure. Future investigations are warranted to assess thrombotic and infectious risks for both approaches.

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