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Brief Report

EVALUATION OF CENTRAL VENOUS ACCESS WITH ACCELERATED SELDINGER TECHNIQUE VERSUS MODIFIED SELDINGER TECHNIQUE

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☐ **Abstract—Background: Central vein catheter (CVC) placement using the modified Seldinger technique is a common procedure in the emergency department, but can be time consuming due to the multiple pieces of equipment included in central line kits and the number of steps in the procedure. Preassembled devices combine a needle, guidewire, dilator, and sheath into one unit and potentially simplify the process and reduce time required for CVC placement using the accelerated Seldinger technique. Objective: Our aim was to evaluate whether the use of combination central line devices and the accelerated Seldinger technique will reduce the time required to place a CVC and increase the ease of the procedure. Methods: This two-arm randomized crossover study comparing the accelerated Seldinger technique to the modified Seldinger technique was performed in a simulation setting. Subjects were selected from among emergency physicians, emergency medicine residents, interns, physician assistants, and medical students. Subjects were timed using the modified and accelerated Seldinger techniques. Ease of use and satisfaction data were collected after both procedures. Results: The use of the accelerated Seldinger technique with a combination CVC device was significantly faster compared to the modified Seldinger technique with a standard CVC kit. Procedure time was reduced by 35% ($p = 0.001$), and ease of use was increased by 7% ($p = 0.046$), without any increase in errors. Conclusions: In the simulated setting, the accelerated Seldinger technique using combination CVC devices is a faster and easier method for CVC placement compared to the modified Seldinger technique. Published by Elsevier Inc.**

☐ **Keywords—vascular access; Seldinger technique; resuscitation; central venous catheter; central venous lines; fluid resuscitation; modified Seldinger technique; accelerated Seldinger technique**

Conflict of Interest: The expired POWERWAND™ combination device kits were donated by Access Scientific for the express purpose to be used in this study; however, no other contributions were made. We approached Access Scientific to obtain the devices to conduct this study. Access Scientific did not participate in the study design, data collection or interpretation in any way. Access Scientific did not have control of whether this study was published. The authors have no financial relationship with Access Scientific.

INTRODUCTION

Central venous access is a common procedure, with some estimates of 8% of hospitalized patients requiring the procedure during their hospital stay. Conservative estimates state that more than 5 million central venous catheters (CVCs) are inserted in the United States each year. Central venous access is often needed for emergency interventions, such as large-volume fluid or blood product resuscitation, administration of central-acting medications or multiple medications simultaneously, and transvenous pacing. In addition to being a potentially time-consuming procedure, there are risks of mechanical

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complications for the patient during CVC placement, such as arterial puncture, pneumothorax, cardiac tamponade, nerve injury, thrombosis, and septic complications. There are also risks to the provider, such as needlestick and body fluid exposure (1,2).

The majority of catheters placed in the emergency department use the modified Seldinger technique (MST), which uses ultrasound guidance to reduce the risk of complications and reduces time to venous cannulation. Ultrasound use also assists with early detection of arterial and venous guidewire malposition (3,4).

The steps for MST include infiltrating the skin with local anesthetic and cannulating the vein (needle or angiocatheter) under ultrasound guidance. The guidewire is then inserted into the vein through the access needle or angiocatheter, with removal of the needle or angiocatheter while controlling the guidewire. A small stab incision in the skin adjacent to the guidewire allows advancement of the dilator over the guidewire into the vein. The catheter is then threaded over the guidewire, and the guidewire is removed. Blood is sequentially aspirated from each access hub and flushed with saline to ensure each catheter functions. Lastly, the catheter is sutured into place and the site-dressed using a sterile technique.

Preassembled devices combine a needle, guidewire, dilator, and sheath into one unit and have the potential to simplify the process and reduce the risks involved with CVC placement by using the accelerated Seldinger technique (AST) (5). With the use of the combination devices, the AST involves fewer steps compared to the MST. The device needle is inserted into the target vein under ultrasound guidance and a flash is observed, the internal guidewire is then advanced into the vein and snapped into the needle hub. Afterwards, the dilator collar is turned one-quarter turn and the dilator and sheath are advanced, locking the needle hub and simultaneously sheathing the needle tip. The dilator hub is disengaged from the needle hub, and the guidewire, dilator, and needle are all removed as a single unit. Afterwards, an appropriate catheter can be placed through the sheath via wire exchange and the sheath removed (6).

Clinical outcomes and patient satisfaction using the AST have been studied in peripheral intravenous (PIV) therapy and suggest that this type of catheter insertion may have benefit for extended PIV therapy (7). However, there is scarce literature available comparing the AST to the current MST in central venous access. Additionally, no studies have investigated this technique for specific use in the emergency department.

The aim of this study was to determine whether use of combination devices and the AST will reduce CVC placement time. A secondary aim was to determine if, by simplifying the procedure, the user's comfort and confidence in CVC placement were increased. We hypothesized that the utilization of the AST significantly decreases time to central line procedure completion, as well as increases the ease of the procedure and user satisfaction when compared to the MST.

METHODS

Study Design

We completed a two-arm randomized crossover study comparing the AST to the MST in a simulation setting. The Institutional Review Board approved the study, and all subjects provided written informed consent.

Setting and Subjects

We conducted the study in a simulated patient room with standardized surroundings and visible equipment (Figure 1). Thirty-five test subjects were recruited from among emergency medicine residents, interns, and staff, as well as emergency medicine physician assistants, residents, and medical students (Table 1).

All subjects had experience placing CVCs using the MST, and all subjects underwent standardized training on both the MST and the AST for approximately 10 min until comfortable with both techniques and devices.

Materials

This study used the POWERWAND™ (Access Scientific, San Diego, CA) 5-French 8-cm catheter kits (preassembled combination CVC) (Figure 2), ARROW® (Teleflex, Wayne, PA) 6-French 10-cm single-lumen percutaneous sheath introducer kit (large-bore, single-lumen CVC), CentraLineMan® (Simulab, Seattle, WA) (torso mannequin with right internal jugular access), and the SonoSite Edge II Ultrasound (FujiFilm Sonosite, Bothell, WA).

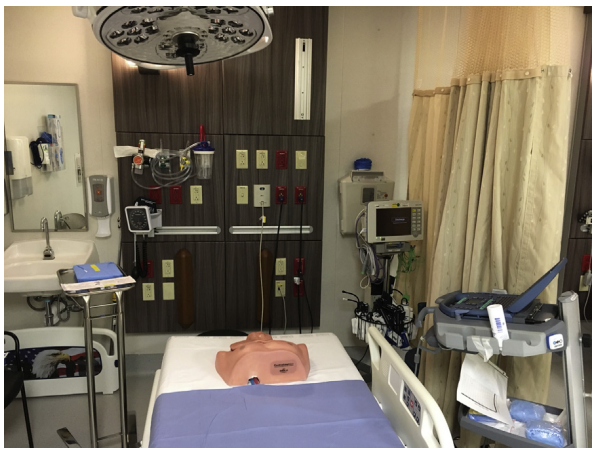

Figure 1. Photograph of the study setting.

Table 1. Characteristics of Subjects

Characteristics	Data
Sex, n	
Male	25
Female	10
Age, y	
Median	29
Mean	30.7
Level of training, n	
Resident, PGY1	13
Resident, PGY2	5
Resident, PGY3	9
Physician assistant	6
Medical student	1
Staff/attending	1
Central lines performed, n	
0–10 Performed	19
10–20 Performed	4
20–30 Performed	7
30+ Performed	5

PGY = postgraduate year.

Study Protocol

Subjects were randomized to perform either the MST (control arm) first, followed by the AST (intervention arm), or vice versa. Subjects were blinded to the purpose of the study. All subjects had a 5-min break between performing the different procedures as a washout period. Subjects were timed while completing CVC placement on a mannequin model using both the MST and the AST. The subjects were observed for errors during the procedure by 1 of 3 research proctors who were trained on the correct use of the device.

In the control arm, subjects used an ARROW® (Teleflex) 6-French single-lumen central line kit to perform the MST on a central line simulation mannequin. Standardized instructions were given on the use of the device and steps of the MST before the simulation was conducted. In the intervention arm, subjects used a 5-French POWERWAND™ (Access Scientific) to perform the AST on the central line simulation mannequin. Standardized instructions were given on the use of the device and steps of AST before simulation was conducted. All subjects were allowed at least 5 min to familiarize themselves with both devices and were asked if they were comfortable with the devices and their use before the simulation was conducted. All other variables remained constant between the control and intervention arm. A CentraLineMan® (Simulab) mannequin was used for both the control arm and the intervention arm. Ultrasound guidance was performed with a SonoSite Edge II and linear probe (FujiFilm Sonosite).

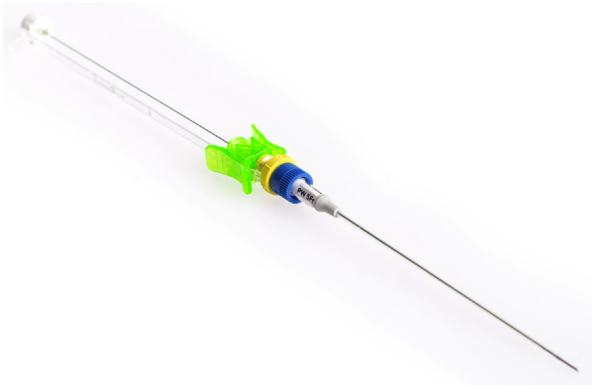

Figure 2. Photograph of the combination device used for the accelerated Seldinger technique arm.

Errors were counted during each procedure to include missed procedure steps, cannulation of the incorrect vessel, multiple attempts, and non-sterile technique (Table 2).

Errors were recorded live by an investigator proctor located next to the subject. An anonymous numbered survey was provided immediately at the end of the simulation, which included visual analog scales for ease of use of both techniques and satisfaction with each device.

Data Analysis

Data sets were compared using Wilcoxon signed rank analysis. A p value < 0.05 was used to determine statistical significance.

RESULTS

The AST was completed in significantly less time versus the MST (Table 3). Of the 35 subjects, all but 5 completed

Table 2. Distribution of Errors

MST	No. of Errors	AST	No. of Errors
Sterile technique, sterilized site per protocol	0	Sterile technique, sterilized site per protocol	0
Lidocaine anesthetic administered	4	Lidocaine anesthetic administered	2
U/S-guided technique	4	U/S-guided technique	2
Seldinger technique (needle advance until flash, wire through needle)	1	Seldinger technique (needle advance until flash, wire through needle)	1
Dilator over wire		Advance sheath/ dilator over wire	3
Catheter over wire	2	Remove dilator/ needle/wire in one device	3
Remove wire		Catheter placement	1
Flush/draw all ports	2	Flush/draw all ports	1
Correct vessel	4	Correct vessel	3
Total errors	17	Total errors	16

AST = accelerated Seldinger technique; MST = modified Seldinger technique; U/S = ultrasound.

Table 3. Statistical Results (Wilcoxon Signed-Rank Analysis)

Variable	Median		IQR		*p* Value
	AST	MST	AST	MST	
Time to completion	69	119	56	73	<0.0001
Ease of use (VAS)	74	75	13	28	0.0456
Satisfaction (VAS)	79	73	19	19	0.2603

AST = accelerated Seldinger technique; IQR = interquartile range; MST = modified Seldinger technique; VAS = visual analog scale.

the procedure faster using the AST, with a mean reduction in time of 35%. This reduction in time was seen regardless of experience level of the subjects (number of central line procedures completed before participating in the study). We also performed comparisons of each study arm for first-run bias, which was not significant ($p = 0.9$). There was no significant difference in the number of technical errors between the two groups, despite the reduction in time to complete the procedure ($p = 0.8$).

Subjects reported increase in ease of use with the AST using a combination device compared to the MST (Table 3). There was no significant difference in user satisfaction or confidence between the AST and MST techniques and associated devices (Table 3).

DISCUSSION

Placing central lines is a common procedure performed in the emergency department for the treatment of critically ill patients. Despite how often it is performed, the procedure can be time-consuming and cumbersome using the MST. Using the AST with a combination device can significantly reduce the time required to successfully place a CVC compared to the MST. This reduction in time was accomplished without increasing the number of errors made during the procedure, despite using an unfamiliar device and procedure. We believe that this is likely a result of a simplified technique that involves fewer steps and may be easier to learn for inexperienced providers. Furthermore, the combination device and AST appear to be easier to use than standard central line kits using the MST, even if the user is less familiar with the technique and device. This is not to say that the AST method is superior to the MST for those who were trained on the MST method previously, and have significant clinical experience.

Although time to and ease of access are crucial advantages of combination devices, in certain settings they may have limited utility. Gauge and length vary and can change flow rates and capabilities of these devices when compared to traditionally used central lines. Although these devices may confer faster time to access, these factors must be weighed when deciding choice of access.

The mannequins used in the study were anatomically accurate and provided a realistic scenario for application of these devices and techniques. The study did not include other external factors that could limit the true speed of the vascular access techniques, such as variation in anatomy, interruptions, assistance, and device malfunction. Other vascular access methods, such as interosseous devices, should be considered. Such devices include their own limitations and risks, and we did not include them in this study.

Limitations

The majority of subjects that participated in this study were resident physicians who had completed fewer than 30 actual central line procedures. Only one staff emergency physician participated in the study and only 14% of subjects had performed more than 30 central line procedures prior to the study. It may be that more experienced physicians who have completed more procedures with the MST may not see a decrease in procedure time or an increase in ease of the procedure when using the AST.

The use of mannequins instead of live tissue or patients in the study limits the application of the study. Multiple factors, such as interruptions and priorities of resuscitation, limit the speed to access in true scenarios and our study did not account for these factors.

The AST must be performed while using an "all in one" device and cannot be used with the traditional central line kit. Concerning function, there are limitations with the all-in-one device compared to the traditional central line. The need for multiple ports and larger bore for pacing would be reasons to choose a different method of access.

CONCLUSIONS

Central line devices that combine a needle, guidewire, dilator, and sheath into one unit, can reduce the time required to complete CVC placement using the AST compared to the MST in a simulated setting. In addition to reducing the time required for the procedure, these devices and the AST are easier to use without increasing errors compared to the MST. Future studies should compare procedure times in additional real-world (human) trials.

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ARTICLE SUMMARY

1. Why is this topic important?

Venous access is important for the care of critically ill patients. The speed and efficiency of access can greatly impact patient care.

2. What does this study attempt to show?

We aim to determine if the accelerated Seldinger technique with a combination device or modified Seldinger technique provides more timely central venous access.

3. What are the key findings?

The use of the accelerated Seldinger technique with a combination central venous catheter (CVC) device was significantly faster compared to the modified Seldinger technique with a standard CVC kit. There was no significant difference in errors between the two techniques and devices.

4. How is patient care impacted?

Quick intravenous access can be essential to the management of the critically ill. This technique and combination devices may improve speed to intravenous access.