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Original Contribution

Needle guides for venous catheter insertion during chest compressions: a crossover simulation trial☆

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ABSTRACT

Purpose: Recent guidelines for cardiopulmonary resuscitation emphasize that all rescuers should minimize the interruption of chest compressions, even for intravenous access. We assessed the utility of needle guides during ultrasound-guided central venous catheterization (US-CVC) with chest compressions via simulation.
Methods: Twenty-five anesthesiologists with more than 2 years of experience performed US-CVC on a manikin with or without a needle guide and with or without chest compressions. Insertion success rate within 2 minutes, insertion time, and subjective difficulty of venous puncture or guide wire insertion were measured.
Results: In normal trials, 1 participant failed US-CVC without compressions, whereas 6 failed with compressions ($P = .04$). In needle-guided trials, all participants succeeded without compressions, whereas only 1 failed with compressions ($P = .31$). Insertion time was significantly longer with chest compressions in both normal and needle-guided trials ($P < .001$, each). Ultrasound-guided central venous catheterization insertion time in normal trials was significantly longer than in needle-guided trials with compressions ($P < .001$). Difficulty of operation on a visual analog scale for venous puncture or guide wire insertion was significantly higher in normal trials than in needle-guided trials with compressions.
Conclusion: Needle guides shortened the insertion time and improved the success rate of US-CVC during chest compressions by anesthesiologists in simulations.

1. Introduction

The European Resuscitation Council (ERC) cardiopulmonary resuscitation (CPR) guidelines emphasize the importance of minimizing chest compression interruptions to maximize coronary and cerebral perfusion pressure [1]. The guidelines also suggest that skilled rescuers should be able to obtain rapid and reliable airway or vascular access without interrupting chest compressions [2,3]. However, securing definite vascular access is often difficult for patients with cardiopulmonary collapse. When peripheral venous access is difficult or impossible to establish, the intraosseous (IO) route is considered an alternative to a central venous line [4].

Although current ERC guidelines do not recommend the use of a central venous catheter (CVC) during resuscitation, it is an established alternative for inhospital resuscitation. Central venous catheter provides a definite and rapid drug administration route and allows for extensive hydration. Recently, the ultrasound-guided CVC (US-CVC) technique has become available. This technique distinguishes veins from arteries and has a visible guide wire for catheter progression, which improves CVC safety. There are some reports on the application of US-CVC for emergency intravenous (IV) line management during resuscitation [5,6]. However, US-CVC can be challenging during chest compressions [7].

A needle guide for US-CVC was recently developed [8,9]. As this needle guide can make the central venous needle clearer, we hypothesized that its use would simplify US-CVC. Thus, in this study, we compared the utility of a needle guide for use in US-CVC during chest compressions by experienced anesthesiologists. As direct clinical evaluations in this context would be unethical, we performed validations with simulators. We hypothesized that the needle guide would shorten the insertion time and improve the US-CVC success rate. To this end, we evaluated the utility of the needle guide with respect to ease of US-CVC during chest compressions by anesthesiologists using simulators.

2. Methods

This study was judged not to require registration by the institutional review board of our institution because it does not include any patient or volunteer intervention. As the study was not performed on human subjects, clinical trial registration also was not required. We selected 25 anesthesiologists with more than 2 years of clinical experience

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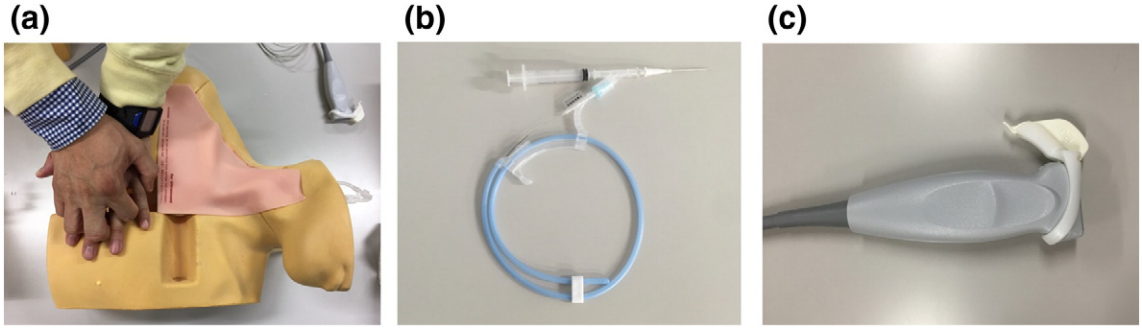

Fig. 1. Central venous catheter simulator, CVC, and needle guide used in the study. Central venous catheter simulator (a), single-lumen CVC (b), and needle guide attached to the ultrasound probe (c).

from members of our department or among those who received simulation training at our institution. All participants had previously undergone simulation-based CVC training. Written informed consent was obtained before the study.

We used a conventional CVC simulator (CVC placement pad; Kyotokagaku, Japan; Fig. 1a), which offers efficient training in guide wire insertion. As the simulator is primarily developed for CVC in the absence of chest compressions, we confirmed that the internal jugular vein and surrounding structures moved up and down during chest compressions by ultrasound. We used a single-lumen CVC (CV Lagaforce; EX, Terumo, Japan), ultrasound machine equipped with a 5 to 10 MHz transducer (iLook; SonoSite, Inc, Bothell, WA), and the needle guide device (Infiniti; CIVCO Medical Solutions, Kalona, IA). Participants performed US-CVC with the internal jugular vein using the long-axis approach in both normal and needle guide trials (Fig. 1b, c).

The simulator was placed on a hard, flat table for "on the bed" simulation. Chest compressions were performed continuously by 3 basic life support instructors at a depth of approximately 5 cm and a rate of 100 compressions per minute, in accordance with current guidelines [1].

Participants were given 5 minutes to practice US-CVC using the long-axis approach, with the instructor available to give advice. The appropriate equipment for each trial was placed in a box next to the manikin's head. Insertion started when the participant picked up the puncture needle and ended at the point of guide wire insertion. The needle guide was attached by the instructor according to the manufacturer's recommendation.

The number of venous puncture and guide wire insertion attempts was recorded. Insertion times to the point of confirmation of venous puncture or guide wire insertion were recorded, for both successful and failed insertions. For chest compression trials, participants were not allowed to discontinue compressions. At the end of the study, participants rated the difficulty of venous puncture and guide wire insertion on a visual analog scale (VAS) from 0 mm (extremely easy) to 100 mm (extremely difficult) [10].

Results obtained from each trial were compared using 2-way repeated-measures analysis of variance for insertion time and VAS and chi-square test for the success rate or number of attempts [11]. Data are presented as mean ± SD. $P < .05$ was considered statistically significant.

The study was designed as a randomized cross-over trial to minimize the learning curve effect. The order of intervention was randomized for each participant using a random number table, resulting in a total of 4 interventions per participant (24 patterns) [12].

Results of an 8-doctor preliminary study showed that the time required for successful CVC without chest compressions was approximately 40 ± 12 seconds. We considered 10 seconds to be a clinically meaningful difference. Thus, we estimated that 20 participants would be adequate for 2 independent groups using $\alpha = .05$ and $\beta = .2$. We recruited 25 participants to compensate for any missing data.

3. Results

The anesthesiologists had 14.0 ± 9.5 years of clinical experience and had performed ultrasound-guided CVC 103.3 ± 85.0 times.

3.1. Venous puncture

The number of venous puncture attempts is shown in Table 1. Without chest compressions, all participants succeeded within 2 trials. The number of venous puncture attempts was higher with chest compressions in both normal and needle guide trials, although the difference between trials was not significant ($P = .29$ and $P = .99$).

3.2. Ultrasound-guided CVC insertion success

The number of successful US-CVC attempts by anesthesiologists for normal and needle guide trials are shown in Table 2. In normal trials, 1 participant failed US-CVC without compressions, whereas 6 failed with compressions ($P = .04$). In needle-guided trials, all participants succeeded without compressions, whereas only 1 failed with compressions ($P = .31$). The insertion success rate during chest compressions was significantly higher in needle guide trials compared to normal trials ($P = .04$).

3.3. Ultrasound-guided CVC insertion time

Fig. 2 shows the insertion time with or without the needle guide and with or without chest compressions. Compressions significantly prolonged the insertion time in both normal and needle guide trials. Time from start to venous puncture did not significantly differ with or without the needle guide, whereas it was significantly shortened by use of the needle guide during chest compressions ($P < .001$) (Fig. 2a). Time from venous puncture to guide wire insertion did not significantly differ with or without the needle guide, regardless of chest compressions (Fig. 2b).

Table 1
Ultrasound-guided CVC venous puncture attempts with or without the needle guide and with or without chest compressions

	Without chest compressions	With chest compressions	*P* value (χ^2 test)
Without needle guide	25/0/0/0/0	18/6/0/0/1	.29
With needle guide	24/1/0/0/0	22/2/1/0/0	.99
P value (χ^2 test)	.79	.85	

Values are presented as the number of venous puncture or guide wire insertion attempts.