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Non-dominant hand quicker to insert peripheral venous catheters under echographic guidance: A randomized trial

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ABSTRACT

Background: Ultrasound guidance for venous catheter placement requires the use of both hands. An accurate and stable ultrasound image is fundamental for obtaining good quality images, consequently permitting accurate needle placement. We hypothesized that the dominant hand could be used to perform echography, leaving the non-dominant hand available for peripheral venous catheter (PVC) insertion.
Methods: Prospective, open-label, randomized, crossover study. Group 1 inserted the PVC with the dominant hand, and held the probe with the non-dominant hand in a first series of 20 insertions, and vice versa in a second series of 20 insertions performed 11 days later. Group 2 punctured with the non-dominant hand in Series 1 and vice versa in series 2. The study population comprised female student nurses (aged 20–30 years) who had learned neither ultrasound techniques nor catheter insertion. The primary endpoint was time to successful puncture. We recorded age, sex, video game use, and the laterality of hands, feet and eyes.
Results: One left-handed and nine right-handed nurses were randomized to each group. Puncture by the non-dominant hand was significantly quicker in both series ($P < 0.001$). There was no difference between groups for time to successful puncture with the dominant hand; however a significant difference was found for the non-dominant hand ($P < 0.01$). According to multivariate analysis, the time to successful puncture was significantly lower when the non-dominant hand was used to puncture (adjusted difference 5.6 s, $P < 0.0001$).
Conclusion: Using the dominant hand to hold the ultrasound probe and the non-dominant hand to puncture and insert the catheter achieves successful insertion in a significantly shorter time.

1. Introduction

Central or peripheral venous catheter insertion is a necessary prerequisite for intravenous (iv) administrations [1]. Successful venous catheter insertion depends largely on vein anatomy and associated morphological characteristics. Echographic guidance for venous catheter placement has been shown to reduce placement failure and complications in adults [2] and to reduce the time required for successful placement in children [3,4]. Blind venous catheter placement is based on the identification of anatomical landmarks and requires the use of only one hand, generally the dominant hand, which holds the catheter and punctures the vein. The other hand serves only to hold or stabilize the area being punctured.

The use of ultrasound guidance for venous catheter placement requires the use of both hands, namely one to puncture and one to

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hold the ultrasound probe to guide the advancement of the catheter towards its final position. The continuous monitoring of the needle tip by echography yields safer and quicker catheter placement [2,3,5–7]. An accurate and stable ultrasound image is fundamental for obtaining good quality images, consequently permitting accurate needle placement.

We hypothesized that it would be useful to use the dominant hand to perform the echography, leaving the non-dominant hand to puncture the vein and place the catheter. We performed a randomized, crossover study to investigate whether there were any differences in the learning and implementation of ultrasound-guided venous puncture according to the handedness of the operator.

2. Materials and methods

This was a prospective, open-label, randomized, controlled, crossover study, with a wash-out period of 11 days between phases.

The study was performed in three steps:

- step 1 comprised intensive teaching of the ultrasound-guided technique for catheter insertion. All participants received instruction for ultrasound-guided puncture from an experienced ultrasound operator in a classroom setting using video and live demonstrations. The following aspects were covered: the basic principles of echography, importance of the probe position for echo reception, long and short axes of a vessel and in-plane versus not-in-plane needle positions. Lastly, hygiene practices when using echography were addressed;
- step 2 was performed immediately after step 1 and comprised a first series of 20 catheter insertions by each participant, performed with one hand, using the other hand to hold the ultrasound probe;
- step 3, performed 11 days later, comprised a second series of 20 catheter insertions performed using the contralateral hand and using the other hand to hold the ultrasound probe.

To minimize the potential bias related to the handedness of the operators, we sought to control a maximum of parameters when selecting the study population. Therefore, our study population was composed of student nurses within a fixed age range, of the same sex and with comparable levels of experience in catheter placement as well as ultrasound use. A questionnaire recording age, sex, use of video games and laterality of the hands, feet and eyes was distributed among all students in their third year of nursing studies at the University of Dijon (Dijon, France). Inclusion criteria were age between 20 and 30 years, female sex and homogenous laterality.

Participants were randomized into two groups of 10 in a crossover design.

Group 1 performed catheter insertion with their dominant hand, while guiding the probe with the non-dominant hand during the first series and vice versa during the second series 11 days later. Group 2 punctured with the non-dominant hand while guiding the ultrasound probe with the dominant hand during the first series and vice versa during the second series. During the 11-day washout period between series 1 and 2, participants were requested to abstain from performing echography. The order in which subjects from each group were called to perform catheter insertion was the same for both series.

All ultrasound-guided venous punctures were performed on a Vascular Access ultrasound-training phantom (Blue Phantom branched 2 vessel ultrasound training block model, CAE Healthcare, Sarasota, FL, USA) using a portable echography machine (Model M-Turbo, Sonosite Inc., Bothell, WA, USA) with a high frequency probe for adults (6–13 MHz 38 mm linear probe). The training phantom contained a branched 6 mm vessel that bifurcates into two individual vessels (4 mm and 6 mm in size) prefilled with red ultrasound refill solution and refillable after use. The ultra-durable, self-healing tissue does not leave marks that could inadvertently serve as landmarks for subsequent punctures. Details and illustrations are available on the manufacturer's website [8]. Simulation on phantoms has previously been shown to be useful for improving proficiency in various clinical procedures [9–12]. Venous puncture was performed using 22 gauge catheters (Terumo, Guyancourt, France). These were changed every 5 insertions or sooner if the catheter was damaged. The vascular access phantom had 2 types of vessels, namely 4 mm and 6 mm in diameter, with anastomosis, and with different courses and lengths. Punctures were performed alternately between vessels, in order to ensure the need to mobilize the catheter for each new puncture.

Successful puncture was defined as the achievement of correct venous catheter placement in the phantom's vein, as assessed by the ultrasound images and liquid reflux in the catheter. The primary endpoint was time (in seconds) to successful puncture, which was defined as the time from puncture of the surface ("skin") of the phantom to the simultaneous achievement of liquid reflux in the catheter and in-plane visualisation of the catheter correctly in place in the vessels in the long axis view.

To measure the accelerations of the ultrasound probe, we used an innovative device. We attached an iPhone (iPhone 4, Apple Inc., Cupertino, CA, USA) to a support that was attached to the ultrasound transducer, ensuring perfect symbiosis between the iPhone and the probe (Fig. 1). The Vibration® application (DLD-LLC, Southington, CT, USA) was used to measure accelerations and movements of the ultrasound probe during the procedures. This application uses the internal accelerometer and gyroscope of the iPhone to measure movement in three spatial axes (X, Y and Z). A sensitivity of approximately 0.02 g guaranteed by the application's developer was optimized by fixing the iPhone 10 cm above the ultrasound probe to amplify the pivotal movement. The construct validity of smartphone-based accelerometers as an adjunct for assessing technical performance during simulation training has previously been reported [13].

Fig. 1. Illustration of the iPhone attached to the ultrasound probe for the measurement of accelerations of the probe during catheter insertion.