Diseño de un novedoso modelo de bajo costo para el entrenamiento de habilidades en el paso de catéteres venosos centrales, con guía ecográfica.

Design of a low-cost simulation-based ultrasound-guided central venous cannulation's model to training and improvement of skill acquisition

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Summary :
    There are multiple simulation models for training and improving technical skills in central venous catheter passage, with ultrasound guidance. However, due to the high cost of various devices, low-cost designs are required to facilitate the training of residents in medical-surgical specialties. In this work, we propose a simulation model for training residents in ultrasound-guided central venous catheter placement. A tissue model was designed from platinum-based silicone rubber with a central tubular structure. Additionally, educational sessions were held for participants to use the models with ultrasound. An anonymous survey was conducted before and after training to evaluate the experience. 20 internal medicine residents were evaluated; most had little experience in passing venous catheters (55% had performed 0 to 5 procedures). Only 20% had used ultrasound at any time, and only 10% had used it in all procedures. Self-perception of ultrasound-guided catheter passage improved significantly after the intervention, with an average increase of 1.67 points on a scale of 1 to 5 (P < 0.0002). We have developed a low-cost simulation model, without associated stress and without risk in its learning to facilitate the acquisition of knowledge and improve technical skills in the passage of venous catheters in residents in training.

Keywords: Central venous catheter, anatomy; jugular vein / diagnostic image; clinical skill, clinical simulation, skill development

Abstract:
    There are multiple simulation models available for training and improving technical skills in central venous catheter placement with ultrasound guidance. However, due to the high cost of various devices, low-cost designs are needed to facilitate training for residents in medical and surgical specialties. We are proposing a simulation model for the training of medical residents in ultrasound-guided central venous catheter placement. A tissue model was designed using platinum-based silicone rubber with a central tubular structure. In addition, educational sessions were conducted to enable participants to use the models with ultrasound. An anonymous survey was administered before and after training to assess the participants' experience. Twenty internal medicine's residents were evaluated, with the majority having little experience in central venous catheter placement (55% had performed 0 to 5 procedures). Only 20% had ever used ultrasound, and only 10% had used it in all procedures. Self-perception of ultrasound-guided catheter placement significantly improved after the intervention, with an average increase of 1.67 points on a scale from 1 to 5 (P < 0.0002). A low-cost, stress-free, and risk-free simulation model was proposed

to facilitate the acquisition of knowledge and improvement of technical skills in central venous catheter placement for residents in training.

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1. Introduction

The implementation of the central venous catheter, since its inception in 1929 with Dr. Forssmann, has marked a milestone in therapeutic options for critically ill patients (1). However, due to the multiple inherent complications associated with this procedure, proper placement, following aseptic technique and efficient insertion, has become a critical indicator of patient safety (2).

In the academic and practical education of residents in various clinical specialties, such as internal medicine, emergency, intensive care, surgery and anesthesiology, they are provided with knowledge of the indications and sterile techniques for the correct insertion of a central venous catheter. However, during the performance of this procedure, multiple secondary complications may arise, such as infections, pneumothorax, arterial puncture, deep vein thrombosis and bleeding, which are the most common (3).

These complications can be classified into two categories: early complications, which are generally mechanical in nature and related to the insertion technique, including arterial injuries, hematomas, pneumothorax/hemothorax, air embolism, cardiac arrhythmias, nerve injuries, and incorrect catheter placement; and late ones, which involve infections and vascular thrombosis and are associated with the care and conditions of the patient (4).

Furthermore, depending on the access route used, complications may vary, since the femoral route tends to present more late complications and fewer acute complications, while the subclavian insertion point is more prone to significant mechanical complications (5).

Our objective has been to implement a simulation model for the development of clinical catheter insertion skills, guided or not by ultrasound, in a safe learning environment under ideal conditions that allows reducing complications associated with the procedure during training, and that also be a low-cost system that allows its wide dissemination.

2. Methods

The Department of Internal Medicine, in its teaching-care agreement with the Universidad del Valle, is made up of internists, who commonly place central venous catheters and dialysis catheters, as well as perform paracentesis, among other ultrasound-guided procedures at the University Hospital. del Valle, in the city of Santiago de Cali. A descriptive, cross-sectional observational study was carried out in which we attempted to determine whether the educational intervention, in this case, sessions with simulation models, improved the knowledge, skills or competencies of the participants in a specific area, such as internal medicine. During the academic years of 2021-2023, the department organized various educational sessions for residents in the specialty of Internal Medicine, which are mandatory for their training.

Each session began with an introductory class, which included an orientation for the use of ultrasound, operation of the equipment, correct sterile technique, and demonstration of

vascular anatomy by visualizing it on a volunteer in the group. After the introduction, participants were divided into groups according to their level of expertise by current academic year. After being assigned to a workstation, they performed sterile equipment placement and central line insertion, using a SonoSite Edge II ultrasound machine, a needle container, a bi-lumen central catheter set, and a low-impact tissue simulation model. cost for puncture and introduction of central catheters (figure 1).
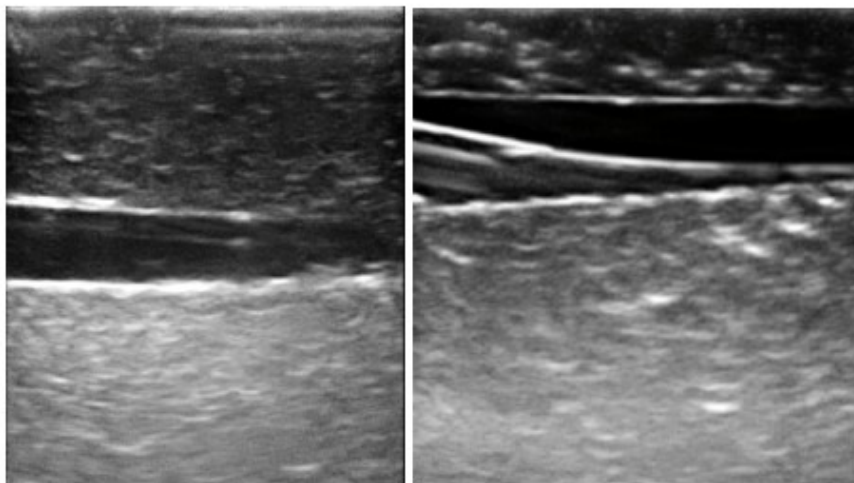

Figura 1. View of the blood vessel by ultrasound with the guidance of the device in 2D mode.

The tissue models were made from platinum-based silicone rubber, within which they had a tubular structure of 6.5 mm in diameter, which ran along the structure. Each edge of the tube, or "vessel", was sealed at both ends and filled under pressure, with a system of rigid hoses that allows the passage of the guide and the advancement of the catheter, with saline solution with red dye to simulate blood. The total cost of each model was approximately 50 USD (figure 2).

Figura 2. Simulation equipment to perform puncture practice.

Over the course of approximately 2 and a half hours per session, in 4 sessions, each participant was trained to visualize vascular structures guided by ultrasound and cannulate vessels guided by image, along with the management of central catheter passage set inputs. , the manipulation of the guide and the different elements to preserve correct sterile technique during the procedure. The training was carried out with 20 residents, corresponding to each year of the three years of specialty, and two teachers as trainers. A general feedback was provided where the safety of using the ultrasound machine and proper cannulation of the vessels was improved, in addition to correcting common errors to preserve correct sterile technique. At the end of the course, they

completed a virtual self-perception survey during the training sessions and previously acquired skills.

3. Results

20 participants were evaluated, all of them residents of the internal medicine specialization. The level of experience in passing venous catheters varied among the students, since most of them had no previous experience (55% had passed between 0-5 catheters). It was striking that only 20% of the participants had used ultrasound at some point to perform the procedure, and only 10% of the participants had used it in all their procedures (Table 1).

The results of the surveys were evaluated using a scale from 1 (not so comfortable) to 5 (very comfortable) to evaluate self-perception regarding the passage of ultrasound-guided catheters, and a baseline difference of 1.5 to 3.35 was found, with a difference significant mean of 1.67 (P <.0002), evaluated by the Wilcoxon test for related samples. Regarding the usefulness of the tissue model, an overall subjective rating of 4 (60%) was recorded on a scale of 1 to 5. The tissue model showed its greatest strength in the ease of education in appropriate clinical practices to maintain the barrier. sterile and obtain an adequate image to begin using the ultrasound as a guide for the passage of catheters. Subsequently, feedback was provided at the level of institutional practice guidelines to implement the ultrasound-guided catheter passage procedure as a patient safety standard.

Table 1. Characteristics in the survey of 20 residents.

Participants	
Men	15 (75%)
Women	5 (25%)
Training level	
First year	15 (75%)
Second year	2 (10%)
Third year	3 (15%)
Previous number of catheters passed	
0 to 1	8 (40%)
2 to 5	3 (15%)
6 to 10	3 (15%)
10 to 50	6 (30%)
Previous use of the ultrasound machine for CVC step	
Always (5)	2 (10%)
Sometimes (2 to 4)	4 (20%)
Never (1)	14 (70%)

4. Discussion

Ultrasound guidance for central venous catheter insertion improves the effectiveness of insertion, mainly for internal jugular and femoral approaches (6), since it reduces immediate mechanical complications associated with the procedure (7). The learning process for procedures is generally based on a hands-on, in-person "see one, do one" approach to patients, in which those being trained rely on other residents or attending physicians for training, despite the variable quality of supervision and the lack of

efficiency inherent in this method (8). During which, patients become training subjects, for novice trainees who are not always familiar with the methodological aspects of the procedure or have not previously been familiar with the equipment.

Simulation training programs in medical education increase knowledge, provide opportunities for safe practice, and shape the development of clinical skills (9). The first study to show the impact of simulation-based training for CVC insertion demonstrated that residents who were previously trained required fewer needle sticks and had better technical skills (10). In our study, the majority of residents (70%) had never performed the procedure guided by ultrasound technique, despite the fact that 60% had already performed the central venous catheter at least twice.

Initially, training models on fresh human cadavers and live animals imply high cost, limited access, with high risk of infections and ethical difficulties; as well as virtual reality simulators that are high cost and restricted access. Therefore, simulators with post-mortem animal parts (turkey and chicken thighs, pork pieces, among others) have been proposed along with inorganic and synthetic models (11). For our part, we have developed a platinum-based simulation model that is reusable and does not involve the use of organic tissues.

By initiating training in a simulation model, a safe environment is created to improve clinical skills and abilities in aseptic technique, catheter insertion, and use of ultrasound guidance; which allows patients to become familiar with the equipment before performing the practices, the opportunity to repeat it without risks and the development of motor skills. Therefore, the implementation of simple and low-cost models facilitates the introduction of clinical simulation in academic institutions (10).

The training model presented here is low cost, useful for the training of any service that manages critically ill patients, to carry out ultrasound management practices and to perform puncture and insertion of catheters in personnel who are in training. Likewise, it allows improving the use of ultrasound with adequate sterile technique and hand-eye coordination. Furthermore, puncture and cannulation can be repeated several times in the same model.

In the limitations of the model, as occurs in other designs, it does not have anatomical variations, considering that in patients the structures can change in size, location and mobility (11). On the other hand, the model is completely inanimate, and no type of movement occurs during the procedure, which facilitates visualization and vascular cannulation, unlike when performed in vivo where the patient can change position.

The decrease in possible complications after resident training is a notable result of this study. Prior to the intervention, most residents performed procedures without the use of ultrasound. Through educational sessions and specific training in this skill, a development of the residents' ultrasound technique skills was observed, which due to this change reflects the effectiveness of the training and its positive impact on the residents' subsequent clinical practice.

5. Conclusions

- Simulation models such as venous catheter insertion improve clinical skill; The development of low-cost simulation models that can be easily implemented is essential in professional training.

- We have designed a short-term training, which, through an initial low-cost simulation model, allowed training in ultrasound-guided technique for personnel who are in the initial phase of their training for the acquisition of soft skills.

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