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Low-cost synthetic phlebotomy model: An alternative learning tool for medical students

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ABSTRACT

Aims: Practicing surgical skills has been gaining space in medical courses, with emphasis on synthetic experimental models. Biological training materials have some disadvantages compared to animal models such as higher cost, smaller durability, more difficult storage, less possibility of reuse, and protection by animal societies. Therefore, a low-cost synthetic phlebotomy model, intended to enable students to practice the surgical technique exhaustively without the need for new materials and avoiding the use of animals, was created for theoretical/practical training in medical schools. This study aimed to assess the effectiveness of a low-cost synthetic model for training the phlebotomy technique.

Method: A synthetic model of phlebotomy was created and offered to medical students, who voluntarily accepted the conditions presented in the Free, Prior, and Informed Consent, for theoretical/practical training. They practiced the surgical technique using the synthetic model and evaluated it through a questionnaire.

Results: The research involved 52 medical students. Most of them (78.84%) reported that the synthetic model is a good option compared to the biological one because it can be reused and is available for training as many times as necessary. However, all the participants affirmed that the synthetic model does not exclude the use of the biological one.

Conclusion: Low-cost synthetic models are an excellent option for practicing surgical skills.

Keywords: Experimental model, Low cost, Phlebotomy, Simulation training, Synthetic

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INTRODUCTION

One of the pillars of surgical practices is the acquisition of techniques and skills. The use of low-cost synthetic models in medical schools aims to cease the problems imposed by the limited time to reconcile theory with

practice and overcome the difficulties in obtaining human and/or animal resources. Additionally, this prevents the use of animals in teaching and research, a well-known polemic issue [1–5].

Phlebotomy consists of dissection, isolation, catheterization, and, in most cases, distal ligation of a vein, performed under local anesthesia. For this purpose, numerous superficial veins such as the basilic and saphenous veins, or deep veins such as the brachial veins can be used. This procedure is indicated mainly in emergency situations, when it is not possible to obtain peripheral venous access promptly, to avoid multiple venipuncture attempts and suffering [6–9].

Nowadays, in medical education, students develop cognitive and technical/motor skills using a range of different methods. Cognitive competences are developed from a theoretical basis, with the acquisition of knowledge through active search, featuring a linear sum of improvements. In turn, technical skills are developed exponentially at first, followed by stabilization and steady improvement. Precisely because of this characteristic, technical skills demand hands-on training, with exhaustive repetition after this first moment, to achieve improvement. In this scenario, bench model training using models that allow continuous repetition and reevaluation, with no time and place limitations, are practical and suitable for the technical development of medical students, so that they can acquire fundamental, technical, surgical, and decision-making skills [10, 11].

In view of the current evolutionary context of medical training mentioned above and taking into consideration the importance for medical students to acquire practical skills to perform phlebotomy, we developed a low-cost synthetic model for training this technique, intended to enable students to practice this surgical technique exhaustively without the need for new materials and avoiding the use of animals. Therefore, the current study aimed to assess the effectiveness of a low-cost synthetic model for training the phlebotomy technique.

MATERIALS AND METHODS

Our team created a low-cost synthetic phlebotomy model to be used for surgical skills training on a life-like model. The materials were chosen to simulate the structures approached during the phlebotomy procedure, namely: skin, subcutaneous tissue, muscles, and vascular-nervous structures. Such materials were arranged in an overlapping manner, using artificial skin, foam for the subcutaneous tissue, a layer of red ethylene vinyl acetate (EVA) to simulate the muscle tissue, and colored plastic straws for the vascular-nervous structures (Figures 1–4). In the blue straw, corresponding to the venous structure, a latex balloon containing red liquid dye was placed at the proximal end to simulate blood and verify the effectiveness of the procedure.

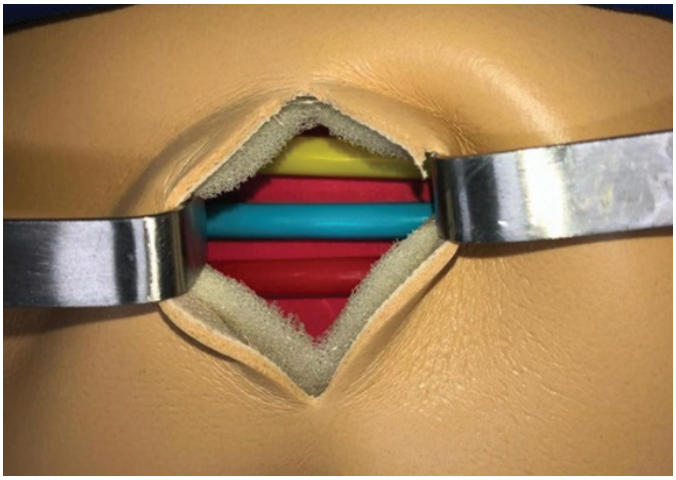

Figure 1: Dissection of the cutaneous and subcutaneous tissues using a low-cost synthetic phlebotomy model and visualization of the vascular-nervous structures: nerve (yellow), artery (red), and vein (blue).

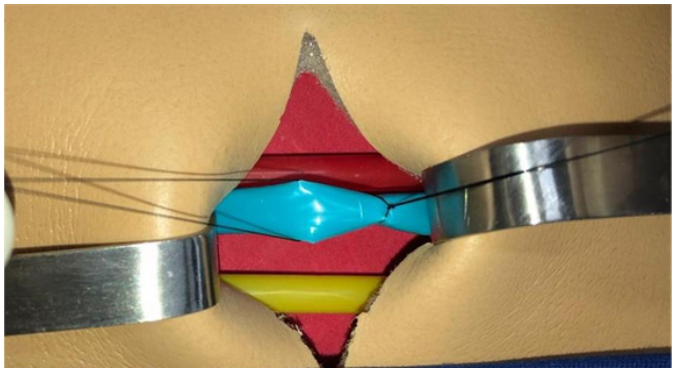

Figure 2: Vein ligation in the distal part and vein repair in the proximal part.

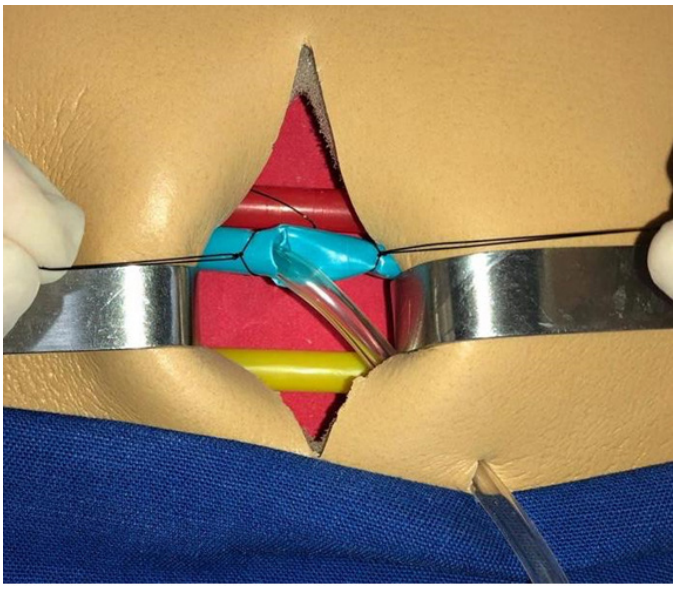

Figure 3: Insertion of the catheter into the vein (through a distal incision) and ligation of the proximal part of the vessel.

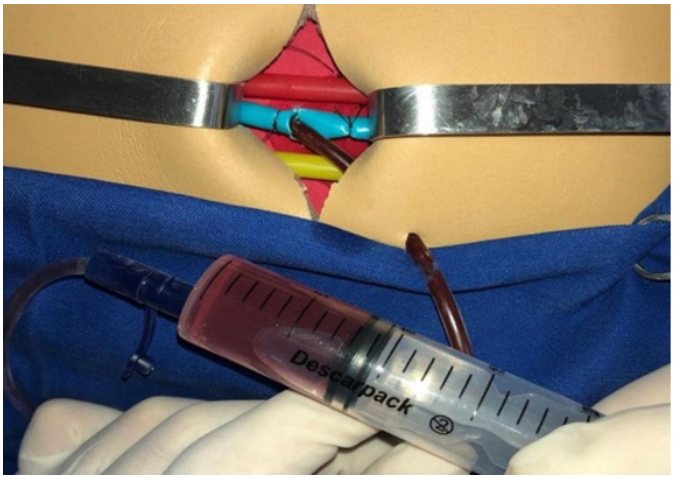

Figure 4: Aspiration of the catheter with the syringe showing the return of venous blood (red liquid dye).

Students of the eleventh and twelfth terms of the medical course at FACERES, who had already taken the surgical skills discipline, were invited to participate in this study (Project approved by the Research Ethics Committee—CEP of FACERES, no. 12359819.9.0000.8083). After signing the Free, Prior, and Informed Consent, they were asked to carry out phlebotomy training in animal parts and in the synthetic model created for this purpose, following the surgical technique guide shown in Table 1. Subsequently, the participants answered a questionnaire about the usefulness and efficacy of the new teaching model using a 5-point Likert scale, ranging from "I strongly disagree" (1) to "I strongly agree" (5).

Table 1: Surgical technique for the phlebotomy procedure

1.	Place the patient in supine position, with the limb in abduction and the surgeon located on the side where the phlebotomy will be performed
2.	Clean the site with chlorhexidine and place surgical drapes
3.	Make a transversal incision of approximately 3 cm in the skin and subcutaneous tissue over the chosen venous path
4.	Divulse subcutaneous tissue using a retractor until the superficial brachial fascia is exposed. Sometimes, it is possible to visualize the vein
5.	Use delicate hemostatic forceps and dissect the vein in the direction of its axis
6.	Repair the vein with two surgical needles, one proximal and one distal
7.	Ligate the distal portion of the vein in a definitive manner
8.	Make a distal incision
9.	Position the catheter through the distal incision
10.	Perform venotomy transversely or longitudinally (if necessary, enlarge the lumen for catheterization)
11.	Insert the catheter slowly and gradually
12.	Perform rotation movements and connect a syringe for bolus injection of saline for vascular dilation if necessary
13.	Secure the catheter to the vessel by ligating it to the proximal vein
14.	Review hemostasis and end catheterization
15.	Observe if there is a free flow of the infused volume and reflux, or the return of blood through the catheter
16.	Perform skin suture
17.	Secure the catheter externally

RESULTS

The project resulted in the creation of a reusable synthetic phlebotomy model, which cost approximately US$ 0.58 each. In total, 52 medical students participated in the research. Most of the participants were male (51.92%), 75% of them were 20–24 years old, and 40.38% were interested in the surgical area.

According to their answers to our questionnaire, 82.69% thought that the material used for making the model is good quality and 76.92% affirmed that the model has good anatomical similarity to the human body. Many participants (92.3%) reported that the synthetic model allows learning the proposed phlebotomy technique, 73.07% of them considered it adequate to be used as an alternative learning tool for training this surgical technique, and 94.23% of the respondents recognized that it brings benefits to the teaching-learning process compared to theoretical knowledge alone.

The synthetic phlebotomy model was described by 78.84% of the participant students as a good alternative tool compared to the biological model, since it can be reused several times and is available for training as many times as necessary. However, all the participants reported that the synthetic model does not exclude the use of the biological model. Finally, 75% of the respondents affirmed that prior training using the synthetic model is extremely important for medical practice.

DISCUSSION

In Brazil, the curricular guidelines of undergraduate schools establish that general practitioners must be capable of performing both clinical and surgical procedures. Because of this, the surgical skills discipline has been increasingly gaining importance in medical schools [12, 13].

Although animal models have been used for a long time in the medical teaching–learning process, they require a series of ethical principles, are difficult to maintain, cost more, and may not be advantageous for certain surgical procedures [14]. Nowadays, investing in alternative models for teaching and respecting the humanitarian principles of animal experimentation has been a worldwide trend. This provides a focus for introducing new methods to replace, reduce, and/or

refine animal use. Due to this change, medical students should be offered opportunities to train and improve surgical techniques using synthetic and reusable models, with no limitations to their learning process [15–17].

The model proposed in this study revealed numerous positive points, including learning the technique better, training as many times as necessary in the same piece, and feeling more confident to perform the procedure *in vivo* posteriorly. There was also criticism regarding the stiffness of the materials used compared to the animal model, but good anatomical similarity was reported by the participants.

Therefore, practicing surgical skills in synthetic models brings the opportunity of offering medical students an environment very close to the real one in a safe manner. The students can have an exhaustive and comprehensive hands-on training in order to prevent iatrogenesis during the *in vivo* procedure [18, 19].

CONCLUSION

The synthetic phlebotomy model emerged as an excellent alternative learning and training tool for medical students to practice surgical skills. The model allows exhaustive theoretical/practical training and improvement of the technique without impairing academic learning. Although the synthetic model cannot totally replace anatomical parts and animal models, it is in line with the worldwide trend of making great efforts to develop and implement non-animal approaches as replacements for animal-based teaching and training models.

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Author Contributions

Pedro Nogarotto Cembraneli – Conception of the work, Design of the work, Acquisition of data, Analysis of data, Interpretation of data, Drafting the work, Revising the work critically for important intellectual content, Final

approval of the version to be published, Agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved

Julia Brasileiro de Faria Cavalcante – Conception of the work, Design of the work, Acquisition of data, Analysis of data, Interpretation of data, Drafting the work, Revising the work critically for important intellectual content, Final approval of the version to be published, Agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved

Italo Nogarotto Cembraneli – Conception of the work, Design of the work, Acquisition of data, Analysis of data, Interpretation of data, Drafting the work, Revising the work critically for important intellectual content, Final approval of the version to be published, Agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved

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Guarantor of Submission
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Written informed consent was obtained from the patient for publication of this article.

Conflict of Interest
Authors declare no conflict of interest.

Data Availability
All relevant data are within the paper and its Supporting Information files.