New technique for ultrasound-guided vascular access training using an animal tissue model

Nova técnica para treinamento em acessos vasculares guiados por ultrassom utilizando modelo de tecido animal

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Abstract

Duplex ultrasonography is no longer only a noninvasive diagnostic method; it has also been applied in therapeutic procedures. Due to the increased use of central venous catheters and ultrasound-guided vascular procedures, concerns have been raised about improving results in terms of accuracy and safety, reducing those procedures complication rates. In order to achieve these goals, training in models (phantoms) should be required, before performing actual procedures in human subjects. Commercially available phantoms are expensive and do not reproduce the echographic density and texture of human tissues. In an attempt to train professionals on ultrasound-guided vascular access, we have developed a low-cost animal tissue model of easy production and excellent applicability.

Keywords: models, animal, training, ultrasonography, Doppler, surgical procedures, minimally invasive.

Resumo

A ultrassonografia Doppler deixou de ter seu uso apenas como método diagnóstico e vem galgando espaço nos procedimentos terapêuticos. Com maior aplicabilidade e uso de cateteres venosos centrais e procedimentos guiados por ultrassom, há preocupação com a melhora da eficácia e segurança durante o procedimento, assim como com a diminuição das potenciais complicações. Para isso, o treinamento da técnica em modelos *(phantoms)* é desejável. Os modelos industrializados para treinamento em acesso vascular guiado por ultrassom são caros e não reproduzem adequadamente a ecotextura e a densidade dos tecidos humanos. Na tentativa de treinar e aprimorar os profissionais para o uso do ultrassom em procedimentos de acessos vasculares, desenvolveu-se um modelo animal de baixo custo, fácil confecção e excelente aplicabilidade.

Palavras-chave: modelos animais, treinamento; ultrassonografia, Doppler, procedimentos cirúrgicos minimamente invasivos.

Introduction

Doppler vascular ultrasonography is a widely used method for the noninvasive diagnosis of vascular diseases. Recently, however, it has not been used only as a diagnostic method, but has also been played an important role in guiding therapeutic procedures. The first description of ultrasound use in internal jugular vein cannulation was described by Ullman et al., in 1978[1].

Currently, it has been used to assist central and peripheral catheter placement,, to guide anesthetic blocks, in arterial puncture for endovascular procedures and it is essential in thermal ablation of varicose veins, in foam sclerotherapy and in the treatment of pseudoaneurysms with thrombin[2-6]. Lately, the increased use of central venous catheters in various situations has resulted in concerns about improving the effectiveness of those procedures and reducing potential complications[7].

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The usual method of catheter placement is based on anatomical landmarks, which are subject to vessel course variations due to patient's physical features and the effects of aging. The result of variations may be an unsuccessful procedure and complications. Such complications range from local hematomas to severe arterial injury, which may end in urgent surgery and even death. Therefore, technical improvement in catheter placement with Doppler ultrasonography guidance seems to be justified[8].

With the use of Doppler ultrasonography, it is possible to visualize the blood vessel and its patency; to identify anatomical variations; to find the best puncture site and plan the needle track in relation to the vessel wall, preventing transfixation of the posterior wall.

The anesthetic blocks, which have been guided by merely anatomical parameters or neurostimulation, can, with proper training of professionals, be directed to the selected nerves, reducing doses of anesthetic drugs and the risks of the procedure[9].

In order to improve the quality and reduce complications of catheter placement, training of medical residents and other professionals should be implemented initially with non-human models[10,11].

The commercially available models are expensive and do not properly reproduce the echotexture and density of human tissues. Thus, a low-cost animal tissue model of excellent applicability has been developed.

Material and methods

The list of materials used is presented below:

- a piece of defrosted chicken breast;
- segments of Dacron® and PTFE® prostheses;
- Nylon®, Prolene® or cotton threads;
- hydrophilic spheres used in plant decoration;
- ultrasound gel;
- Sonosite® hand-carried ultrasound equipment, model: M-Turbo®.

Production of the complete model

The animal tissue model production used: defrosted chicken breasts, in which Dacron® e de PTFE® prostheses with expired date were introduced, sutured with stitching needle or cotton thread and filled with hydrophilic spheres (ornamental gel for plants). The total cost is about R$ 3.21 per model (Figures 1 and 2).

The chicken piece, purchased frozen, was defrosted the day before. For a better mimicry of tissue texture, the chicken skin was kept. In the chicken breast, two tunnels were made between the internal and external chest muscles, one on the right side and one on the left side, by digital dissection or by using a blunt and long instrument. Dacron® or PTFE® prostheses were cut into segments which extension varied from approximately 5 to 10 cm (depending on the chicken piece size), sutured at one end with Nylon®, Prolene® or cotton thread and filled with gel spheres until half the prosthesis volume. The other end was then sutured and the prosthesis immersed in water for about 12 hours. With hydration, the gel spheres absorb enough water to expand more than ten times their original volume, forcing air out of the prosthesis and changing it into a tubular structure of tense and homogeneous content (Figures 3 e 4). The prostheses that had been prepared beforehand were introduced in the tunnels between the muscular planes of the chicken piece. The muscular tunnels were closed with cotton thread and stitching needle (Figures 5 to 7). This way, air infiltration was prevented, in order to avoid artifacts that may disturb the echographic visualization of the prostheses.

Figure 1. Defrosted chicken chest piece.

Figure 2. Segments Dacron® prostheses and hydrophilic spheres.

Results

An echographic image of the tubular structure was obtained with easy visualization, well defined limits, and precise identification of the anterior and posterior walls. Surrounding the prosthesis, the muscle tissue of the chicken chest piece presented a similar echographic density to the human muscle tissue. The model proved to be convenient for puncturing and, due to the gel material used to fill the prostheses, it is possible to puncture several times the same model, making training easier (Figures 8 to 10). The model can also be frozen and reused.

Discussion

Vascular access to large vessels is one of the most frequent procedures performed in hospitals. The increase in the number of central venous access procedures for placement of short- or long-term catheters either in the emergency unit for acute clinical conditions or in chronic nephrology[12] or oncology patients is a reality.

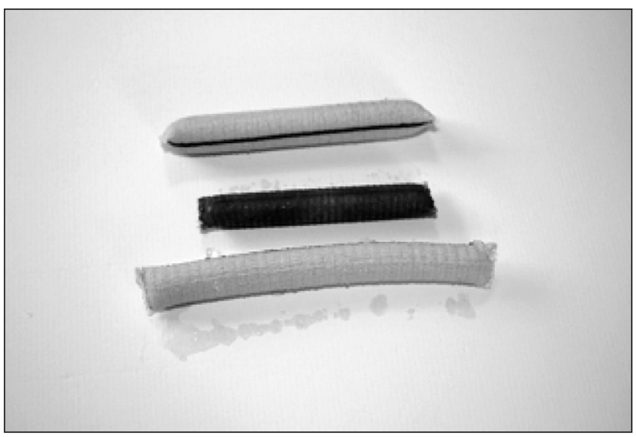

Figure 3. Tense and homogeneous tubular structure with synthetic graft.

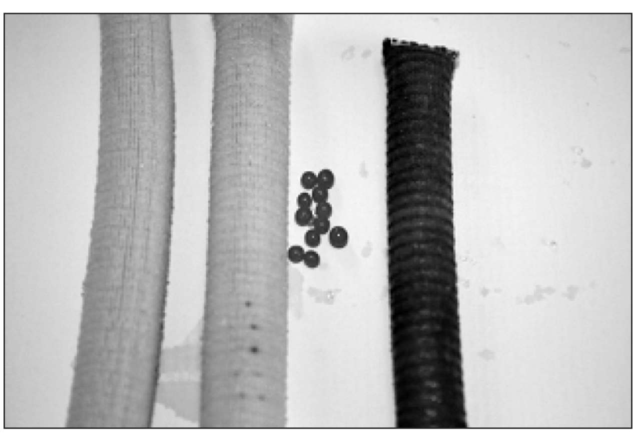

Figure 4. Tubular structure filled with hydrophilic spheres.

Deep vascular accesses are made usually considering the topographical anatomy of the vessels. However, anatomical variations or due to patient's physical features, effects of aging and atherosclerosis and prior vascular access can make the anatomical landmark technique more difficult and lead to unsuccessful

Figure 5. Creation of a tunnel between the muscles of the chicken piece.

Figure 6. Introduction of the tubular structure with synthetic graft in the produced tunnel.

Figure 7. Suture of muscle tunnel end.

Figure 8. Insonation of the prepared chicken piece.

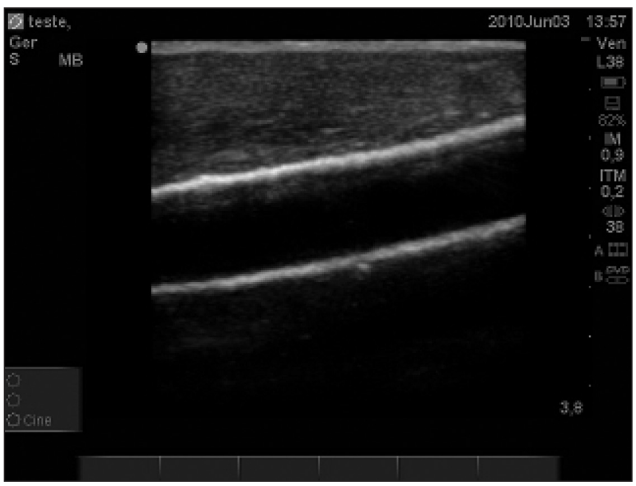

Figure 9. Ultrasound image of the produced model.

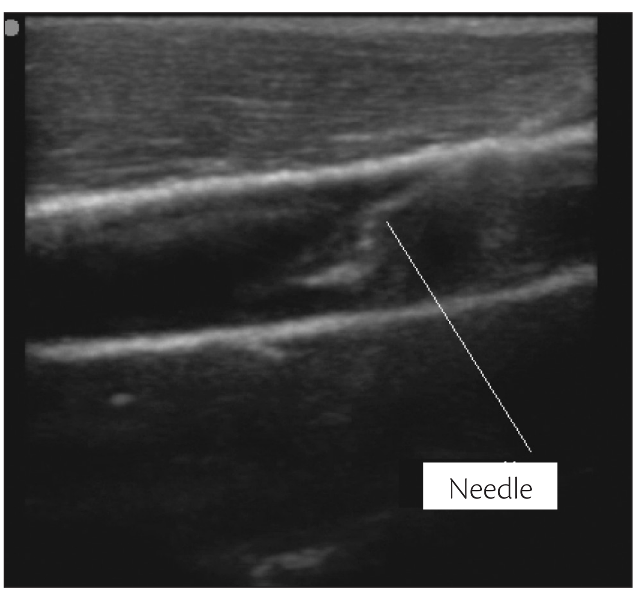

Figure 10. Image showing the needle introduced in the model.

procedures or even to hemorrhagic or other complications (pneumothorax,,pseudoaneurysm formation)[13]. In this context, the use of ultrasound as a vascular visualization tool provides higher safety when guiding the needle track to the blood vessel and the guide wire into the vessel. In a study, femoral arterial puncture for angiography was compared to ultrasound-guided angiography, with improved success rate in the first attempt, reduced number of attempts, reduced procedure time and reduced accidental vein puncture, as well as fewer complications[14].

The need of higher quality methods in order to increase the success rate of vascular access procedures, to avoid complications and to reduce costs[15], training of professionals on ultrasound-guided techniques is required. As many health professionals are not used to the interpret live ultrasound images, it would be more rational to provide training using non-human models.

Several ultrasound-guided techniques of anesthetic nerve block have been successfully applied, reducing the procedure time and the anesthetic dose injected, providing better safety to the procedure[16].

The cost of commercially available models (phantoms) makes the acquisition more difficult, considering that they are imported, paid in foreign currency and involve high import taxes – a model piece with three blood vessels may reach values in the range of thousands of U.S. dollars.

The model develop in this study offers the advantages of each acquisition of materials and low total cost of production. The amounts described below may vary, depending on the geographical location and temporal variation. The defrosted chicken price, corrected to the date of this article submission, is about R$ 5.99. On average, a large chicken breast weighs 500 g. Then, each animal piece costs about R$ 3.00 The gel spheres are acquired in stores for plant decoration, and one envelope (that can be used to produce five models for puncturing) costs approximately R$ 1.00. The fragments of Dacron® and PTFE® prostheses can be obtained from leftovers, not used in arterial operations, or as donations from manufacturers of these prostheses near the expiration date of sterilization. Nylon® and Prolene® threads can be obtained from the same source as that of prostheses. The cotton thread spool of 91.4 m, of household use, costs around R$ 0.77, and each model requires 50 cm. This way, the total cost of production for this animal tissue model for vascular access costs around R$ 3.21.

Conclusion

The animal tissue model for ultrasound-guided vascular access training developed by the authors of this article is low cost and of easy production and applicability in training professionals involved in such procedures.

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Statistical analysis: N/A
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