



Special Article

Cómo lo hago (*How I do it*)

Preparation of an ultrasound-guided vascular puncture simulator: How should I approach it?

Confección de un simulador de punción ecoguiada para el entrenamiento vascular. ¿Cómo lo hago?

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Simulator. Ecoguided puncture.

Abstract

The first manoeuvre to perform in all endovascular procedures is vessel puncture. It is known that puncture is more correctly done using an echography guide than considering classical anatomical references and pulse palpation. Practice with simulators helps experience obtention without danger for patients. We present this paper. It talks about how to produce a homemade simulator to practice eco guided puncture, cheap and easy to make for all Vascular Surgery departments.

Palabras clave:

Simulador. Punción guiada.

Resumen

La primera maniobra que debe realizarse en cualquier proceso de cirugía endovascular es la punción del vaso elegido. Está demostrado que esta punción es más correcta si se realiza de forma ecoguiada que mediante las clásicas referencias anatómicas y la palpación de pulso. Es obvio que la práctica con cualquier tipo de simuladores ayuda a ganar experiencia sin poner en riesgo a los pacientes. De todas estas afirmaciones, nace este artículo, en el que se presenta cómo construir un simulador que permita un entrenamiento de punción ecoguiada barato y fácil de fabricar, al alcance de cualquier servicio de angiología y cirugía vascular, docente o no.

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INTRODUCTION

The endovascular option is the first-line strategy for a large number of surgical procedures in vascular disease. The very first maneuver in any of these procedures is vascular access via percutaneous vessel puncture. Traditionally, arterial access has relied on pulse palpation and venous access on anatomic landmarks. Over the past decade, ultrasound-guided puncture has become widely adopted for central venous access (1). The UK's National Institute for Clinical Excellence and the US Agency for Healthcare Research and Quality have recommended routine ultrasound guidance for central venous catheter placement, establishing it as the standard of care (2,3). For arterial punctures, access-site complications occur in 1.5-4 % of patients undergoing diagnostic or interventional cardiac catheterization via the femoral artery (4,5). The goal of creating a puncture simulator is to acquire the skills required to perform proper ultrasound-guided puncture while minimizing the risk of complications and potential patient harm.

MATERIALS

- 1. *Plastic container.* Used as a mold for the gelatin. A capacity of 3.5 liters is recommended—large enough to create multiple puncture levels without being unwieldy (Fig. 1).
- 2. *Powdered gelatin.* The base puncture medium. It can be purchased in bulk online or in supermarkets (typically boxes with two 80-g packets). The target concentration is 800 g per liter of water (i.e., 10 supermarket packets per liter).



Figure 1. Example 3.5-L container.

- 3. *Plantago ovata (psyllium husk).* Adds echogenicity to the gelatin. Sold in pharmacies as a laxative (boxes of 30 packets, 3.5 g each). Use 5 packets per liter of water.
- 4. *Penrose surgical drains.* Used to create simulated vessels. Diameters vary; smaller diameters increase puncture difficulty. Typically, three drains per simulator.
- 5. Silk ties/sutures (size 2-0 to 1).
- 6. *Water-soluble dye.* purely cosmetic—to distinguish “artery” (red) and “vein” (blue). Food-grade gel colorants in tubes (red/blue/green/yellow) from baking aisles work well.
- 7. *Syringes.* For filling Penrose drains with dyed water. Any size; 10 mL standard works well.
- 8. *Liquid latex.* Final surface layer over the gelatin and Penrose drains to mimic “skin” and provide puncture resistance under ultrasound. Sold at costume/makeup shops.

METHOD

The build has four phases: (1) prepare Penrose drains as simulated vessels; (2) prepare the gelatin; (3) fill the container and assemble the simulator (4); apply liquid latex.

- 1. *Preparing Penrose drains as simulated vessels*
 - a) Mix red and blue dyes separately with water in two cups (no fixed dilution; adjust to desired intensity).
 - b) Tie one end of each Penrose with a silk ligature and reinforce with a second tie.
 - c) Fill the drain with the chosen dye using a syringe and tie the other end, again with two ligatures.
 - d) To purge air, hold the drain vertically before the final knots; place the second (reinforcing) ligature about 2 cm below the first so any residual air rises above it (Fig. 2).
 - e) Measure the container's diagonal to size the drain so it fits corner-to-corner..
 - f) Figure 3 illustrates a finished set of prepared Penrose drains.
- 2. *Preparing the gelatin*
 - a) Premix the powdered gelatin with Plantago ovata before adding to water (Fig. 4).

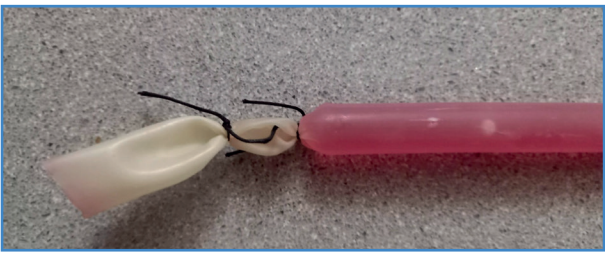


Figure 2. Detail of drain end ligation.

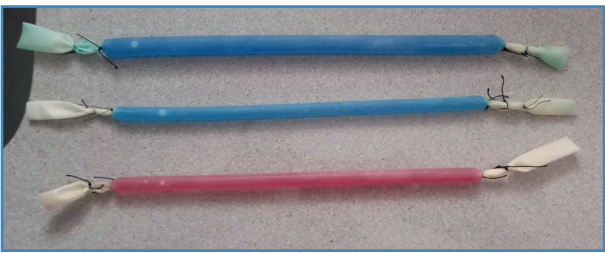


Figure 3. Final appearance of simulated vessels.



Figure 4. Gelatin and Plantago ovata amounts for 2 liters of water.



Figures 5 and 6. Evolution of the gelatin mixture from clumpy to homogeneous.

- b) Although formulas are given per liter, it is time-efficient to work in 2-liter water batches. With a 3.5-L container, 2 L of water (plus the corresponding gelatin/psyllium) often fills one simulator; you can also proceed liter by liter.
 - c) Heat the water (boiling not required).
 - d) Reduce to medium heat once hot to avoid protein denaturation at a full boil.
 - e) Gradually sprinkle in the gelatin-psyllium mixture while gently stirring. Avoid dumping large amounts at once, which causes hard-to-dissolve clumps.
 - f) Critical: Do not over-stir; excessive agitation traps air and reduces echogenicity. Stir just enough to break clumps and homogenize.
- Figures 5 and 6 illustrate the transition from clumpy to a smooth final mixture.
- 3. *Filling the container and assembling the simulator*
 - a) You do not need the mixture very hot; lukewarm gelatin is easier to handle.
 - b) Pour a ~2-cm base layer into the container (Fig. 7).
 - c) Chill in the refrigerator to set.
 - d) Once set, place the first layer of simulated vessels on the base (Fig. 8).
 - e) Add enough gelatin to fix these drains in place (Fig. 9). Work with lukewarm gelatin—if it is too hot, Penrose drains will tend to float.

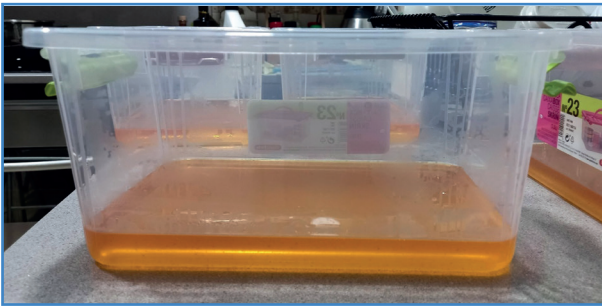


Figure 7. Gelatin base layer.



Figure 8. Simulated vessels placed on the base layer.



Figure 9. Fixation of vessels with a thin gelatin coat.

- f) Return the container to the refrigerator.
- g) After this layer sets, add more gelatin to fully cover the drains and create space for a more superficial puncture level.
- h) Chill again to set.
- i) Position the superficial Penrose drain, fix it with a thin layer of gelatin, and cover as above (Fig. 10).
- j) Perform a final refrigeration to set.
- 4. Applying liquid latex
 - a) Liquid latex smells strongly (ammonia/"fishy"); this is normal and disappears once dry.

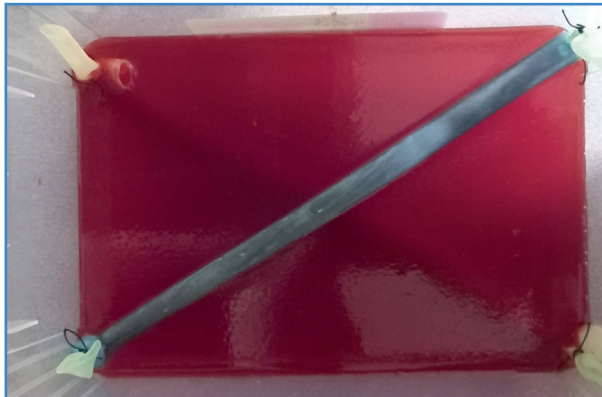


Figure 10. Positioning of the superficial simulated vessel.

- b) Apply an extremely thin latex layer: latex attenuates ultrasound, and a thick layer will block echoes.
- c) To achieve a thin coat, pour a small stream of latex at one edge and tilt the container to let it sheet across. If needed, spread lightly with a tongue depressor—an irregular, thin layer is far preferable to a thick one.
- d) Allow to dry for 24 hours.

Figure 11 illustrates the final appearance with the latex "skin." Figure 12 illustrates the ultrasound view of the simulator with Penrose "vessels."

If the development of a simulator for practicing percutaneous closure procedures is considered, it is advisable to choose a container with less height but greater length. This design facilitates the complete insertion of closure devices. To increase the complexity of the puncture technique, it is recommended to introduce various objects between the Penrose drains to imitate foreign bodies. We suggest using gummy candies for this purpose¹ or eggshell over segments of the simulated vessels to mimic calcifications "2". In addition, the incorporation of curves in the Penrose



Figure 11. Final result with latex surface.

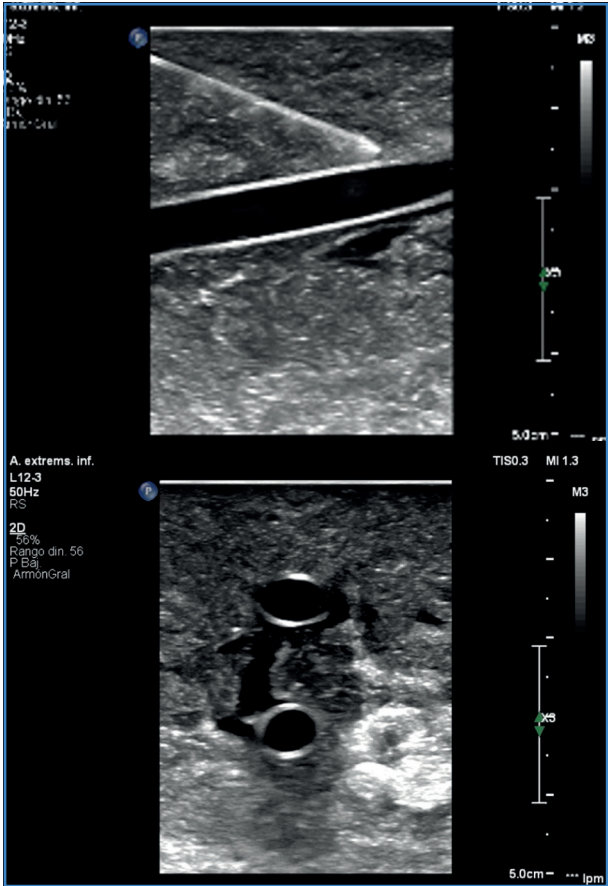


Figure 12. Ultrasound image of the simulator with Penrose "vessels."

drains and the use of different diameters—especially those as small as possible—further increase the complexity of the simulation setup, thereby creating a more challenging station.

CONCLUSIONS

Building a low-cost, home-made model for ultrasound-guided puncture is straightforward and widely accessible. It can meaningfully accelerate skill acquisition for this essential maneuver across endovascular procedures and serves as a useful teaching tool for all services—with or without trainees.

RECOMMENDED REFERENCES

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