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Short communication

Training phantom for ultrasound guided biopsy

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Abstract. Commercial phantoms designed for radiologists to practise the skills needed to biopsy lesions under ultrasound guidance can be prohibitively costly, and do not have an indefinite shelf-life. A gelatin-based in-house model has been developed to recreate the conditions found in human tissues, using materials which are cheap and in everyday use. This phantom remains useful for several weeks, although tears produced by the biopsy needle take progressively longer to bond when the reconstructed gelatin is older than a month. However, new phantoms can be built quickly and easily using fresh gelatin while recycling other components.

Introduction

Ultrasound guidance for interventional procedures such as percutaneous biopsy, cyst aspiration or catheter insertion is a well recognized and frequently used technique. Various needle guides that attach to the ultrasound probe are available but many radiologists, once adept at the technique, prefer to perform interventional techniques "free hand". It is, however, quite a difficult technique to learn. Most trainee radiologists' first attempts at locating needles in soft tissues and subsequently guiding them into lesions are associated with considerable anxiety and frustration. A suitable phantom would therefore be very helpful in allowing the trainee to practise the necessary skills before attempting any procedures on patients.

An ideal phantom will reproduce the texture and resistance of human tissue and inhibit sideways movement of the needle. There should be sufficient ultrasound penetration to enable identification and location of targets to a depth of about 10 cm, but close matching of the attenuation of the medium with tissue is otherwise unnecessary. Approximate matching of the velocity of sound is desirable as this determines distances in the ultrasound image. Damage caused by the insertion of the needle should be easily repairable.

Targets must be clearly distinguished from the surrounding medium in the ultrasound image, but the difference in accoustic impedences should not be so great as to produce reverberations. Targets must not corrode with time. It should be clear to the operator when contact has been made by the needle with the target.

Materials and method

200 ml gelatin solution was made up to four times the normal concentration and allowed to set in the base of a 20 cm diameter hemispherical teflon mixing bowl (Woolworths). Gelatin has firm texture at this concentration, with smooth resistance to passage of the needle. 10% formalin can be added to the solution as a preservative, but refrigeration has proved sufficient to prevent degeneration for up to 1 month.

A wire frame was placed over the bowl and used to drape several layers of latex rubber (taken from disposable gloves) so they roughly followed the curves of the container and simulated soft tissue layers. Small holes were made in the latex to prevent it pulling sideways through the gelatin when pierced by the biopsy needle. Further gelatin solution was cooled and poured down the inside edge of the bowl, taking care not to trap air bubbles.

Before adding the final surface layer, three holes were gouged at different positions and 8 mm plastic beads inserted. The beads had a slightly roughened surface so that the needle would not slip on contact. Gelatin was then poured in to fill these holes and provide the surface layer.

Just before the phantom set, a circular piece of 3 mm ribbed rubber matting, cut to size, was placed on the surface (again excluding all air) to minimize reflective echoes from the base. A Perspex stand was positioned over the rubber base, keeping it flat until the gelatin had set.

The phantom was hardened in a refrigerator, then inverted onto its stand and removed from the bowl. The latex rubber sheeting (0.18/0.25 mm Pearlsheen Gold from 4D Rubber Ltd) was stretched over the surface and secured with adhesive tape to the underside of the rubber base. It was now ready for use. For storage, the phantom, complete with latex covering and ribbed rubber base, is inverted back into the bowl, covered with the Perspex stand and placed in an airtight container for refrigeration. It is important that the phantom is not left at room temperature for long

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periods as this causes the gelatin to "weep". For an "advanced" phantom, "ribs" can be simulated by incorporating strips of the ribbed rubber approximately 1 cm deep in the gelatin. Super-glue is a good adhesive for this material. Figure 1a shows the rib structure in the gelatin phantom without the latex covering. Figure 1b shows the completed phantom in use.

Results

The gelatin mix provided adequate penetration and tissue simulation and lost only 3% of its volume through drying out in the first month. Distances measured using the machine callipers were correct to within 5%. Figure 2 shows the ultrasound image of the phantom with insertion of a 20 gauge spinal needle. The reflections caused by the layers of latex can be clearly seen, as can the passage of the needle through the gelatin. Confirmation that the target has been correctly hit is seen by the movement of the target on the ultrasound monitor and also by feeling when the needle hits the roughened edge of the bead. The needle track persists following withdrawal of the needle, but the defect disappears after a few hours, allowing multiple practice sessions from one

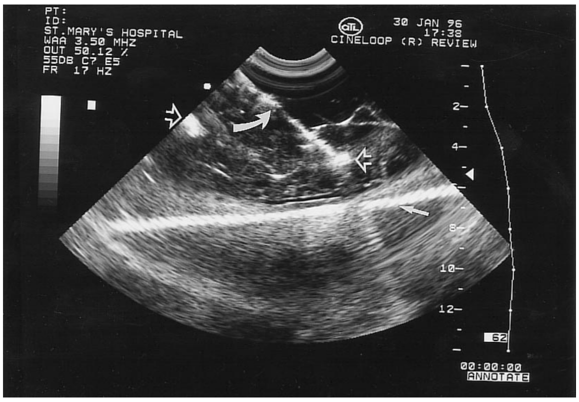
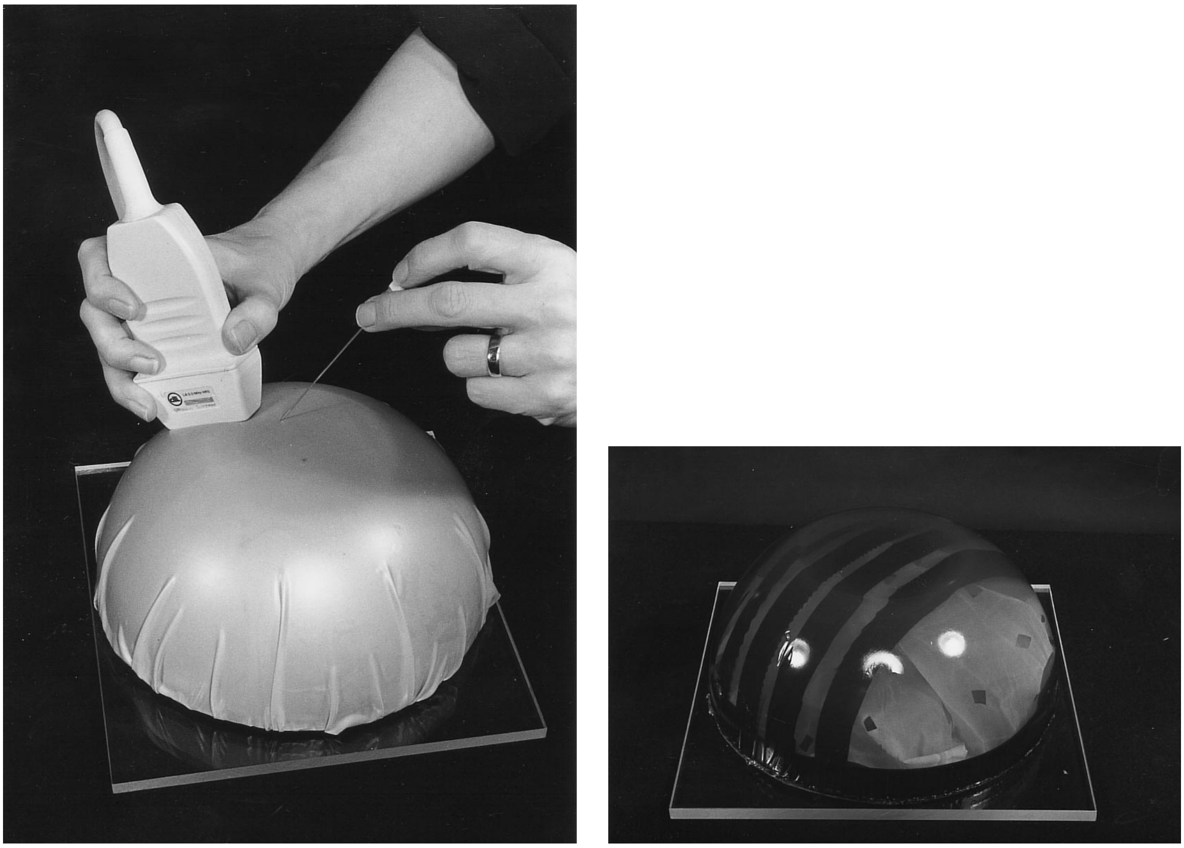


Figure 2. The ultrasound image of the phantom including two of the targets (open arrows). A spinal needle (curved arrow) is being guided towards one of the targets and the ribbed rubber base is indicated by the small arrow.

phantom. Persistence of the needle track is minimized by using needles with central stylets to avoid introducing air into the gelatin.

There have been no problems from repeated puncturing of the latex covering; 1 square cm of latex under tension could be punctured over 100 times without tearing.

The phantom has been used by both experienced



(a) (b)

Figure 1. (a) The training phantom before the latex cover has been added. The membranes representing organ boundaries can be seen, along with strips of ribbed rubber matting which simulate the ribs. (b) The completed phantom in operation.

and inexperienced radiologists and found to be very useful as a teaching aid.

Discussion

There is undoubtedly a need for a phantom on which to practice freehand needle guidance. Systems have been produced but they are expensive and have a limited shelf-life, rarely exceeding 2 years.

An alternative suggestion has been the use of animal models, specifically turkey breasts [1], but again they can only be used for a very limited period of time and need frequent replacement.

These phantoms can be used for up to a month. They are relatively easy to prepare, taking approximately 3 h, and are cheap with total material costs amounting to less than £20. Most of the component parts are reusable so a replacement can be created for the cost of the gelatin (under £3) when the original phantom eventually becomes non-usable.

Addendum

A difficulty encountered in preparing the phantom related to buying small quantities of the latex covering and ribbed rubber matting. The latex rubber is supplied by some, but by no means all, fabric retailers at approximately £14 per metre. 40 cm should be adequate to cover both basic and advanced phantoms. A 20 cm square of ribbed rubber matting is required for the base of each phantom, and any excess may be used in constructing the ribs.

Reference

1. Sheils WE, Babcock DS. Practical models for invasive sonography, RNSA Scientific Exhibit. *Suppl Radiology* 1991;181:336.