An indigenous model for learning ultrasound-guided interventions

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Abstract

Ultrasound-guided interventions require good hand–eye coordination with respect to probe control and needle orientation. We describe a method of making an ultrasound phantom for practice purpose using an edible jelly mixture. The phantom is easy to make, reproducible, cheap, and simulates *in vivo* target.

Key words: Ultrasound-guided biopsy; ultrasound phantom; home made phantom

Introduction

Ultrasound phantoms are of two types.[1] One group which is made of agar with suspended component, for example, graphite,[2] polyurethane foam,[3] and magnesium silicate gels,[4] approximates the acoustic properties of tissue *ex vivo*. The phantoms in this group are mostly used as test phantoms for evaluation of ultrasound equipment and to study tissue–acoustic interactions.

The other group of phantoms approximates the sonographic appearance of tissue and is useful as a biopsy training model.

Several homemade biopsy phantoms have been described for simulation of ultrasound-guided biopsy. They include corn flour in gelatin suspension,[5] agar,[6] or silicum carbide powder in agar suspension.[7] Few organic materials such as chicken breast and pork tissue have also been described.[8,9]

Technique

We tested preparing one such phantom using the gelatin solution or a mixture of corn flour with gelatin. However, after freezing the solution, we observed that it is quite difficult to pass a needle into the frozen block. Also, the phantom was not sufficiently sonolucent.

We also tested making a phantom using the commonly available jelly crystals [Figure 1] and describe the same here. Around 350-400 ml of boiling tap water is poured into a plastic or glass bowl which contains the gel powder (70-80 g). Small grapes are placed within the mixture to simulate a sonolucent target, for example, cyst [Figure 2]. Mustard seeds placed within the mixture can simulate microcalcifications. Solid target can be simulated using a half-cut lemon/walnut secured to the base of the bowl using adhesive tape [Figure 3].

The mixture is allowed to cool down at room temperature for 30 min. Subsequently, it is placed within the non-freezer compartment of a refrigerator (4°C) for a period of 12 h.

Once it solidifies, it can be either used as such (in the plastic bowl) [Figure 4] or the solidified gel can be poured out by warming the glass container from the outside (by placing it in lukewarm water).

The ultrasound probe is covered with a plastic bag and the phantom could be used for practising ultrasound-guided targeting using needles of varying sizes.

Discussion

Ultrasound-guided procedures such as needle aspirations,

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Figure 1: The jelly pack used to prepare the phantom

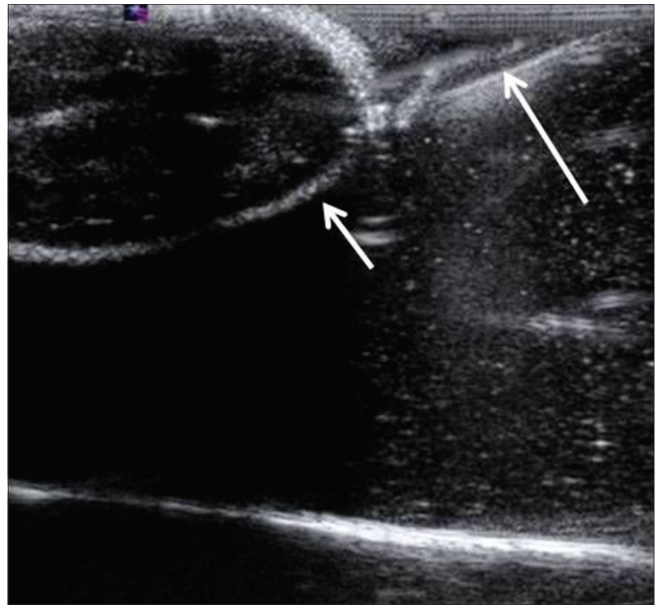

Figure 2: The grape embedded within the jelly simulates a cyst (short arrow) with good needle visualization (long arrow)

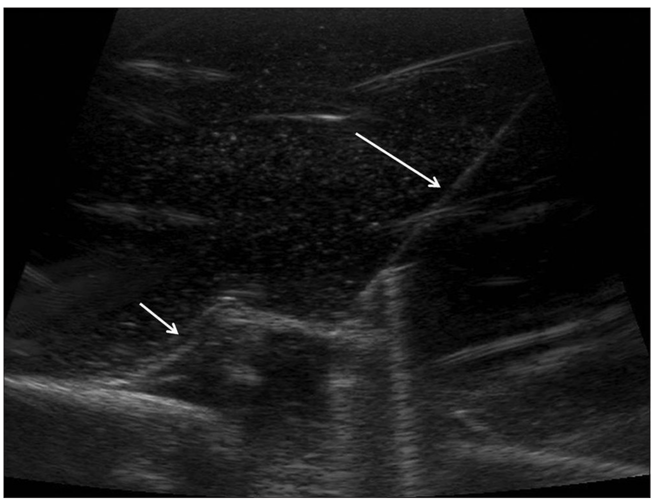

Figure 3: A walnut (short arrow) used to simulate a solid lesion. The long arrow indicates the needle

Figure 4: The appearance of the prepared phantom in a plastic bowl

biopsies, and drainage of abscesses/collections constitute an important segment of workload in a radiology department. For accurate needle placement within the target with minimum number of passes, it is imperative that the radiologist has good coordination between the hand, needle, and the projected sonographic image. Use of a biopsy phantom can shorten the learning curve of this process.

Either commercially available phantoms or the ones made using household raw materials can be used. The former are costly and difficult to procure. Several household phantoms have been described in the literature.

Bude and Adler[1] described a phantom made using gelatin and psyllium husk. They used substances like grapes, water-filled gloves, etc., to simulate cystic targets and solids like macaroni, carrot pieces, olives, etc., to simulate "masses." They prepared the phantom in stages in order to incorporate the targets within it. According to the authors, the phantom is easy to prepare, provides good sonographic simulation, and does not undergo microbial degeneration for many weeks if refrigerated.

Another phantom described by Xu *et al.*[8] uses a tendon embedded within a porcine muscle. According to them, this phantom is less likely to show an artifact after repeated needle passes than a gelatin-based phantom. The disadvantage of this phantom is that only a solid target can be embedded within it.

Silver *et al.*[6] used an agar mixture filled enema bag to prepare a phantom. They also used water-filled glove tips to simulate cysts, with macaroni and carrot pieces to simulate solid targets. Their phantom generally lasted 1 week, and according to the authors, it costs $20.

A gelatin-based phantom was described by Osmer.[10] The author used quadruple strength gelatin and suspended objects like macaroni and grapes within it as targets.

The qualities of an ideal ultrasound biopsy phantom are: sonolucent, relatively opaque from the exterior, easy to prepare, long lasting, and economical.

We observed very good tissue-mimicking properties of our model with regards to both sonolucency of the gel which ensured good needle visualization [Figure 2] and excellent target gel distinction which ensured good visualization of the target (cysts and microcalcifications).

No ultrasound gel is required between the probe and the phantom. The probe should not be pressed too hard on the phantom; otherwise, it may crack at the surface.

The colored gel makes the phantom relatively opaque. So, it precludes needle visualization from the exterior, thereby approaching an *in vivo* situation. The phantom was used in different angles to demonstrate its use in superficial and deep location of suspended objects. The phantom is suitable to mimic both superficial (up to 3 cm) and deeper (3-10 cm) tissues using high- and low-frequency probes.

The cost of a gel pack is Rs. 45 (less than a dollar) and is available at most neighborhood provision stores. The phantom can be used for 40-50 needle passages.

The advantages of this phantom compared to the commercially available phantoms are: affordable cost (a commercial phantom costs about $100) and relative ease of preparation. The phantom is stable and usable for several weeks when stored at room temperature away from direct sunlight. These factors are especially important in developing countries where the radiology department of a tertiary care hospital performs an average of 100 ultrasound-guided procedures per month, and hence, good hand–eye coordination is paramount for a practising radiologist.

There are certain shortcomings of the phantom described here by us. In our observation, the jelly breaks at its surface after 40-50 needle passes. On certain occasions, the jelly does not set properly and one has to keep it in the refrigerator longer than 12 h.

The consistency of the prepared jelly is not always constant. If it is too soft, the user has to be careful so that the probe pressure does not break the jelly surface.

Graded layering and preparation of the jelly can be an improvement on this model whereby the targets can be embedded within it rather than being secured by tape.

Conclusion

The authors believe that this low-cost technique for making an ultrasound phantom can be extremely useful for training of ultrasound-guided needle placement within a target. This would help the radiology trainees to develop a hand–eye coordination necessary to perform ultrasound-guided interventions without trying it for the first time on a patient. However, the authors admit that this is not a substitute for the high quality, but expensive commercially available ultrasound phantoms.

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