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Novel Homemade Trans-Rectal Ultrasound Biopsy Training Phantom

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Key Words

Biopsy • Phantom • Trans-rectal ultrasound biopsy • Prostate

Abstract

Ultrasound phantoms are very helpful in allowing the trainee to develop the necessary manual coordination skills before attempting any procedure on patients and compromising their safety. The construction of agar-based trans-rectal ultrasound prostatic biopsy phantom, using inexpensive and simple materials, is described. Features include tissue-equivalent reflectivity, the ability to implant targets for biopsy taking and reasonable shelf life of several weeks. Our phantom is an effective mean of training and skill acquisition for a one of the frequently performed invasive urological procedure.

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Introduction

Since the introduction of prostate specific antigen (PSA), as a marker in the diagnosis of prostate cancer, the rate of biopsies taken from the prostate has increased. Currently, prostate biopsy is one of the frequently performed urological interventions.

Since Hodge et al. [1] demonstrated the superiority of the trans-rectal ultrasound (TRUS) guided needle biopsy of the prostate over digital guided biopsy; it has been the standard technique in the diagnosis of prostate cancer both in hospital and office settings. The TRUS guided biopsy of the prostate is considered to be an invasive procedure with a significant morbidity, especially when more biopsy cores are taken to increase cancer detection [2]. Simulation of the ultrasound appearance, by using tissue phantom, during TRUS guided biopsy of the prostate would therefore be very helpful in allowing the trainee to develop the necessary manual coordination skills prior to attempting any procedure on a patient and compromising his safety.

Important features of any tissue phantom are tissue equivalent velocity, reflectivity and long-life [3]. Although commercial TRUS phantoms are available, their main disadvantages are; the cost and degradation of the ultrasound medium with multiple and/or improper use (such as injection of fluid/air into the phantom).

In this paper we present our originally designed TRUS guided prostatic biopsy phantom that we have developed which is inexpensive, effective, and renewable.

Table 1. Materials and concentration

Tissue equivalent materials	Tissue type	
	Soft tissue	Prostate
Agar concentration (%)	4	4
Corn flour (g/l)	120	–

Material and Method

Our phantom uses bacteriological agar gel based on published models [3–5]. Varying proportions of corn flour was used to manipulate echogenecity. In addition, Chlorhexidine is added to prevent putrefaction. The materials required and their relative concentrations are presented in table 1.

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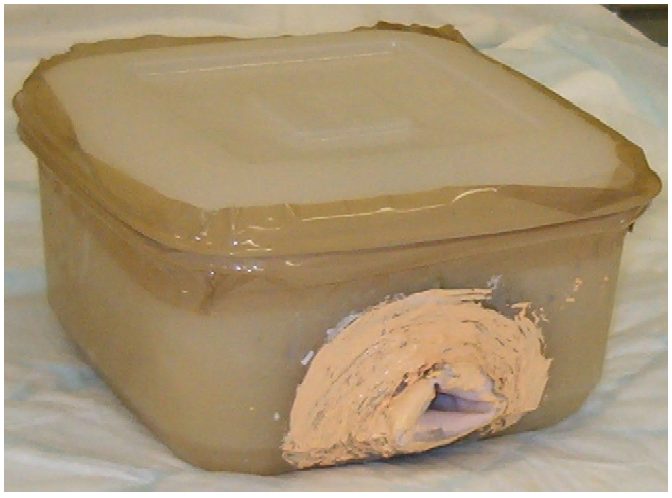

Fig. 1. Completed phantom ready for use.

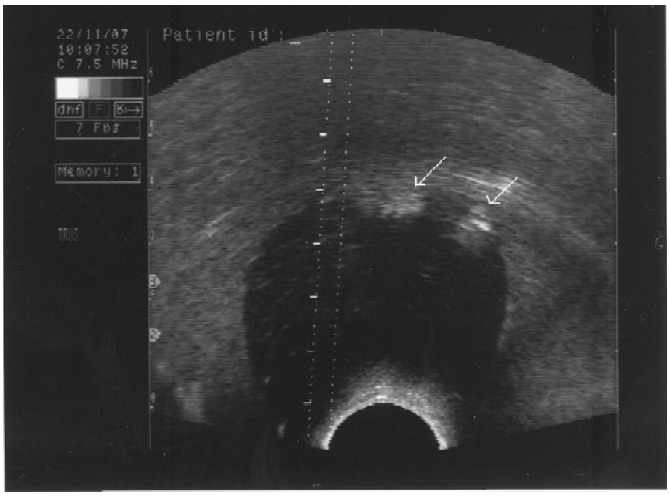

Fig. 2. the ultrasound image of the phantom with the needle biopsy guide on the screen.

The first step is to choose a reasonable plastic container 2–3 l in capacity with a lid cover and at least 10–15 cm in height. We used a 3 l food storage container (Woolworths, London, UK). On the sidewall of the container a 3-cm circular hole is cut through to imitate the anal opening for the insertion of the ultrasound probe. The middle finger of a household kitchen glove (Lidl, Wimbledon, UK) is cut and secured to the inside margin of the anal opening on the container with a silicon sealant (B&Q, Hampshire, UK) in a watertight fashion to act as the rectum.

The second step is making the agar solution, to form the prostate gland and the surrounding soft tissues.

Boil 2–3 liters of water (depending on the container capacity) and whilst stirring, slowly add the agar powder (we used Agar No 1- Biotec Laboratories Ltd, Suffolk, UK) to prevent clumps formation . After boiling the liquid agar for 3–4 min, it is then removed from the heat.

Next, Chlorhexidine is added while continuously stirring (we used two 25 ml Unisept® sachet containing chlorhexidine gluconate 0.05% w/v-Medlock, Oldham, UK). At this point, the prostate gland is made; by aspirating 60–80 ml of the liquid agar solution, using a 50 ml bladder syringe, and then injecting it into a rubber balloon. The rubber balloons were found to be most successful for this purpose (can be bought from the majority of superstores). To simulate the target cancerous lesions, 3–4 Raisins (dried grape) are placed into the balloon first followed by injection of the liquid agar. The balloon is then tied off with silk or any thread. To prevent the stretching and deformation of the balloon because of the hot agar, it is immersed in a cup of cold water and kept it in the fridge till it has hardened.

To the agar-Chlorhexidine mixture, corn-flour is added (can be bought from any food store). However, to prevent clumps formation, the corn-flour is dissolved into a small cup of warm water to form a liquid milky solution that is slowly added to the agar while stirring. The mixture must be constantly stirred after adding the corn-flour, to prevent it settling out.

Pour the mixture into the container up to and just above the level of the finger glove (rectum) and immediately put it in a freezer to cool and set this first layer of agar. Meanwhile, keep stirring the remaining hot mixture and if necessary re-heat it again to keep it in the liquid state. After 15–20 min the agar in the container will have hardened. Remove the prostate gland from the fridge and position it over the finger glove (rectum) to resemble the normal anatomy. Following that, pour the rest of the hot agar mixture over it to fill the rest of the container and form a second layer. Again place the container in the fridge and keep it in for 4–5 h to completely set the phantom.

Once the phantom is complete, a thin layer of baby oil or light vegetable oil is poured over the surface to form an air tight protective layer. Furthermore, should the agar gel separate from the container wall, oil will then disperse to fill the gaps and prevent air being trapped in and degrade the quality of the ultrasound image. The container is then covered with the lid and sealed with a silicon sealant around the edges. An optional sealing tape can be applied to the covering lid to secure it in place. Figure 1 shows completed phantom ready for use.

Results

The described training phantom is effective for simulating TRUS guided biopsy of the prostate. The agar mixture provides an adequate tissue simulation and penetration. Figure 2 shows the ultrasound image of the phantom with the needle biopsy guide on the screen. The reflection caused by the peripherally located targets lesions can be clearly seen, as can the passage of the biopsy needle through the agar mixture. There have been no problems from repeated use and puncturing of the glove

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finger or the rubber balloon. The phantom has been tried by the urology team at our department as a training tool. All staff reported positive feedback and were satisfied with the use of this training phantom for acquiring TRUS guided prostatic biopsy skills.

Discussion

Traditional methods of teaching involve practice during the performance of procedures on patients under the supervision of an experienced instructor. However, to minimize performance error and maximize performance quality, many professions rely on the concept of using skill repetition in a non threatening environment.

With increased public expectation and demand for better training before embarking on minimally invasive procedures, training models have been developed in many areas of Medicine and surgery. Models will allow repetitive performance of complex and/or invasive procedures and are invaluable for initial training as well as continuing education as new devices are introduced.

Some investigators assessed the direct transferability of skills learned on a training model to the clinical setting [6, 7]. They demonstrated that these models are useful for learning and, that the skills acquired were transferable to the clinical environment.

Phantoms represent 'constant patients', which may be scanned by different individuals at different times – with identical results if the same technical setting and scan techniques are used. Therefore, they could provide valuable preclinical scanning experience. Also of significance, this scanning is obtained without concern for patient safety.

Interest in the use of phantoms dates to the 1970s when Madsen and Zagzebski [3] developed tissue-mimicking material for use in ultrasound phantoms. Since then commercially available phantoms have been produced for health care professionals to practice and enhance the skills needed to biopsy various lesions under ultrasound guidance. However, they can be expensive and have limited shelf life, especially with repeated use. Therefore, many reports on simple made in-house models developed using materials which are inexpensive and in everyday use, have been published [8, 9]. Our phantom is easy to prepare, inexpensive with total material cost of less than £30 ($ 55), and can be used for up to a month with most of the components being reusable.

Furthermore, because of the similar anatomical configuration to the prostate and the several embedded targets in the phantom, the trainee can search for these items and thereby develop the hand-eye coordination skills that are ultimately of paramount importance in ultrasound guided biopsy techniques.

Conclusion

We believe that we have developed a novel, inexpensive and realistic simulator for the training of TRUS biopsy of the prostate. Our phantom is an effective mean of training and skill acquisition for one of the frequently performed invasive urological procedures. Patient care and safety are not compromised, thereby, creating a suitable environment for supervised, repetitive performance of demanding manual skill.

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