

Preparation of a Homemade Ultrasound Biopsy Phantom

M. P. McNamara, Jr., MD, and Meghan Edith McNamara

Sonographic guidance has long been employed for biopsy with sector scanners by utilizing attachable offset guides,¹⁻⁵ by dedicated linear array systems,^{6,7} or by "free hand."⁸ All of these techniques are bimanual, in contrast to a diagnostic scan or biopsy alone.

The dedicated systems provide a slot that causes the needle to be directed into the center of the scanning plane. When the procedure is done free hand, a greater degree of hand-eye coordination is necessary to achieve success. Based on the position and depth of the target, one must estimate the correct angle of attack, as well as maintain the axis of the needle within the scan plane. Recent papers by Fournage et al.⁹ and Reading et al.¹⁰ have confirmed that with skill and experience, excellent results can be obtained free hand with linear array probes. We believe use of a biopsy phantom can shorten the "learning curve" by allowing the learning and practice of the bimanual skills and hand-eye coordination necessary for successful biopsy.

In this paper, we present a method for easily making a biopsy phantom. The substance of the phantom is a hyperconcentrated gel solution. Flour serves as a scatterer and produces background echogenicity similar to liver parenchyma. Our favorite target is a small water-filled balloon containing a pebble.

MATERIALS AND METHODS

To make this target, a small pebble is placed within a finger of an examining glove. Water is placed into the finger, which is then gently tapped to exclude small air bubbles. It is then twisted so that the water is squeezed into the fin-

gertip portion. A knot is tied near the upper and lower portion of the twist, and a cut is made between the knots so that the distal water-filled portion of the finger becomes a small balloon.¹¹

The following ingredients are utilized for the phantom substance:

- 50 grams of unflavored commercially available powdered gelatin (6 packets of Knox brand gelatin)
- 25 grams of all-purpose flour (1 level cook's tablespoon)
- 375 mL (1½ cups) boiling water
- Ice cubes sufficient to make 125 mL (½ cup) of water when melted (since ice cubes do not come in standard sizes, we empirically found the correct number of cubes by placing them one by one, into a Pyrex measuring cup and heating until melting occurred)
- A bowl to hold the phantom that, when filled, will contain slightly more than 2 cups by volume

Combine the unflavored gelatin with flour in the bowl. Add 1½ cups boiling water, and stir until the gel/flour mixture has dissolved. This usually takes approximately 10 minutes.

At times, there will be small clumps of gelatin that remain undissolved and these can be discarded without affecting the quality of the phantom. Following this, the ice cubes are added one at a time, allowing each to dissolve before putting in the next. Stirring is continued as each dissolves. It is important not to add too much ice too quickly, as substantial gelling of the portion of the solution immediately adjacent to the ice can occur prematurely. The goal is to cause it to cool as uniformly as possible so the flour is evenly dispersed. The solution generally begins to thicken slightly as the cubes are added. However, at times the beginning of gelling occurs near the end of the ice addition, and in that situation no further ice is added and the undissolved fraction of the last cube is spooned out. The target is then put into the phantom. The

From the Department of Medical Imaging, Adams County Hospital, West Union, Ohio. For reprints contact M. P. McNamara, Jr., MD, Department of Medical Imaging, Adams County Hospital, 210 North Wilson Drive, West Union, Ohio 45693-0271.

phantom is placed in the refrigerator where it is allowed to continue to cool and firmly gel, approximately 2 hours to 3 hours.

DISCUSSION

The acoustic properties of gel-based phantoms have been extensively studied by Madsen et al.¹² Since our phantom is utilized for biopsy rather than for performance evaluation of the ultrasound equipment, the speed of sound, scattering coefficients, and attenuation coefficients are unimportant, and additives such as alcohol (which adjust the speed of sound in the material) are unnecessary.

Our phantom simulates the ultrasound appearance of a gallstone within a gallbladder surrounded by liver substance (Figure 1). Consistency of the phantom is somewhat spongy; it is not a firm block. The needle can be inserted without difficulty and its sonographic appearance is quite similar to what is seen during patient biopsy. The phantom will last for approximately two days at room temperature before

desiccation and microbial growth become a problem.

Commercially produced biopsy phantoms are no longer available as stock items but it is possible (although costly) to have a phantom specially fabricated (ATS Laboratories, Inc., 404 Knowlton Street, Bridgeport, Connecticut 06608, or Radiation Measurements, Inc., 7617 Donna Drive, Middleton, Wisconsin 53562).

A homemade biopsy phantom has been previously described by one of us (MPM) utilizing an intact beef liver.¹¹ An Agar-based phantom that can be made within a laboratory setting¹³ has also been reported. Our current phantom is the most easily produced and is very inexpensive (less than one dollar). It can be made out of readily available ingredients by individuals inexperienced in either cooking or laboratory techniques. The recipe is "forgiving" as minor deviations still result in a quite acceptable phantom. Our one "failure" resulted when there was premature settling of the flour, resulting in a gradation of background echogenicity. This was easily compensated for by increasing the near gain.



FIGURE 1. Needle within the phantom.

A variety of targets can be utilized, but "simple cysts" are not feasible. A water-filled balloon will float to the top of the solution before it gels without the ballast provided by the small stone. One can place a small piece of fruit into the balloon with the pebble or just simply put the pebble, itself, at the bottom of the phantom to be used as a target.

Although the phantom described is utilized for small-parts biopsy practice, larger phantoms can be constructed by doubling or tripling the recipe as needed.

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