International Journal of Basic and Applied Biology
Print ISSN: 2394-5820, Online ISSN: 2349-2539, Volume 2, Number 6; July-September, 2015, pp. 404-407

http://www.krishisanskriti.org/ijbab.html

Development of Bacteriological Gelatin - Based Breast Phantom Training Tool for Ultrasound - Guided Procedures

Ashwani Kumar[1], Anju Gupta[2], Pradaman Singh[3] and Ravinder Kumar[4]

[1,2]Department of Biomedical Engineering, Guru Jambheshwar University of Science & Technology, Hisar (Haryana) India
[3]Department of Radiology, Janta Hospital, Barwala (Hisar) Haryana India
[4]Faculty of Physics(HES-II), Department of School Education Haryana, Panchkula (Haryana) India
E-mail: [1]asgundli281@gmail.com, [2]anjugupta.bme@gmail.com, [3]drpradman@gmail.com, [4]ravinderkumar17@gmail.com

Abstract—*The prime motive of using an ultrasonic tissue phantom is to experience the trainee / beginner to exercise free-hand over ultrasonic-guided procedures like localization of targets of interest, needle biopsy, needle localization and core biopsy. Several ultrasonic phantoms have been developed using various materials such as agar, tofu, chicken breast, gelatin etc for the same. Molecular gelatin used for developing gelatin based phantoms is very expensive and targets of interest are embedded layer by layer. In present study, bacteriological gelatin is mixed with different proportions of pasteurized double toned milk and tap water for developing a breast tissue phantom to be used as a training tool for ultrasonic-guided procedures. This mixture is stirred slowly and heated at 90^{o}C.Then mix preservatives and food color to this molten mixture at 50^{o}C. The mixture is then poured into plastic, non-reactive breast dummy model .Some targets that mimic cystic lesion, solid lesion and other targets of interest embedded simultaneously without creating any layers. After freezing at 6^{o}C for hours, the solid breast shaped phantoms are removed from dummy and examined under ultrasound modality for surface texture and echogenicity. The resulting images were then carefully examined and analyzed in comparison with images of human breast with cystic lesions and images of other expensive breast phantoms available in market. It is found that the images of bacteriological gelatin phantom almost resemble the human breast tissue fat in texture with echogenic medium and all targets of interest are clearly visible. Hence, this phantom may be used as a training tool for ultrasound-guided procedures.*

1. INTRODUCTION

The breast is the tissue overlying the chest (pectoral) muscles. Women's breasts are made of specialized tissue that produces milk (glandular tissue) as well as fatty tissue. The amount of fat determines the size of the breast.

In India, the average age of developing a breast cancer has undergone a significant shift over last few decades. An increasing numbers of patients are in the 25 to 40 years of age, which is a very disturbing trend [www.brestindiacancer.com]. Initially many imaging methods failed to differentiate between benign and malignant lesions. Later with evolution of breast ultrasound hopes of a screening method that could replace x-ray mammography were generated. Now ultrasound is the second most used modality for diagnosing breast abnormalities followed with mammography or alone after feeling physical breast hardness.

In medical terminology, phantoms are physical models which simulate some characteristics of real human tissues and are developed for the purpose of providing clinical education. An ultrasonic guided clinical education includes localization of targets of interest, needle biopsy, needle localization and core biopsy. Safe and successful performance of such procedures requires a high level of spatial reasoning and hand-eye co-ordination skills, which must be developed through intensive practice. Again intensive practice may require more female patients with life threatening risk to patient. Patient care and ethical issues demand for some physical model for free hand practice. In this paper, we present a simple procedure to develop a breast tissue phantom that almost mimics the echogenic texture of normal human breast adipose tissue ideally suited for ultrasound imaging. Simulated targets with different echogenicity are also embedded in breast phantom. This phantom is more eco-friendly than currently available phantoms as it uses cheap bacteriological gelatin instead of molecular gelatin.

2. MATERIALS AND METHODS

The bacteriological phantom is developed using commonly available household materials. The procedure is carried out at Fermentation and Immuno-Technology Laboratory, Bio and Nano Science Centre, Guru Jambheshwar University of Science and Technology (Hisar), Haryana (India). In this procedure 100 gms of soybean daal (Indian commonly used food pulses) is boiled with 250ml tap water for 5-7 minutes on an electric heater (temperature of heater set to be at 100^{o}C).

Simultaneously 350 ml pasteurized double toned milk is repeatedly boiled and cooled for three times. Each time the fat layer obtained is removed after cooling. 100ml of boiled soybean-water is filtered, and is added to 120 gms of bacteriological gelatin (Fisher Scientific India Pvt. Ltd.) at 90^0C. The mixture is slowly stirred with a plastic stir rod for 2-3 minutes without letting the formation of air bubbles. This gives the required fat texture to the phantom. Then, 200ml of the boiled milk is added to the gelatin mixture and is continuously stirred for 15-20 minutes allowing the gelatin to dissolve completely. Addition of milk produces echogenic medium for ultrasound mechanical waves and also gives strength to the fat texture. The mixture is cooled to 50^oC and 0.2 gms of EDTA (Ethylenediaminetetraaceticacid, disodium salt, SRL Company) is added as preservative. To make the phantom opaque, 1 drop of red and 2 drops of yellow food color dyes (ANUJA) are added to the mixture. Simulated targets are adjusted into a non-reactive, plastic breast dummy model assisted by threads. In this study, simulated targets are a water balloon (which mimics cystic lesion), stone and marble (which mimic solid lesion), 2 macaroni pieces, 1 potato piece, 1 needle (acting as target of interest); ensuring that targets are tied tightly, otherwise water balloon may float, needle may come out from the mixture and other targets may settle down. After cooling the molten mixture to 37^oC, it is poured into the non-reactive plastic breast dummy and is placed in a freezer at 6^oC for 15-18 hours. This method enables us to introduced simulated targets without creating any layers. Layers create impedance issue which affects the scan. After freezing solid mixture is kept out from dummy and is ready to be used as breast phantom training tool for ultrasound guided procedures.

Fig. 1: Bacteriological Gelatin - Based Breast Phantom (Developed in the lab)

Fig. 2: Image of Phantom available in Market [www.bluephantom.com]

It is found that without adding EDTA, phantom degrades within 4-5 days and fungus grows on its surface. The role of EDTA greatly improves the shelf-life of phantom to 15-18 days, which can be stored at a temperature of less than 15^0C in an air-tight container.

3. RESULTS AND DISCUSSIONS

Ultrasound systems use special processing circuits to translate the amplitude of echoes into brightness levels on the video monitor. As per the objective of presented paper, for clear visualization of simulated targets embedded within phantom, Ultrasound (US-Scan) of phantom is performed under US-Modality (GE Voluson P8) at Janta Hospital, Barwala, Distt. Hisar (Haryana). US modality consists of high resolution linear and concave transducers. The phantom is placed on a stable, level surface for scanning. Fig. 3 shows the echogenicity of the fat texture in the phantom which mimics fat texture as seen in sonogram of the normal breast tissue (Fig.4).

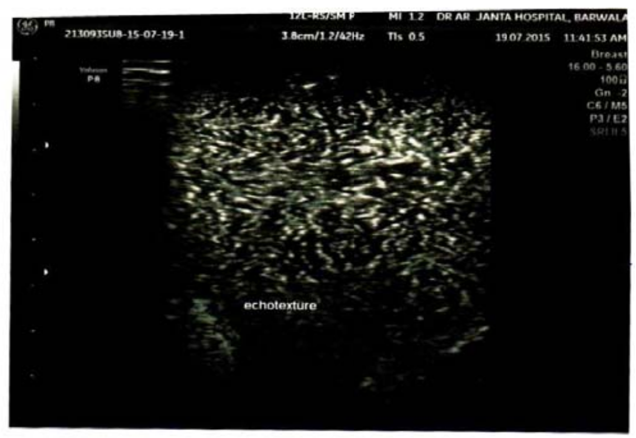

Fig. 3: Sonogram of Phantom Echotexture (Imaging done at Janta Hospital, Barwala)

Comparison of the US-Scan of fig. 3 and fig. 4 shows that phantom almost resembles the breast parenchyma.

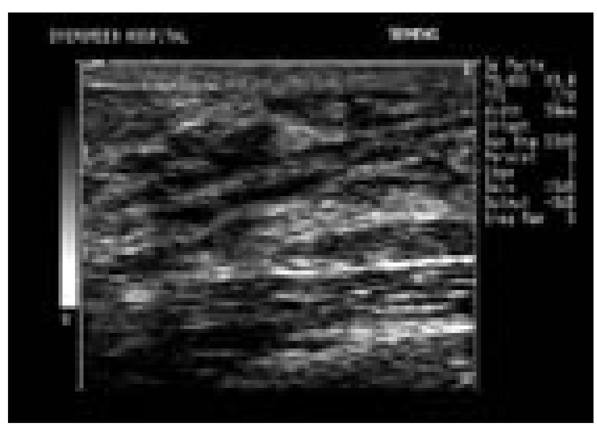

Fig. 4: Sonogram of Normal Breast Fat Tissue [Image courtesy: www.google.com/normal breast sonogram]

Fig. 5. shows how a water balloon target looks like in US scanning. It is observed that the water balloon looks like a simple cyst in phantom which simulates a simple cyst in normal breast fat tissue (as shown in Fig. 6) and also in US Scan of phantom available in market (as shown in Fig. 7).

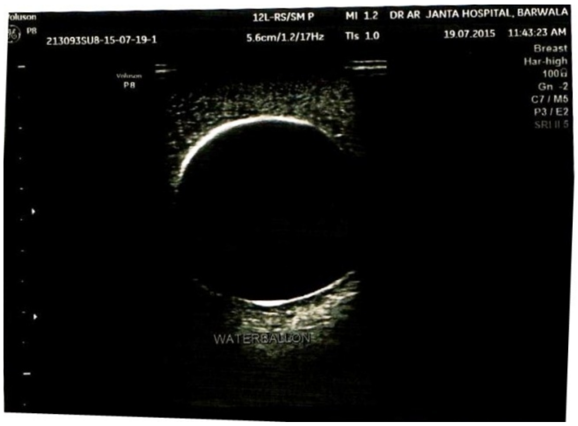

Fig. 5: Sonogram of Water Balloon (mimicked cystic lesion) in phantom (Imaging done at Janta Hospital, Barwala)

Fig. 6: Sonogram of Simple Cyst in Normal Breast [Image courtesy: www.google.com/cystic breast sonogram]

Fig. 7: Sonogram of Cyst in Phantom Available in Market [Image courtesy: www.blue phantom.com]

Fig. 8 gives the true picture of target of interest, stone and needle overlying the stone reflect the ultrasound waves as microcalcification does in normal human breast tissues (Fig. 8).

Fig. 8: Sonogram of Stone in Phantom (Imaging done at Janta Hospital, Barwala)

Fig. 9 and Fig. 10 give the true picture of other targets of interest embedded in phantom during development.

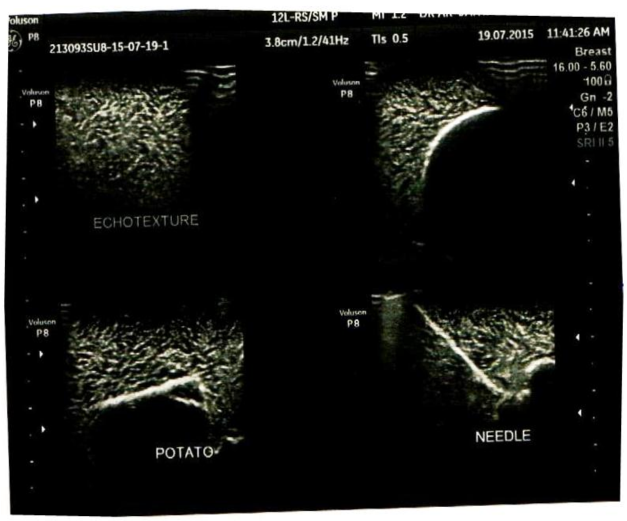

Fig. 9: Sonogram of Echotexture, Potato, Needle and Marble in Phantom (Imaging done at Janta Hospital, Barwala)

These results fulfill the objective of clear visualization of all simulated targets and achieve the desired fat texture which mimics the texture of normal human breast tissue. Some caution during scanning are mandatory like not to press the transducer into the scanning surface with great force. This damages the scanning surface and will shorten the life of the phantom. For curved transducers, water or a thick gel layer is used. The scanning surface is immediately cleaned after use with a soft cloth or paper. A 5.5 MHz probe will provide a good overall view of the phantom for this demonstration.

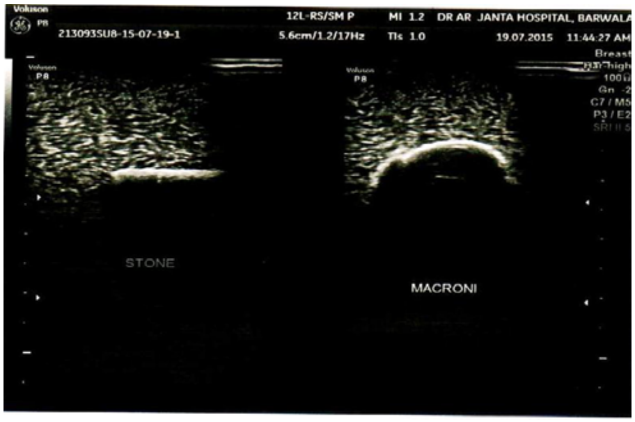

Fig. 10: Sonogram of Stone and Macroni in Phantom (Imaging done at Janta Hospital, Barwala)

4. CONCLUSION

This simple phantom can be made swiftly at virtually very low cost in comparison to the presently available phantoms in the market and can be used to improve performance, as well as, increase confidence for learning ultrasonic guided procedures like free-hand biopsy, needle localization, needle insertion and core-biopsy.

5. ACKNOWLEDGEMENTS

The entire work of phantom development would not have been possible without the valuable guidance, help and co-operation of Dr. Anil Bhankar, Mr. Rohit, Mr. Pradeep, Ms. Hemlata, Ms. Pooja and Mr. Bintu of Department of Bio & Nanotechnology, GJUS&T, Hisar (Haryana).

REFERENCES

[1] Warren D. D'Souza, Ernest L. Madsen, Orhan Unal, Karl K. Vigen, Gary R. Frank and Bruce R. Thomadsen," Tissue mimicking materials for multi-imaging modality prostate phantom", Med. Phy. Vol. 28 (4), April 2001.

[2] E.L. Madsen, G.R. Frank, T.A. Krouskop, T. Varghese, F. Kallel and J. Ophir," Tissue-Mimicking Oil-in-Gelatin Dispersion for Use in Heterogeneous Elastography Phantom", Ultrasonic imaging 25, 17-38 (2003).

[3] Peter J. Dempsey, MD," The History of Breast Uitrasound", J Ultrasound Med 2004; 23:887-894.

[4] Helen Morehouse, Harsada Pranav Thaker, Chandowti Persaud,"Addition of Metamucil to Gelatin Realistic Breast Biopsy Phantom" J Ultrasound Med 2007; 26:1123-1126.

[5] Jun Dang, Philippe Lasaygues, Dachum Zhang, Stephan, Nicolas Felix," Development of anthromorphic phantoms for combined PET-ultrasound breast imaging", IEEE International Medical Imaging Conference, 2009, United State. pp. 1-9.

[6] Syed Farjad Sultan, George Shorten, Gabriella Iohom," Simulators for training in ultrasound guided procedures", Med Ultrason 2013 vol. 15, no.2, 125-131.

[7] Joseph Sutcliffe, Rulon L. Hardman, Nella Carol Dornbluth, Ken A. Kist," A Novel Technique for Teaching Challanging Ultrasound-Guided Breast Procedures to Radiology Residents", J Ultrasound Med 2013;32:1845-1854.

[8] Anna Maeva, High Frequency Shear Wave Imaging: A Feasibility Study in Tissue mimicking Gelatin Phantoms, Department of Medical Biophysics, University of Toronto, Master of Scince Thesis, 2014.