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LOW-COST ULTRASOUND PHANTOM FOR IMAGE ARTEFACT (LOW-CUP)

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ABSTRACT

Ultrasound procedures are becoming more challenging over time as diseases become more complex. Before training on a live patient, operators should learn to identify ultrasound artefacts because they can tamper the diagnostic process and thus affect the detection and diagnosis of life-threatening diseases. Simulated training using an ultrasound phantom provides the opportunity for operators to identify ultrasound image artefacts. This study aims to construct a simple, homemade, and low-cost phantom suitable for basic training in ultrasound artefacts identification. Five basic ultrasound image artefacts: posterior acoustic enhancement, posterior acoustic shadowing, mirror image artefact, reverberation artefact, and comet tail artefact were created using materials that can be easily found in daily life. The created ultrasound image artefacts were then categorized by four sonographers from different hospitals to investigate the observer's agreement. The total cost spent to create the ultrasound image artefact phantom was RM1.45. The Kappa coefficients showed an excellent inter-observer agreement with kappa more than 0.9 ($p<0.001$). This indicates that the ultrasound artefacts created using this homemade phantom closely resemble the image artefacts that are routinely seen in a clinical setting. With this low-cost homemade ultrasound image artefact phantom, lecturers can effectively teach more learners the process of image artefact formation and identification at a much more reasonable price.

Keywords: *Artefact, Homemade, Low-cost, Phantom, Ultrasound*

1. INTRODUCTION

Ultrasound artefacts represent a false portrayal of image degradations related to false assumptions regarding the interaction of ultrasound with tissues (Bönhof, 2016). Imaging artefacts can tamper with the diagnostic process and thus affect the detection and diagnosis of life-threatening diseases. Simulated training provides the opportunity for operators to identify ultrasound image artefacts in a safe, controlled, and reproducible environment without inducing any risk of harm to the patients. This simulated training can be achieved by using an ultrasound phantom. A commercial ultrasound phantom can cost from 200 USD to 3500 USD depending on the type of phantom. To our knowledge, there is no image artefact phantom available in the market neither for teaching nor training purposes. Thus, this study aims to construct a simple, homemade, and low-cost phantom suitable for basic training in ultrasound artefacts identification.

2. METHODOLOGY

This study focused on five basic ultrasound image artefacts that are commonly seen during ultrasound procedures. The artefacts are posterior acoustic enhancement, posterior acoustic shadowing, mirror image artefact, reverberation artefact and comet tail artefact.

2.1 Posterior Acoustic Enhancement

Posterior acoustic enhancement refers to the increased echoes deep to structures that transmit sound exceptionally well (Martin et al., 2015). This is the characteristic of fluid-filled structures. To construct a fluid-filled structure, a latex glove was filled with tap water. The distal portion of the glove (finger portion) was tightened and cut once it was fully distended with water to create a fluid-filled structure (Figure 1).

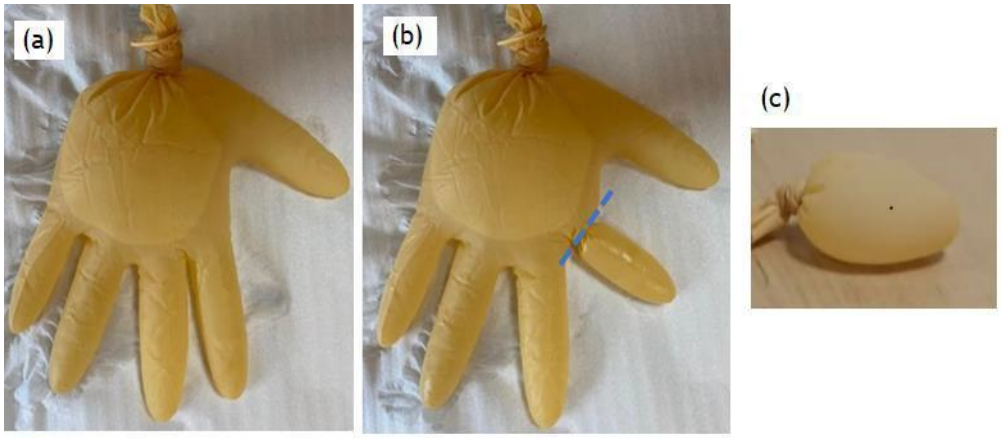

Figure 1 The Making of a Fluid-filled Structure

2.2 Posterior Acoustic Shadowing

Posterior acoustic shadowing refers to the signal void behind structures that strongly absorb or reflect ultrasonic waves (Martin et al., 2015). This is the characteristic of dense, solid, and closely packed structures such as stones and bone. To produce posterior acoustic shadowing, a stone was used.

2.3 Mirror Image Artefact

A mirror image artefact is seen when there is a highly reflective surface such as a diaphragm the path of the primary beam (Martin et al., 2015). To create a highly reflective surface, a clear plastic container lid was cut into 10cm x 10xm (length x width). A fluid-filled structure (constructed from a latex glove or balloon) mimicking a lesion was attached to the plastic sheet (Figure 2a).

2.4 Reverberation Artefact

Reverberation artefact occurs when an ultrasound beam reflects back and forth between two strong parallel reflectors (Martin et al., 2015). To create two parallel reflectors, a 5cm flexible PVC cable was used. The wire within the PVC cable was removed to achieve a hollow space between the PVC cable (Figure 2b).

2.5 Comet Tail Artefact

Comet tail artefact is a form of reverberation between two closely spaced reflectors causing the echoes to be displayed as triangular lines (Martin et al., 2015). To create two close space reflectors, two wires within the PVC were used by pressing them closely together (Figure 2b).

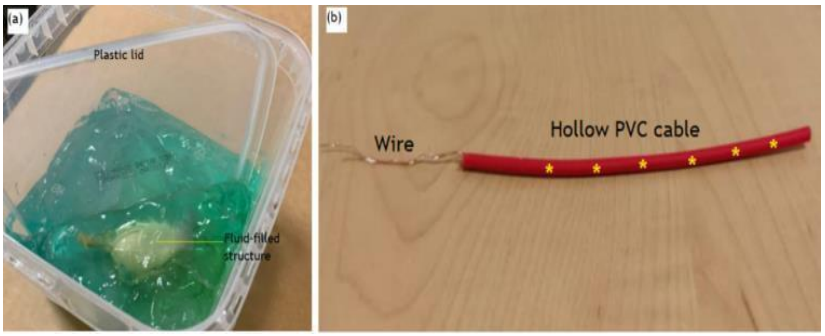

Figure 2 Comet Tail Artefact

Figure 2 shows the arrangement of the plastic lid and fluid-filled structure for mirror image artefact. Both materials were placed closely and submerged into an ultrasound gel tank. Flexible PVC cable was used to create the reverberation artefact and comet tail artefact. The wire within the cable was pulled out thus creating a hollow space within the cable (yellow asterisk) to produce a reverberation artefact. The pulled-out wires were pressed closely to create a narrow space between them, and the wires were used to create a comet tail artefact.

2.6 Transmitting Medium

To visualize the image artefacts, all the materials used to create artefacts must be submerged into a medium. To create the transmitting medium, commercial ultrasound gel or homemade ultrasound gel using corn-starch-based is suggested. The corn-starch-based ultrasound gel can be prepared based on the studies by Binkowski et al. (2014). 300gm of corn-starch was mixed with 6000mL of water and heated at 35˚C-45˚C for 10 minutes until the mixture became smooth.

2.7 Image Acquisition

Conventional ultrasound was performed using an ultrasound scanner and a linear array transducer (RS85, Samsung Medison, Seoul, Korea). All materials were submerged into a container filled with ultrasound gel (Figure 2a and Figure 3).

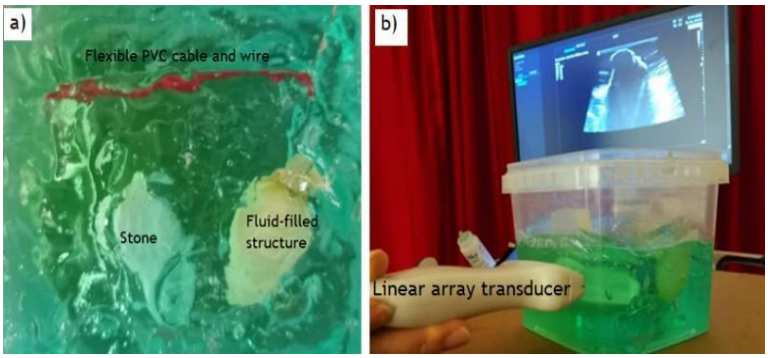

Figure 3 Conventional Ultrasound

2.8 Inter-observer Agreement

Created ultrasound artefact images were assessed by four sonographers (range of working experience 8 – 20 years) from 3 different medical centres: Universiti Malaya Medical Centre (UMMC), Hospital Pengajar Universiti Putra Malaysia (HUPM), and Hospital Pengajar Universiti Sultan Zainal Abidin. The sonographers were requested to name the type of artefacts created and they were blinded to each other's answers (Figure 4).

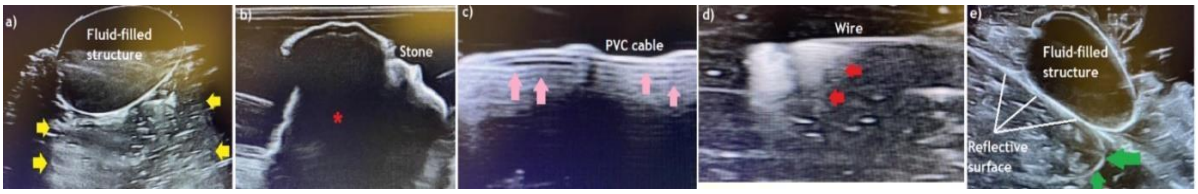

Figure 4 Image Artefacts Created Using Homemade Ultrasound Phantom

From left to right: a) posterior acoustic enhancement (yellow arrow), b) posterior acoustic shadowing (red asterisk), c) reverberation artefact (pink arrow), d) comet tail artefact (red arrow), and e) mirror image artefact (green arrow).

3. FINDINGS

The total cost spent to create an ultrasound image artefact phantom was RM1.45 (Table 1). Based on the Kappa coefficients, the inter-observer performance showed an excellent agreement with kappa more than 0.9 ($p<0.001$). This indicates that the ultrasound artefacts created using this homemade phantom closely resemble the image artefacts that are routinely seen in a clinical setting.

Item	RM/unit	Quantity	Total cost (RM)
Glove - Polythene Non-Sterile	0.03/ piece	1	0.03
Square Microwable Container (lid)	0.20	1	0.20
Stone	-	-	-

Flexible PVC cable (with wire)	0.45/m	5cm	0.02
Corn starch	1.4/350gm	300gm	1.20
Total cost			1.45

Table 1 Total Expenditure for a Homemade Ultrasound Image Artefact Phantom

4. CONCLUSION

This study provides an easy example for beginners to start making a phantom for themselves. Considering there is no ultrasound image artefact phantom available in the market presently, thus, this homemade ultrasound phantom manual would be a potential supplementary material for better teaching.

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Kelulusan daripada pihak tuan dalam perkara ini amat dihargai.

Sekian, terima kasih.

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