Homemade ultrasound phantom for teaching identification of superficial soft tissue abscess

Mark D Lo, S Heath Ackley, Patrick Solari

Department of Pediatric Emergency Medicine, Seattle Children's Hospital, Seattle, Washington, USA

Correspondence to
Dr Mark D Lo, Pediatric Emergency Medicine, Seattle Children's Hospital, 4800 Sand Point Way NE, Seattle M/S B-5520, Washington, USA; mark.lo@seattlechildrens.org

Accepted 20 August 2011
Published Online First 21 September 2011

ABSTRACT

Background Point-of-care ultrasonography (POCUS) is often used to distinguish abscess from cellulitis in superficial soft tissue infections. With the increased use of POCUS in emergency medicine, it is important that training to use POCUS is enhanced by practice using phantom models.

Objective To create an easily made, inexpensive, homemade phantom capable of simulating an abscess in superficial soft tissue infection.

Methods Increasing amounts of Jell-O (Northfield, Illinois, USA) brand gelatin and sugar-free Metamucil (Cincinnati, Ohio, USA) brand psyllium hydrophilic mucilloid fibre were experimented with until a satisfactory model was achieved. Various liquids were injected into it to simulate superficial abscess formation. The desired goal was for the phantom to appear similar to superficial human soft tissue under ultrasound scan and to be firm enough to withstand pressure from an ultrasound probe scan. The goal for the simulated abscess was to appear as a hypoechoic space under ultrasound scan. A Sonosite M-Turbo (Bothell, Washington, USA) bedside ultrasound machine with linear array transducer probe was used for the ultrasound scans.

Results The optimal homemade phantom incorporated 12 tablespoons of Jell-O and four tablespoons of Metamucil in one liter of water.

Conclusion An easily made, inexpensive phantom model for instruction on identification of superficial skin abscess was achieved.

INTRODUCTION

Point-of-care ultrasound (POCUS) is increasingly used in the emergency department for a variety of purposes.[1] Its rapidity and ease of use make ultrasound well suited for the pace of emergency care. Both adult and paediatric emergency medicine literature support the use of POCUS in patients with superficial soft tissue infections (SSTIs) to distinguish cellulitis from abscess.[2 3] Ultrasound training through simulation is important for emergency care providers, and commercial products simulating abscess and foreign bodies are available. This study describes our experience in the preparation of ultrasound phantoms using commonly available home products, and compares different substances used to simulate abscesses within homemade ultrasound phantoms.

METHODS

Our goal was to use an easily made, low-cost phantom model for teaching ultrasound identification of skin abscesses to emergency care providers. We wanted the phantom model to be consistently reproducible, as well as quickly obtainable. First, we attempted to make the phantom model ultrasonographically similar to the consistency of human soft tissue. We then tried to best replicate the appearance of a superficial skin abscess under ultrasound imaging.

We used commercial products readily found in grocery stores to make our ultrasound phantom. We experimented with increasing amounts of Jell-O (Northfield, Illinois, USA) brand gelatin and sugar-free Metamucil (Cincinnati, Ohio, USA) brand psyllium hydrophilic mucilloid fibre until a satisfactory model was achieved. Previous homemade phantom recipes described in the literature have used these two components in various concentrations. We chose a red colour for the gelatin because it was opaque and would hide any simulated abscess or foreign body in the phantom. As there was no previous information on optimal amounts of flavoured gelatin required to make a phantom, we experimented with increasing amounts, as well as increasing amounts of Metamucil (table 1). We evaluated our phantom on both ultrasonographic appearance and firmness without liquidity. Our desired goal was a phantom with an appearance similar to superficial human soft tissue under ultrasound scan, firm enough to withstand pressure from an ultrasound probe scan.

After the phantom was firm, we experimented with injecting various liquids into it to replicate abscess formation. We used liquids that were commercially available, which would mimic the viscosity and appearance of pus inside a superficial soft tissue abscess. We tried such liquids as lotion, ketchup, mayonnaise, candies with liquid centres, and honey (table 2). Our goal for the injection in the phantom was for it to have a defined space and appear hypoechoic on ultrasound interrogation, similar to a real abscess.

We used a Sonosite M-Turbo (Bothell, Washington, USA) bedside ultrasound machine with an L25x/13–6 MHz linear array transducer probe to scan our homemade phantom models. Images were stored on the machine hard drive and exported later.

RESULTS

We found that the optimal phantom was formed using water, one 6 oz box of Jell-O gelatin cherry flavour, and four tablespoons of sugar-free Metamucil (figure 1). We mixed 1 litre of boiling water with one box of Jell-O brand gelatin (approximately 12 tablespoons) and stirred until completely dissolved. An additional half-box of gelatin (approximately six tablespoons) may be added for increased firmness of the phantom, but a small

Table 1 Amounts of Jell-O and Metamucil in 1 litre of water experimented with to make a phantom

Jell-O (tablespoons)	Metamucil (tablespoons)	Result
4	2	Watery
4	4	Thin liquid, flows easily
4	6	Too soft, breaks apart
4	8	Too soft, breaks apart
6	2	Thin liquid, flows easily
6	4	Too soft, breaks apart
6	6	Too soft, breaks apart
6	8	Too soft, breaks apart
8	2	Thin liquid, flows easily
8	4	Too soft, breaks apart
8	6	Too soft, breaks apart
8	8	Too soft, breaks apart
10	2	Gelatinous, but still flows like a liquid
10	4	Gelatinous form, but does not keep shape
10	6	More firm, but Metamucil is too clumped
10	8	Breaks easily and does not withstand much pressure from ultrasound probe; Metamucil is too clumped
12	2	Gelatinous but jelly-like, without adequate firmness
12	**4**	**Smooth consistency and withstands pressure from ultrasound probe**
12	6	Adequate firmness, but Metamucil is too clumped
12	8	Adequate firmness and scattering under ultrasound, but Metamucil is too clumped

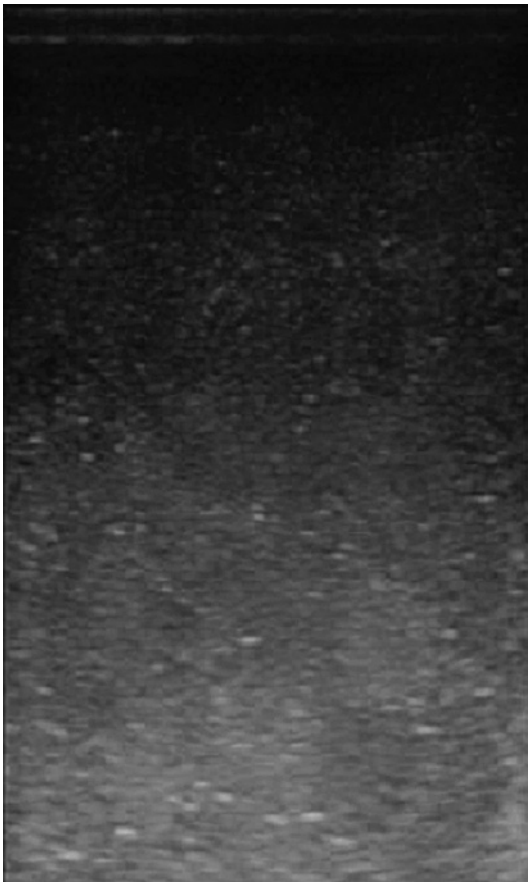

Figure 1 Gelatin phantom as seen by linear probe (12 tablespoons Jell-O, 4 tablespoons Metamucil).

amount of gelatin may then precipitate out of the solution. We mixed the four tablespoons of Metamucil into the hot gelatin solution, stirring or whisking vigorously. Any large clumps of Metamucil were strained out at this time. The 1 litre of mixture adequately filled a pre-greased baking tray (5 inch×9 inch×2.5 inch). The phantom was then allowed to cool and was refrigerated for at least 4 h until firm.

We found that the best simulation of abscess in our gelatin phantom was 3–5 ml injected ultrasound gel (figure 2). Our goal was to have a defined space appear hypoechoic under ultrasound scan, allowing for a slight hyperechoic rim. A secondary goal was ease of injection. We used readily available items to replicate an abscess, with varying degrees of success. We found that a small 22-gauge needle allowed the ultrasound gel to be easily injected into the homemade phantom without trace of where the 'abscess' might be, and the red colour of the gelatin mould prevented easy identification of the 'abscess' location.

Table 2 Results of injecting different liquids into the phantom to simulate abscess formation

Liquid	Result
Honey	Hypoechoic on ultrasound, but difficult to inject because of viscosity
Keri Lotion (Parsippany, New Jersey, USA)	Hyperechoic on ultrasound
Ketchup	Hyperechoic on ultrasound
Salsa	Very difficult to inject into phantom
Ultrasound gel	**Hypoechoic if no air bubbles introduced; easily injected into phantom**
Mayonnaise	Hyperechoic on ultrasound
Rolo candy	Hyperechoic with much shadowing on ultrasound
Lubricating jelly	Hypoechoic but many air bubbles
Mustard	Hyperechoic on ultrasound
Ranch salad dressing	Hyperechoic on ultrasound

DISCUSSION

In both adult and paediatric emergency literature, the use of POCUS has been shown to alter management decisions in patients with SSTIs.[4 5] Patients (especially children) may require sedation if a suspected abscess is to undergo incision and drainage. Sedation in children can require increased nursing and monitoring resources, and ultimately may result in longer length of stay in the emergency department. With the use of POCUS as an adjunct to evaluate SSTI, the immediate goal is to aid a 'yes–no' decision on whether there is an abscess with pus requiring immediate incision and drainage.

All emergency care providers require training sessions in order to become familiar with the ultrasound machine. The most effective training sessions generally include a didactic component as well as hands-on practice. Our easily made phantom is useful in facilitating the training of providers to rapidly identify soft tissue abscess using POCUS. Phantoms are useful for providing non-organic models to practise scanning.[6] The eventual goal of using the training phantoms would be to acquire skills necessary to differentiate between abscess and cellulitis in a real patient. Generally, identification of superficial skin abscesses by POCUS shows a hypoechoic mass that may or may not include hyperechoic sediment. The abscesses may appear spherical in shape, but not necessarily (figure 3).[7]

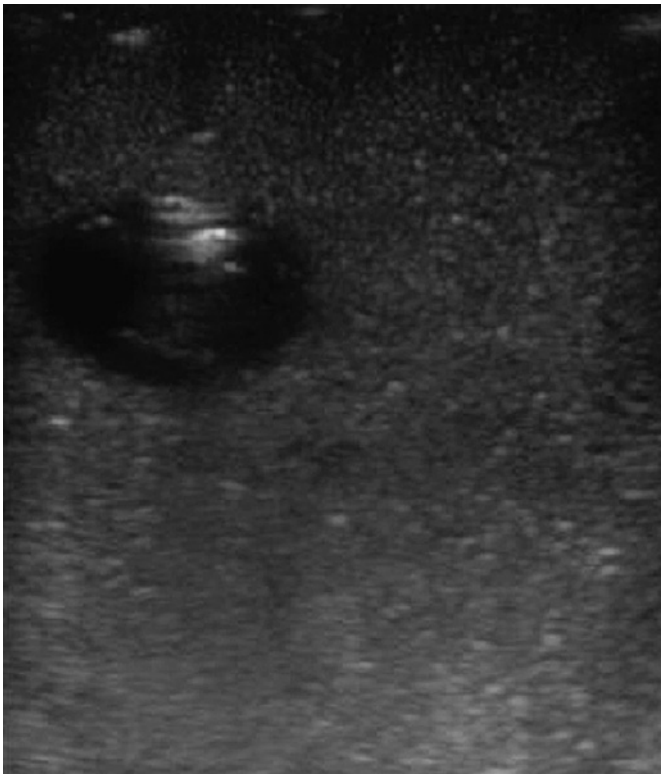

Figure 2 Ultrasound image of simulated abscess (ultrasound gel) in phantom.

Previous literature describing homemade phantoms has recommended a layering technique.[8–11] We did not find layering to be necessary for abscess simulation in our phantom model. We similarly chose readily available items to make our phantom, opting for Jell-O brand red gelatin for its opaque colour, instead of generic gelatin. The gelatin is an adequate bulking agent for the phantom, and the Metamucil simulates ultrasound wave scattering, similar to human tissue. We also found that immediate vigorous mixing of the Metamucil into the hot gelatin mixture was beneficial, as Metamucil quickly clumps in a cooler solution. Combining the two mixtures after each had initially dissolved was another way to avoid clumping. Of note, small Metamucil clumps, if not removed before chilling the phantom, appeared to be 'cobblestoning' on ultrasound, possibly helpful for simulating cellulitis in an SSTI. We found that pouring the gelatin mixture into smaller containers (same volume but with greater height) also contributed to phantom firmness and resistance to breaking apart. We recommend covering the phantom with plastic wrap to protect ultrasound probes as well as to improve phantom durability.

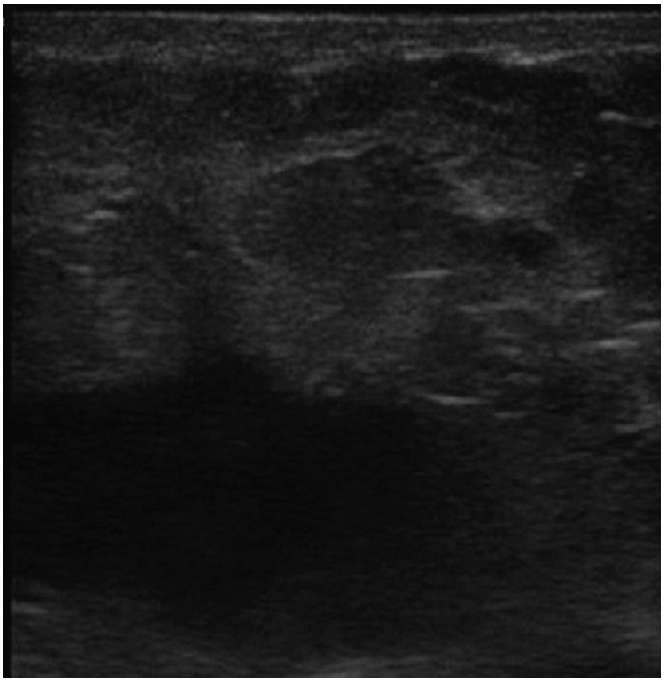

Figure 3 Ultrasound image of actual superficial soft tissue infection (abscess) in a patient: dark hypoechoic area in the bottom half of the screen.

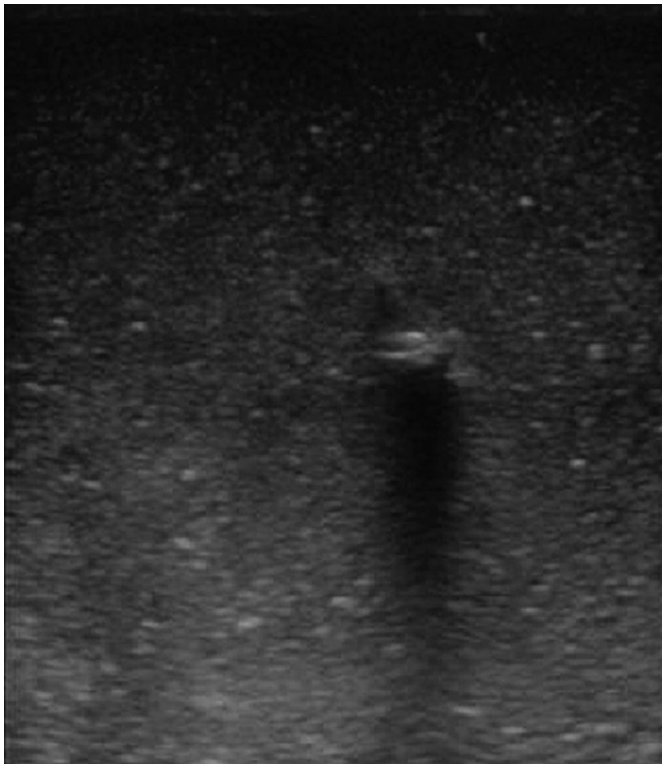

Figure 4 Ultrasound image of simulated abscess (honey) in phantom.

Simulating an abscess in the phantom was surprisingly more difficult than initially expected. The best simulated abscess on ultrasound was injected ultrasound gel. Alternative simulated abscesses that were adequate but not optimal included lubricating jelly, honey (figure 4) and a Rolo brand candy (Hershey, Pennsylvania, USA) with a caramel middle. The honey was too viscous to easily inject, the lubricating jelly was not viscous enough and difficult to remove air bubbles from, and the candy had more shadowing than intended. Ultrasound gel was easily injected through a small-gauge needle and appeared hypoechoic on ultrasound scan, similar to an abscess (figure 2). With larger-gauge needles (19 G) and bubbles in the ultrasound gel, air may also be introduced into the phantom, producing unwanted hyperechoic artifacts in the ultrasound image. Using a Pyrex glass pan (17 cm×27 cm×5 cm) to form the gelatin phantom may be useful for simulating human tissue and vessel cannulation, but we found that containers with more depth such as baking pans provided more wall stability for gelatin firmness and better facilitated injection of ultrasound gel for abscess simulation.

Many excellent commercial phantoms exist in the marketplace, such as the Blue Phantom models used at many training centres.[12] These phantoms are relatively expensive (~US$400), but do provide a consistent training experience as well as durability for many users. However, the higher cost of these commercial phantoms may discourage injection of substances for abscess simulation, as well as practising abscess aspiration/incision on the phantoms. Our gelatin phantom is a low-cost and easily made POCUS training model of SSTI.

Our phantom/abscess model provides an inexpensive and easily reproducible way to introduce identification of abscesses as part of an ultrasound curriculum. In particular, the phantom helps emergency care providers to learn the skills necessary to use ultrasound to identify drainable abscesses and perform the procedure in a simulated environment. As POCUS becomes more common in both adult and paediatric emergency departments, standard training and simulation is necessary to ensure quality.[13] Ultrasound phantoms could have an important role in the training and credentialling of providers.

Competing interests None.

Contributors MDL and SHA designed the experiment with assistance by PS. MDL wrote the manuscript with revision and direction by SHA and PS.

Provenance and peer review Not commissioned; externally peer reviewed.

REFERENCES

1. **Levy J,** Noble V. Bedside ultrasound in pediatric emergency medicine. *Pediatrics* 2008;**121**:e1404—12.
2. **Squire B,** Fox J, Anderson C. ABSCESS: applied bedside sonography for convenient evaluation of superficial soft tissue infections. *Acad Emerg Med* 2005;**12**:601—6.
3. **Ramirez-Schrempp D,** Dorfman D, Baker W, *et al*. Ultrasound soft-tissue applications in the pediatric emergency department: to drain or not to drain? *Pediatr Emerg Care* 2009;**25**:44—8.
4. **Tayal V,** Hasan N, Norton H, *et al*. The effect of soft-tissue ultrasound on the management of cellulitis in the emergency department. *Acad Emerg Med* 2006;**13**:384—8.
5. **Sivitz A,** Lam S, Ramirez-Schrempp D, *et al*. Effect of bedside ultrasound on management of pediatric soft-tissue infection. *J Emerg Med* 2010;**39**:637—43.
6. **Xu D,** Abbas S, Chan V. Ultrasound phantom for hands-on practice. *Reg Anesth Pain Med* 2005;**30**:593—4.
7. **Cosby KS,** Kendall JL. *Practical Guide to Emergency Ultrasound*. Philadelphia: Lippincott Williams and Wilkins, 2006:331—5.
8. **Kendall J,** Faragher J. Ultrasound-guided central venous access: a homemade phantom for simulation. *CJEM* 2007;**9**:371—3.
9. **Bude R,** Adler R. An easily made, low-cost, tissue-like ultrasound phantom material. *J Clin Ultrasound* 1995;**23**:271—3.
10. **Osmer C.** A gelatine-based ultrasound phantom. *Anaesthesia* 2008;**63**:107.
11. **Bellingham G.** A low-cost phantom of the lumbosacral spine. *Reg Anesth Pain Med* 2010;**35**:290—3.
12. **Blue Phantom Company Website.** http://www.bluephantom.com (accessed 10 May 2011).
13. **Moore CL,** Copel JA. Point-of-care ultrasonography. *N Engl J Med* 2011;**364**:749—57.