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MINIREVIEWS

Review of simulation model for education of point-of-care ultrasound using easy-to-make tools

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Abstract

Point-of-care ultrasound (POCUS) is a powerful diagnostic tool and provides treatment guidelines in acute critical settings. However, the limitation of using POCUS is operator dependent. Appropriate and validated training for acquiring and using skills in practice must be conducted before using POCUS in clinical settings in order to keep patients safe. Simulation education models have been introduced as a way to solve and overcome these concerns. However, the commercial simulator with sufficiently secured fidelity is expensive and not always available. This review focused on the inexpensive and easily made simulators for education on POCUS in critical specific situations related to the airway, breathing, circulation, and disability. We introduced the simulators that used non-infectious materials, with easily transportable features, and that had a sonographic appearance reproducibility similar to human tissue. We also introduced the recipe of each simulator in two parts: Materials surrounding disease simulators (surrounding materials) and specific disease simulators themselves (target simulators). This review article covered the following: endotracheal or oesophageal intubation, lung (A-lines, B-lines, lung sliding, and pleural effusions such as hemothorax), central vein access, pericardial fluid (cardiac tamponade), the structure related to the eyes, soft tissue abscess, nerve (regional nerve block), and skull fracture simulators.

Key Words: Critical care; Education; Emergency medicine; Simulation training; Point-of-care; Ultrasonography

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Core Tip: Inexpensive and easily made simulators for education on point-of-care ultrasound provide a sonographic appearance and resistance similar to human tissue. There were various recipes for making simulators; however, the materials used were similar. These materials were readily available, and the preparation methods were simple. We found that the gelatine with Metamucil and polyvinyl chloride mixtures appear to be most similar to actual human tissue in terms of resistance and sonographic appearance. We introduced each recipe of the simulators in two parts: materials surrounding simulators (surrounding materials) and the specific disease simulators themselves (target simulators).

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INTRODUCTION

Point-of-care ultrasound (POCUS), which has been implemented as a complementary tool in clinical examinations in the medical field, provides improvements in diagnostic abilities, an increase of confidence, in timely therapeutic decision-making, and in reduction of the complications from invasive procedures[1-4]. It does so particularly in critically unstable patients who need a timely diagnosis and a quick emergent treatment decision. These include cases of hemothorax, pneumothorax, cardiac tamponade, hemoperitoneum, rupture of abdominal aortic aneurysm or dissection, or resuscitation due to shock in an intensive care unit or emergency room. The importance of POCUS in a clinical practice context is well-established[3,5-7].

The most important limitation of ultrasound is known to be operator dependent[4,5]. Appropriate and validated training for acquiring skills and transferring these into practice must be conducted before using POCUS in clinical settings, in order to keep patients safe[3,5,6,8]. In critical situations in particular, misinterpretations of POCUS findings may threaten patients' safety due to missed or inadequate diagnoses and delays of proper treatment[3,4]. Therefore, training on POCUS is a necessary condition before implementing POCUS in critical situations. However, in-field teaching of POCUS and live models with pathology are restricted due to there being few opportunities to use POCUS[2,9-12]. There are rarely cases of cardiac tamponade in real clinical practice, and there is also a fear of incurring harm in critical patients, as well as ethical issues and patient safety concerns[2,9-12].

Simulation education models using simulators have presented a way to solve and overcome these concerns, because they provide a safe, stress free, and supportive environment, with excellent reproducibility and fidelity[2,9-12]. Furthermore, simulation education models possibly lower the learning curve of skill acquirement[2,9-12]. Nowadays, a large number of simulators have been developed and introduced[2,9,12,13]. However, the commercial simulator that has a sufficiently secured fidelity is expensive and not always available to trainees[2,9,12,13]. Pioneers in the medical field have developed inexpensive and easily made simulators for POCUS educational purposes, and have reported admirable educational achievements[2,13-16]. An ideal simulator should be inexpensive, easily made, not be time-consuming to produce, has no infection issues, easily transportable, and has a reproducibility of the sonographic appearance and resistance that is similar to human tissue[2,9,17].

The focus of this review article was to investigate easily made simulators close to or according to the conditions of ideal simulators. The scope of reviewing simulators was related to POCUS use in emergency medicine and critical care medicine, where clinicians must be trained before implementing POCUS in the clinical field to ensure patients' safety. To meet these points of view, this review article is largely divided into two themes. The first part focused on the materials surrounding target simulators such as veins, nerves, or the trachea. The materials surrounding target simulators that have a sonographic appearance and resistance similar to human tissue are also important. This ability to create a surrounding material that is similar to human tissue allows us to make various simulators that are suitable for specific situations. The second part focused on specific target simulator structures related to airway, breathing, circulation, disability, and other situations such as fracture, soft tissue abscesses, and regional nerve blocks. Therefore, this review article covered the following simulators;

endotracheal or oesophageal intubation, lung (A-lines, B-lines, lung sliding, pleural effusion such as hemothorax), central vein access, pericardial fluid (cardiac tamponade), the structure related to eye, soft tissue abscess, nerve (regional nerve block), and skull fracture simulators.

Because of space constraints, the article will not provide the validation methods, results, figures, or creation methods; these are well presented in the original reports on the subject. The review will be limited to the introduction of the recipes or substances used to make the POCUS simulators and the appearance of the ultrasounds. The authors hope that this review article can guide user's searches for specific, easy-to-make made simulators. The authors would like to introduce a website that has a collection of articles and Youtube addresses describing the simple, homemade simulators https://www.ultrasoundtraining.com.au/foamus/diy-phantom-compendium accessed December 27, 2019).

SIMULATORS SURROUNDING TARGET, SONOGRAPHIC APPEARANCE SIMILAR TO HUMAN TISSUE

An ideal simulator should represent the texture and resistance of human tissue and have a sonographic appearance similar to human tissue[2,18,19]. Researchers have been searching for materials that look similar to real human tissue, and using them to come up with simulators[18-21]. We would like to introduce some materials used for making simulators to soft human tissue. The method of producing each material cannot be fully described due to space constraints; these are well presented in the original papers on the subjects. The materials, material ratios, methods, and times to produce each simulator are presented briefly in Tables 1 and 2. Table 3 was summarized and compared the pros and cons of various simulation materials.

Main materials used in making simulators

Gelatine: Gelatine is a common material for ultrasound simulators because it is easy to get, cheap, and has a similar echogenicity to human tissue[2]. It is reusable, but has relatively short shelf life and has problems with durability[22-24]. Gelatine also requires special ingredients and recipes to make simulators that are more similar to a real tissue and that do not melt at room temperature[22,24]. Generally, 100 to 500 g of gelatine is used per 1000 mL of water, and if the proportions of the other additives are high, a small amount of gelatine is used[13,15,18,22,24-31].

Agar: Agar is a promising material for ultrasound simulators because it is not easy to melt or decompose by itself, and does not need to be refrigerated in the process of making it[32,33]. However, it has weaknesses in terms of accessibility and cost. Earle *et al*[32] compared several simulators models that used 2.5%–10% agar, and found out that the 5% model had the ideal texture and distensibility. They mixed 750 mL of cold water with 38 g (900 g/cm^2) of agar gel and stirred the mixture periodically as it boiled[32]. They then sprinkled 1 teaspoon of flour into the mixture and stirred it until it homogenized[32]. About half of the hot mixture was poured into a container and cooled for 20 min at room temperature[32]. Other studies using agar produced simulators using mixtures of similar concentration[33].

Ballistics gel: Ballistics gel was originally developed to replace human tissue in firearms testing[34,35]. The density and texture of ballistics gel is similar to human tissues, thus, it is good for ultrasound simulations[35]. In practice, its ultrasound images appear very similar to human soft tissue[34,35]. It has advantages in many aspects, including durability, cost, and reusable, risk of transmission, and leaking, compared to other materials used in previous studies[35]. It can be used repeatedly it is self-sealing, but it becomes slightly yellowish when reused over time[36]. The 10% ballistic gelatine (Clear Ballistics, LLC, Fort Smith, AR, United States) which the authors used in their study has a melting point of about 93.3 °C[34,35]. Before heating, the ballistic gel was divided into small pieces to decrease the melting time[34-36]. Since each manufacturer has a different melting point, it is important to check it well and slowly heat it up and melt it[34-36]. Then pour it into a container after melting and let it cool for about 30 to 40 min to harden at room temperature[34-36].

Special ingredients added to simulators

Additives to increase echogenicity and opacity: To obtain an ultrasound image similar to real human tissue, surrounding materials are made by adding other

Table 1 Ingredients and classification of simulator according to surrounding materials used in simulators

Surrounding materials	Ref.	Brand of main materials (A)	Ingredients for echogenicity (B)	Other ingredients (C)	Ratio or amount (A: B: C)	Target simulator
Gelatin based	Lo *et al*[18] Wilson *et al*[53]	Jell-O gelatin cherry flavor (Kraft Foods, Northfield, IL, United States)	Sugar-free Metamucil (P and G, Cincinnati, OH, USA) brand psyllium hydrophilic mucilloid fiber	NA	12:4 tablespoons in 1 L water	Soft tissue abscess
	Chao *et al*[23]	Unflavored gelatin powder, not mentioned brand name	sugar-free psyllium fiber (Metamucil Sugar Free; P and G)	NA	40 g: 20 g in 250 mL water	Soft tissue abscess, central vein access, foreign body
	Seguin and Tessaro[29] Merali *et al*[13]	Beef gelatin powder, not mentioned brand name	Orange colored psyllium fiber (Metamucil sugar free; P and G)	NA	90 mL: 60 mL in 500 mL water	Intubation
	Do and Lee[28]	Gelatin, not mentioned brand name	Agar, no mentioned brand name	NA	20 g:1 g in 60 mL water	Lung, A-lines, B-lines, pleural effusion
	Zerth *et al*[26]	Plain gelatin, not mentioned brand name	NA	Green and red food coloring, surgical iodine solution	16 oz (473 mL): several drop of coloring agent + 120 mL iodine in 4 quarts (3785 mL) water	Pericardial effusion
	Cuévas Gonzales[25]	Unflavored gelatin, not mentioned brand name	NA	70% ethanol	100 g: 30 mL in 500 mL water	Eye (normal, foreign body, ONS, dislocation of lens, vitreous hemorrhage, retinal detachment)
	Murphy *et al*[15]	Unflavored gelatin, not mentioned brand name	sugar-free psyllium powder (*e.g.*, Metamucil Sugar Free Dietary Fiber Supplement; P and G)	NA	Not mentioned gelatin amount, one tablespoon Metamucil in 250 mL water	ONS
	Soucy *et al*[27]	Sugar-free gelatin, not mentioned brand name	Metamucil (P and G)		20 g: 10 g (1 tablespoon) in 250 mL water	Skull fracture
	Amato *et al*[24]	Unflavored gelatin, not mentioned brand name	NA	NA		Vascular access
	Cheruparambath *et al*[22]	Plain gelatin, not mentioned brand name	Coarsely ground finger millet (Eleusine coracana) flour	NA	15 g: 20 g in 1.2 L water	Vascular access
	Chao *et al*[23]	Unflavored gelatin, not mentioned brand name	Sugar-free psyllium fiber (Metamucil Sugar Free; P and G)	NA	40 g: 20 g in 250 mL water	Vascular access
	Rathbun *et al*[39]	unflavored Knox gelatin (Kraft Foods)	Sugar-free psyllium hydrophilic mucilloid fiber (sugar-free Metamucil; P and G)	NA	4 envelopes of Knox gelatin add 1 tablespoon of Metamucil (2 cups a of cold water)	Nerve block
Agar based	Earle *et al*[32]	Agar, not mentioned brand name		Flour (1 teaspoon) Red dye ethanol	38 g: 750 mL water (for 5% model) Compare 4 different concentrations (10%, 7.5%, 5%, 2.5% by weight)	Vascular access
	Nikitichev *et al*[33]	Agar (A7002; Sigma-Aldrich, St Louis, MO, United States)	NA	NA	5.5% by weight	Vascular access

Ballistics gel based	Morrow *et al*[35]	10% ballistic gelatin (Clear Ballistics LLC, Fort Smith, AR, United States)	Not required. Main material provided the sonographic appearance similar to human tissue	Clear gel dye if needed	NA	Soft tissue abscess
	Seguin and Tessaro[29]	ballistic medical gelatin #3 (Clear Ballistics)	psyllium fiber (Metamucil sugar free; P and G),	ballistic gelatin dye (Clear Ballistics)	250 mL: 5 mL: 45 mL	Intubation
	Young and Kuntz[38]	Ballistics gel, plastic Halloween skeleton thorax, plastic, manikin dress-form torso	NA	flesh-colored dye	NA	Pericardial effusion
	Morrow and Broder[34]	10% ballistic gelatin (Clear Ballistics LLC)	NA	NA	NA	Vascular access
	Amini *et al*[36]	Clear ballistic gel, not mentioned brand name	NA	NA	NA	Vascular access
Gel and wax based	Campo Dell'orto *et al*[20]	Gel wax (mixed store, 74532 Ilshofen)	Gel (Sonosid 1 L, Asid Bonz GmbH, 71083 Herrenberg, PZN 5362311)	Silicon skin/Thera-Band (Schmidt Sports PHYSIO TAPE, 42699 Solingen, Art.Nr. 111202)	NA	Pericardial effusion
	Daly *et al*[37]	Gel wax, flour, plastic artificial rib cage (axial skeleton)	NA	Silicon skin/Thera-Band (Schmidt Sports PHYSIO TAPE, 42699 Solingen, Art.Nr. 111202)	One gallon (4546 mL) gel wax + three tablespoons of flour	Pericardial effusion

NA: Not applicable; ONS: Optic nerve sheath.

substances[13,15,18,20,22-30,32-39]. In gelatine-based simulators, one study used coarsely ground finger millet (Eleusine coracana) flour to increase echogenicity[24]. Metamucil was added as an ingredient for echogenicity, however, there was no information of the amount of Metamucil added[13,15,18,23,27,29,30,39]. Lo *et al*[18] made a simulators of a skin abscess simulation with gelatine and sugar-free Metamucil. They made several simulators using these two materials in various concentrations and found out a ratio of 12:4 tablespoons in 1 L water of Jell-O brand gelatine to sugar-free Metamucil showed the best results[18]. They evaluated the variety of simulators concentrations on both firmness and ultrasound appearance[18]. The ratio of 12:4 tablespoons had the best results in both of these aspects[18]. There is no validation research on this, as this was the only paper that studied the concentration of these two compounds. Li *et al*[40] proposed the use of modified polyvinyl chloride for ultrasound simulators for the first time. They made a novel ultrasound simulator from a mixture of polyvinyl chloride (PVC), mineral oil, diethyl hexyl adipate plasticizer softener, and chalk[40]. Pepley *et al*[19] made the modified PVC polymer mixture using three different concentrations for an ultrasound guided vascular access simulators[19]. They measured the axial needle force of a needle insertion into the simulators and designed a survey to compare the ultrasound images to real images[19]. A total of nine simulators materials were tested including three different concentrations of modified PVC simulators, two kinds of commercial simulators, gelatine, agar, ballistics gel, and cadavers[19]. It was found that

Table 2 Method and time to produce of simulator according to surrounding materials used in simulators

Surrounding materials	Ref.	Heating	Refrigeration	Time to produce	Target simulator	Material for target simulator
Gelatin based	Lo *et al*[18]	Required	At least 4 h to firm	at least 5 h	Soft tissue abscess	Ultrasound gel
	Wilson *et al*[53]					
	Chao *et al*[23]	Required	NA	NA	Soft tissue abscess, central vein access, foreign body	Pipette bulbs with water, latex rubber tube, NA
	Seguin and Tessaro[29]	Required	Required, overnight at 4°C	NA	Intubation. Trachea, esophagus	Holes, the block that came out when making the hole
	Merali *et al*[13]					
	Do and Lee[28]	NA	NA	NA	Lung, A-lines, B-lines, pleural effusion	Dressing material (Medifoam®, Mundipharma, South Korea), balloon with water
	Zerth *et al*[26]	Required	Required for at least 2 h	NA	Pericardial effusion	Balloon with red food coloring water
	Cuévas Gonzales[25]	Required	Required for 2 h	NA	Eye (normal, foreign body, ONS, dislocation of lens, vitreous hemorrhage, retinal detachment)	Printing was required using aluminum paper mold on gelatin
	Murphy *et al*[15]	Required	Required	At least 30 min	ONS	Ping-pong ball, Vinyl tube + a stylet of 18-guage needle with metal tip
	Soucy *et al*[27]	Required	Required	NA	Skull fracture	Coconut
	Amato *et al*[24]	Required	Required	NA	Vascular access	Removed plastic tube
	Cheruparambath *et al*[22]	Required	Required	NA	Vascular access	Plastic tube
	Chao *et al*[23]	Required	Required	NA	Vascular access	Latex rubber tube
	Rathbun *et al*[39]	Required	Required	Approximately 2–3 h	Nerve block	Hot dog and straw
Agar based	Earle *et al*[32]	Required	Cooling at room temperature	NA	Vascular access	Penrose drain or long latex balloon
	Nikitichev *et al*[33]	Required	Cooling at room temperature	NA	Vascular access	Removed rod
Ballistics gel based	Morrow *et al*[35]	Required	Cooling at room temperature	Various time according to heating methods	Soft tissue abscess	Water
	Seguin and Tessaro[29]	Required	Cooling at room temperature	At least 1 h	Intubation	Marker embedded in surrounding materials
	Young and Kuntz[38]	Required	Cooling at room temperature, ice underneath the plastic manikin torso	NA	Pericardial effusion	Ping-pong ball in 250 cc normal saline bag
	Morrow and Broder[34]	Required	Cooling at room temperature	Less than 1 h	Vascular access	Latex tube
	Amini *et al*[36]	Required	Cooling at room temperature	NA	Vascular access	Removed plumbing tube
Gel and wax based	Campo Dell'orto *et al*[20]	Required	Not required	1 h	Pericardial effusion	Celluloid table tennis ball with red colored water in balloon
	Daly *et al*[37]	Required	Cooling at room temperature for 1 h	NA	Pericardial effusion	Ping-pong ball in 250 cc normal saline bag

NA: Not applicable; ONS: Optic nerve sheath.

the PVC mixture with a ratio of 11:0:1 (PVC polymer to softener to mineral oil) and ballistics gel provided the best results in terms of needle resistance most similar to cadaveric tissue[19]. The survey results showed that a PVC mixture with a 9:1:2 ratio (PVC polymer to softener to mineral oil) was the best performing material with the most realistic image[19]. Ballistics gel and agar showed the worst performing materials in the image-comparing survey[19]. On both aspects of resistance and ultrasound appearance of the simulators, in addition to the gelatine and Metamucil mixture, we think the PVC mixture model will be able to get the spotlight as a high-performance material. In contrast, agar showed the worst performance as a main material of the simulators, and had a less realistic image and poor needle forces[41].

Surface resistance: In a simulator made of gelatine, the actual skin resistance can be different and it can easily be broken[20,23]. Hydrocolloid dressing materials (DuoDERMR CGF® dressings; ConvaTec, Skillman, NJ, United States) were put on the surface of the simulators to avoid disruption of the surrounding material[23]. This is a sonolucent material and can be tightly adhered to the surface of surrounding material[23]. It has many advantages such as protection from bacteria, avoiding disruption from transducer movement, and can be punctured several times because it increases durability[23]. In a pericardial effusion simulation study, Campo Dell'orto *et al*[20] and Daly *et al*[37] covered home-made simulators in silicon skin such as Schmidt Sports PHYSIO TAPE (THERABAND, Akron, OH, United States), which are used for gymnastic exercise, to make the resistance similar to real skin and prove that it can be used as a skin analog[20,37]. While securing skin resistance, it also had the effect of increasing realness[20,37].

Colour: Several substances, such as various colours of dye, can be used to colour surrounding materials[26,32,38]. There are different advantages of using transparent materials compared to coloured materials. Transparent materials have external visibility, so they allow a novice to compare real anatomical locations and ultrasound images with the naked eye[24,34]. In addition, when the beginner fails a procedure during the simulation, they can confirm the problems themselves[34]. For the more advanced learners, coloured simulators can offer more realistic and difficult simulations[34]. It is important to add colours to make the models more real, but from an educational point of view, using a transparent simulator to learn relative positions of objects and where the ultrasound probe should go is more important. We thought training using coloured simulators would be of great help as the next step.

SIMULATORS OF SPECIFIC TARGETS

In this section, we describe the simulators of specific situations in terms of the surrounding material for simulating human tissue (part of surrounding material) and the recipe/materials used to create the simulator for specific disease (part of target simulator). If the recipe was described in the reference, the recipe is introduced briefly. The authors of this review article would like to note that this article does not describe the definition or explanations of the sonographic findings, as that is beyond the scope of this article. However, several sonographic findings were explained as a convenience to readers if sonographic signs are unfamiliar to them. The materials used to make the target simulators are introduced in Table 2. The general method of making easy-made simulator is briefly schematized in Figure 1.

Related to A- airway

POCUS related to airways is used for detection of cricothyroid membranes or trachea rings for cricothyroidotomy or tracheostomy, tracheal or oesophageal placement of endotracheal tubes, and diaphragmatic movement or lung sliding for confirmation of tracheal placement[2,5-7,21]. The simulators related to POCUS of lungs will be introduced in the next section, "related to B- Breathing". To the best of our knowledge and PubMed searches, there have not been any articles related to simulators that detect cricothyroid membrane, trachea, or diaphragmatic movements. The only two articles that we could find for simulators used to confirm the placement of endotracheal tubes (trachea *vs* oesophagus) were introduced by Merali *et al*[13] and Seguin and Tessaro[29]. Merali *et al*[13] reported on the educational effects of the simulator made by Seguin and Tessaro[29]. Therefore, the two simulators made by Seguin and Tessaro[29] are introduced in this section.

Surrounding material — neck tissue: One simulator was made using beef gelatine

Table 3 Special features of surrounding materials used in simulators

Surrounding materials	Available	Cost	Time	Durability and resusable	Infection	Coloring	Reality of the image	Reality of resistance	Need for additives
Gelatin based	Easy	More cheaper	Need more time (usually need refrigeration) Approximately 2–3 h and can take up to 5 h	Weak	Relatively vulnerable	Easy	Very good	Relatively unrealistic	Often needed
Agar based	Easy	Cheap	Relatively less time	Good	Relatively vulnerable	Easy	Good	Relatively unrealistic	Rarely needed
Ballistics gel based	Not difficult	Relatively expensive	Short preparation time (about 1 h)	Excellent	Resistant	Not difficult	NA	Great realism	Usually not required

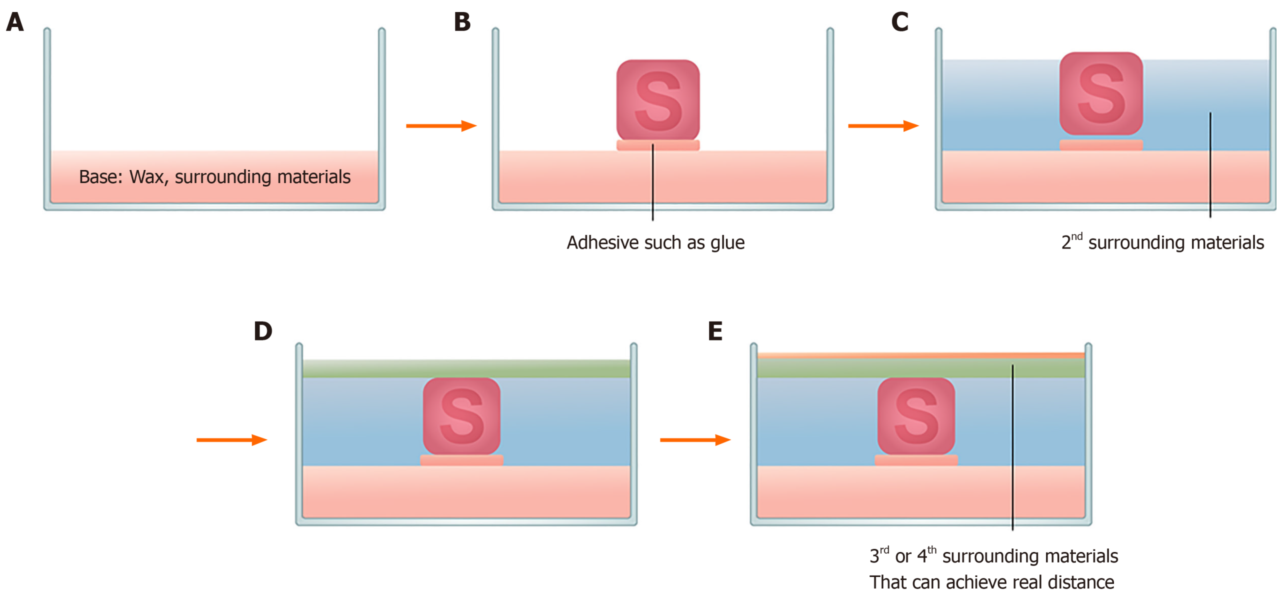

Figure 1 General method to produce the simulator. The surrounding material and specific simulator are used in a container box. A: The surrounding material or wax is used to form a base in a container box prior to the specific simulator insertion; B: When the base material solidifies, the specific simulator is glued with an adhesive; C: The process of inserting the surrounding material; D and E: The surrounding material can be inserted at once or may be split into two depending on the purpose of the project. At this time, air bubble is removed using a spoon.

powder (90 mL) and 60 mL of orange coloured psyllium fibre (Metamucil sugar free; P and G, Cincinnati, OH, United States) mixed with 500 mL of boiling water[13,29]. The mixture was poured into a 1 L container and refrigerated at 4 °C overnight. The other was made using a 250 mL volume of ballistic medical gelatine 3 (Clear Ballistics), psyllium fibre powder (5 mL), and 45 mL of ballistic gelatine dye (Clear Ballistics)[29].

Target — trachea, oesophagus, and simulation of the placement of endotracheal tubes: Two holes were made in the surrounding materials to simulate a trachea and oesophagus[13,29]. The two holes are separated by a gap between the trachea and oesophagus, and are 5 mm from the wall of the margins of the surrounding materials, in order to achieve a real sonographic appearance[13,29]. In the first model using beef gelatine, two holes was made by using a 10 mL syringe with the tip cut off, once the surrounding material was completely ready[13,29]. In the second model using ballistic gelatine, the holes were made using two felt markers (Crayola)[29]. The two felt markers were planted into the surrounding material mixture before solidifying the surrounding materials[29].

The methods for confirming the placement of the endotracheal tube using POCUS are the static method (double tracheal sign, enhanced tracheal posterior shadow sign, transcricothyroid membrane bullet sign and lung sliding sign) and the dynamic method (snowstorm sign, and shape change of the transcricothyroid membrane from triangular to bullet sign)[41,42]. Among these findings, the double tracheal sign was easily applicable to clinical practice[42]. The double tracheal sign simulated an oesophageal intubation[41,42]. The presence of air in both the trachea and the oesophageal lumen produces two reverberation artefacts[42].

To simulate the double tracheal sign and bullet sign, Seguin and Tessaro[29] used a block that came out when a hole was made using a syringe or felt marker. Therefore, the block was the same material as the surrounding materials. The block in the first simulator that used beef gelatine was made using a syringe while making holes in surrounding material[29]. To make the block in the second simulator, the surrounding material mixture (ballistic gelatine) was poured into a 10 mL syringe with the tip cut-off[29]. If the block was not planted in the hole that represented the oesophagus, the double trachea sign was shown in ultrasound[29]. On the other hand, the simulation with the block in the hole that represented the oesophagus did not show the double tracheal sign, and represented tracheal intubation[29]. However, the simulator by Seguin and Tessaro[29] has the limitation of not demonstrating all the POCUS signs mentioned above. The stage of making intubation simulator is briefly schematized in Figure 2A.

Related to B- breathing

POCUS related to breathing such as dyspnoea is used for detection of hemothorax, pleural effusion, pneumothorax, pulmonary embolism, pneumonia, alveolar/interstitial disease, and thoracentesis by using a lung ultrasound[3,5-7,43]. The definition of the lung ultrasound findings was not described in this review article because they are out the scope of this review. The definitions of A-line, B-line, lung sliding, and so on in terms of lung ultrasound findings have been well described by Lichtenstein and Meziere[44]. Hand ultrasounds were compared to simulated normal lung or pneumothorax models (presence or absence of lung sliding)[45,46]. A gelatine-based model that simulated a normal lung or pneumothorax, pulmonary oedema, or pneumonia (B-lines), and pleural effusion was also tested[28]. Another gelatine-based model that simulated the diaphragm, pleural fluid, and lung parenchyma was used in order to train for thoracentesis[30]. Sponge and dressing materials in both the hand and gelatine simulators generated A-lines and B-lines[16,28,47].

Surrounding material — chest wall and ribs: Simulations using hands are similar to the sonographic appearance of lungs. This is because the parallel bony structure of metacarpal bone is similar to ribs, the soft tissue between the metacarpal bones is similar to the intercostal space, the interface between air and skin is similar to the lung and pleura interface, and similar to the soft tissue of the anterior chest wall[16,45]. The gelatine model, involving 20 g of gelatine, 60 mL of water, and 1 g of agar used as an additive, was used to represent the thoracic wall[28]. Tree branches were used to make the simulator represent ribs[28]. In another report that simulated pleural effusions, a gelatine cage was used to represent the thoracic wall and ribs; however, the recipe was not described[30].

Target - lung sliding, A-line, B-line, and pleural fluid: The dorsal skin of the hand[16,45] or the dry polyurethane dressing foam underneath the dorsal hand and gelatine model[16,28] represented the pleura and created A-lines. The dorsal skin or dry polyurethane dressing foam with motion from side to side generated lung sliding/sea-shore sign with A-lines, while no movement generated pneumothorax (absence of lung sliding/stratosphere sign) with A-lines[16,28,45]. The educational effects of these lung simulators have been sufficient to teach novices lung ultrasound techniques[16,28]. Furthermore, the materials such as sponges and dressing materials were similar to the structure of lungs; therefore, they were able to simulate lungs, A-lines, and B-lines[16,28,30,47]. Depending on the dry or wet (soaked in water) condition of the sponge and the dressing materials, they were able to create A-lines (dry) or B-lines (wet)[16,28]. Pleural effusion was simulated by using a balloon filled with water to contact the bottom of the simulator[28]. In the other report that simulated pleural effusion, a sponge and water in a plastic container was used to represent lung and pleural effusion[30]. In this simulator, the gelatine simulators that represented the thoracic wall and rib was placed above some plastic wrap, over the sponge and water, in a plastic container[30]. This model was able to allow trainees to perform a thoracentesis[30]. However, this article did not provide the recipe[30].

Related to C- circulation

POCUS related to circulation such as shock and vascular access for resuscitation is used for the detection of pericardial effusion such as cardiac tamponade. This can

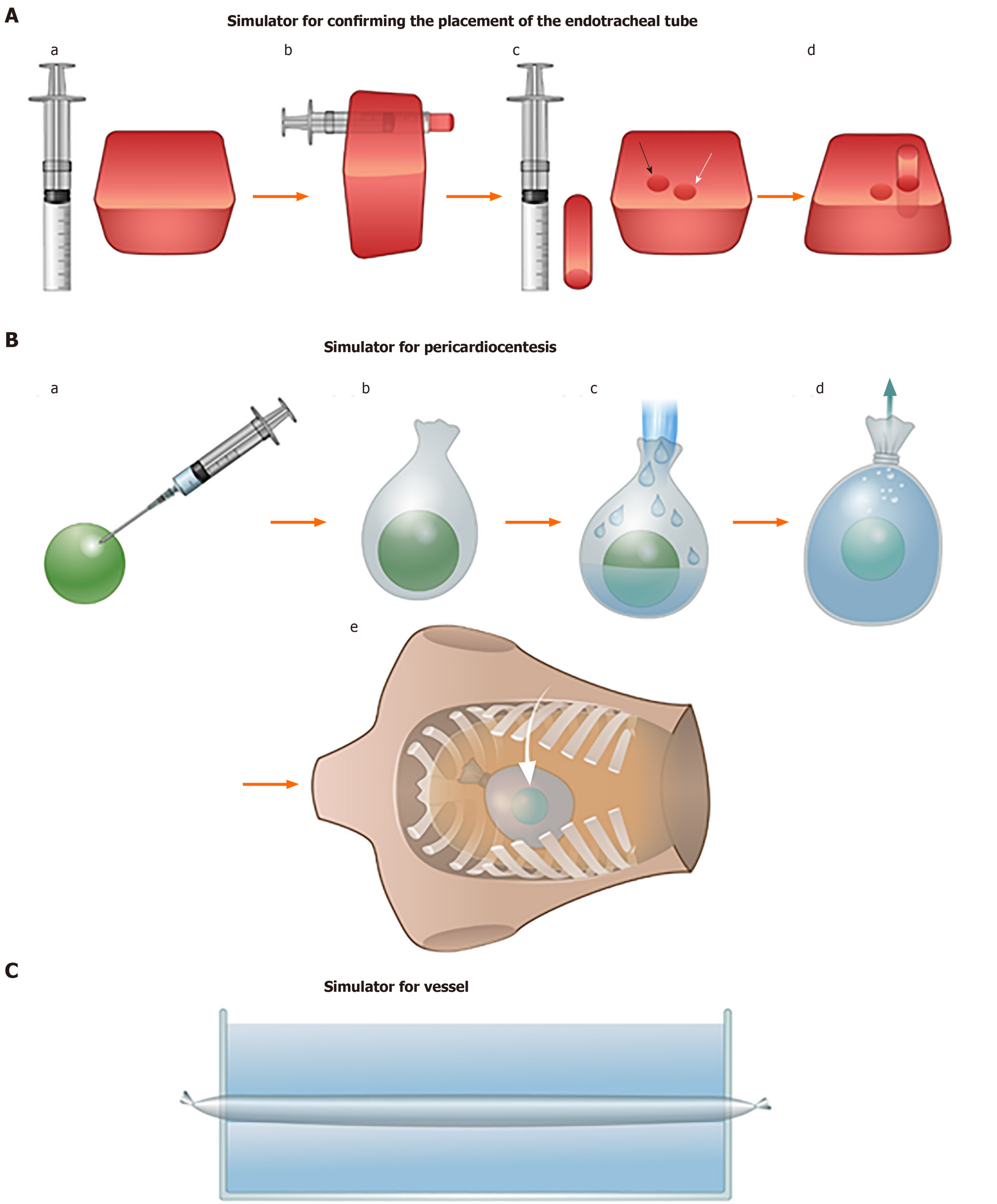

Figure 2 S specific simulator: The process of making some specific simulator that is complicated to make. A: Simulator for confirming the placement of the endotracheal tube A (a) beef gelatin powder (90 mL) and 60 mL of orange-colored psyllium fiber (Metamucil sugar free; P and G, Cincinnati, OH, United States) mixed with 500 mL of boiling water in a 1 L container. A 10 mL syringe with the tip cutoff; A (b) The two holes are separated by a gap between the trachea and oesophagus; they are 5 mm from the wall of the margins of the surrounding materials to achieve a real sonographic appearance. Two holes were made using a 10 mL syringe with the tip cutoff once the surrounding material was completely ready; A (c) White arrow shows the trachea. Black arrow shows the oesophagus; A (d) The simulation with the block in the hole that represented the oesophagus did not show the double tracheal sign and showed tracheal intubation. B: Pericardiocentesis simulator B (a) Prick a hole in a ping-pong ball and fill with water. It represents a heart; B (b) The ball then is inserted into a balloon or a 250 cc saline bag, which represents the pericardium; B (c) The balloon is filled with water to show the pericardial fluid; B (d) A spoon or a syringe is used to remove the bubbles; B (e) the simulator is used in an order as in Figure 1, with an artificial rib cage or a dummy. The posterior portion of the artificial rib cage and posterior portion of a dummy are removed so that it can be used as a container. And C: Vessel simulator such as latex or balloon are inserted in process Figure 1.

include pulmonary embolisms, severe dysfunction of left ventricle, regional wall motion abnormalities, evaluation of the aorta (aortic dissection or aortic aneurysm), or determine vascular access for resuscitation by using a vessel ultrasound[3,5-7,43]. In terms of focused echocardiography, four articles on cardiac tamponade and pericardiocentesis detection were found[20,26,37,38]. In terms of vessel ultrasounds, 11 articles regarding venous catheterization were introduced in this review article[17,22-24,32-34,36,48-50].

Surrounding material — chest wall and soft tissue: In the cardiac tamponade simulator, the surrounding material that represented chest wall was created by Zerth *et al*[26] using gelatine with green food colouring, Campo Dell'sorto *et al*[20] using gel wax, ultrasound gel, silicone skin, three tablespoons of flour, Daly *et al*[37] using gel wax, flour, artificial rib cage, and latex exercise resistance bands (TheraBand™) with a moulding bucket, and Young and Kuntz[38] using ballistic gel with flesh-coloured dye and artificial rib cage moulding in a plastic mannequin dress-form torso. What is very interesting is that by using an artificial rib cage or mannequin dress-form torso, the pericardiocentesis simulators were very similar to real thoracic cages[37,38]. These simulators were able to provide a more realistic environment by showing external anatomic landmarks, allowing trainees to practice finding the correct positioning of probes and needles[37,38].

Target — heart, pericardial effusion, and pericardial sac: A golf ball[26], water-filled celluloid ball[20], and red-dyed water-filled ping-pong ball[37,38] were used to represent heart. The pericardial sac was represented by a 16-inch punching balloon[26], 30 cm balloon[20] and 250 mL normal saline bag[37,38]. Pericardial effusion in all simulators was represented by red-coloured water[20,26,37,38]. To make a thoracic cage with a pericardial sac and heart, it took two to four steps[20,26,37,38]. In the first step, a base floor was made for the purpose of a stable base[20,26,37,38]. The second step was to fix the correct position of the heart and pericardial sac by pouring a melted gel[20,26,37,38] or sonographic gel[20] around the heart and pericardial sac while they were centred. The third step was to add the melted gel into a moulding container (Daly *et al*[37]'s method), or mannequin (Young and Kuntz[38]'s method) to make the distance between the sternum and the heart simulator similar to a real human. The last step was to cover it with silicone skin to generate a resistance similar to a human and draw the external anatomical marks[20,37]. The stage of making pericardiocentesis simulator is briefly schematized in Figure 2B.

Target — vessels: POCUS related to vascular approach techniques has been one of the most widely used practices in emergency departments. Various kinds of materials have been used in several studies to represent vessels; examination glove[49], intravenous infusion sets[17], Penrose drains[50], balloons[14,32,48], silicone tubes[23,34], latex tubes[23,24] and plastic tubes[22]. Nolting *et al*[49] introduced a simulators made using a water-filled glove finger and SPAM®. They used a large straw for driving a tunnel through the entire SPAM® block[49]. The tunnel played the role of a vessel with a water-filled glove finger inserted[49]. Another method was to plug one end of the tunnel, and fill it with ultrasound gel[49]. However, the authors did not discuss which materials were more practical[49]. Wells and Goldstein[17] suggested using an intravenous infusion setline connected to an IV saline bag as vessel, and polony as the surrounding material. There was no mention of whether it has a similar tactile sensation to real human tissue[17]. We thought it seemed easier to replenish a fluid to simulate the "blood." A balloon model was suggested for vascular access[14,48]. Fürst *et al*[14] used the latex straw balloon to represent the vessel, and chicken breast for the surrounding material. A latex straw balloon, typically used for decoration and sculpturing, was placed into the tunnel (made by Kelly using forceps) in the chicken breast[14]. The authors reported that the two combinations had the most similarity to human tissue in echogenicity and compressibility[14]. Rippey *et al*[48] also used chicken breast as a material for the simulators and introduced various materials for implementing vessel, including balloons. Various balloon diameters were used to simulate veins; their thin walls simulated the ultrasound appearance and tactile sensation of punctures[48]. By adjusting the tension of the balloons, the compressibility made by the ultrasound probe could be determined[48]. This can be used to represent a hypovolemic state of a vein by filling it loosely with fluid[48]. To express slightly harder feeling of an artery, instead of a balloon, a latex or silicon tube was used[48]. The authors made models with varying complexity that could easily be changed, using chicken breasts and various kinds of balloons or silicone tubes[48]. They provided video clips where they create various simulators that embody various shapes and types of blood vessels[48].

The materials we introduced earlier were made by inserting "the blood vessel" into the surrounding material. The stage of making vessel simulator is briefly schematized in Figure 2C. A latex rubber tube was used to melt the gelatine or agar used to make the simulators, instead of using balloons[23,34]. We felt that the appearance on ultrasounds, tactile sensation and durability were similar when compared to balloons. Two studies used a Penrose drain, but did not describe its differences compared to other materials[32,50]. Sanchez-de-Toledo and Villaverde[50] used boneless pieces of chicken breast with a tunnel made using tweezers. A 10 cm Penrose drain was inserted through the tunnel as a vessel[50]. Earle *et al*[32] used a Penrose drain and latex balloon as a vessel, with agar as the surrounding material. They recommended that different materials depending on the situation and environment be used to simulate blood vessels[32]. Cheruparambath *et al*[22] made a simulator with plastic tubes and gelatine. When compared with other vessel materials such as latex or rubber, using plastic tubes was less realistic and felt more rigid[22]. However, it showed advantages in durability and reusability[22].

The materials introduced so far showed more hyperechoic images of vessel walls than actual human tissue does on ultrasounds. Some of the researchers have suggested wall-less simulators in which vessel-mimicking materials are absent[24,33,36]. Using these type of simulators, realistic images can be obtained[24,33,36]. A simple method to construct wall-less simulators is to remove the rod or tube positioned in the surrounding material, which is composed of gelatine, agar, or ballistic gel[24,33,36]. First, they made a hole for the rod on both sides of the plastic chamber and inserted the rod through the chamber[24,36]. With the rod in, they then poured the tissue-mimicking material (gelatine, agar, or ballistic gel) and waited until it hardened[24,36]. Then they removed the rod through the holes[24,36]. However, these methods have been limited in their widespread use due to problems with skill, equipment, and resources[33]. In a study proposed by Nikitichev *et al*[33], a three-dimensional (3D) printer was used to solve these problems and create a simulation model without difficulty. They could also simulate different shapes of blood vessels and various clinical environments without difficulty[33]. Using a 3D printer, a rectangular chamber with two holes on each side was designed by two freely available software programs: Blender (Stichting Blender Foundation, Amsterdam, the Netherlands), and FreeCAD (Juergen Riegel, Werner Mayer, and Yorik van Havre; OpenSource, www.freecad.com)[32]. Of the two types of 3D printers they used, an additive polymer resin printer (Objet30 Pro; Stratasys, Eden Prairie, MN, United States) using a rigid opaque white or blue material with a gloss finish (VeroWhitePlus RGD835 or VeroBlue; Stratasys) produced better results than the others[33]. Agar with a 5.5% weight concentration was used as the surrounding material, and polytetrafluoroethylene (DirectPlastics, Sheffield, England) was used as the rod material[33]. The rods had minimal adhesion to the agar[33]. We recommend referring to the paper for detailed methods and other details.

Related to D- disability

POCUS related to disability is used for detection of stroke by transcranial color-coded POCUS *via* the temporal bone, retinal detachment, a foreign body, vitreous haemorrhage, retrobulbar hematomas, or measurement of the optic nerve sheath diameter (ONSD)[5,7,25,51,52]. To the best of our knowledge after several PubMed searches, there have not been any articles related to simulators for transcranial color-coded POCUS. The three articles we did find are related to simulators for ocular POCUS. Jafri *et al*[51] made simulators that represented normal anatomy, foreign bodies, vitreous haemorrhages, retinal detachment, and ONSD measurements. The simulator also simulated lens dislocations, and Jafri *et al*[51] simulated retrobulbar hematomas. The appearance of the ocular simulator for ONSD measurements made by Murphy *et al*[15] might be closer to the sonographic images of humans than the previous simulators. However, the simulator by Murphy *et al*[15] did not represent the anterior structure of the eye (such as lens), and Cuévas Gonzales' method was made using simple methods and simulates more pathologies[25].

Surrounding material soft tissue and vitreous humour: The simulators for ocular POCUS were more focused on the ocular simulators themselves rather than the surrounding materials[15,25,51]. Jafri *et al*[51] made eyeball simulators without surrounding materials. Murphy *et al*[15] fixed the ocular simulator using three packs of unflavoured gelatine, one tablespoon of sugar-free psyllium powder (*e.g.*, Metamucil Sugar Free Dietary Fibre Supplement, P and G), and 250 mL water in 473.176 mL plastic cups (*e.g.*, Solo Plastic Party Cup, Dart Container Corporation, Mason, OH, United States). The surrounding material used in this model[15] looked more similar to human tissue than other simulators[25]. Cuévas Gonzales[25] made a square-shaped block and printed the shape of an eyeball, lens, and iris using aluminium paper. This block was made using 500 mL water, 100 mg of gelatine, and 30 mL of 70% ethanol into a bowl or

Tupperware container[25].

Target - eyeball, retinal detachment, foreign body, vitreous haemorrhage, retrobulbar hematoma, and optic nerve sheath: Using an aluminium paper mould to represent a normal eyeball. They made the eyeball mould, iris mould (anterior chamber), and posterior lens mould using aluminium, and these moulds were printed on the hard gelatine already prepared as described above[25]. In addition, a piece of aluminium paper represented a foreign body embedded somewhere in the rear chamber[25]. For vitreous haemorrhage, one or two grooves (1 cm to 1.5 cm irregular shapes, using a scalpel) filled with a mix of instant coffee and water were made somewhere in the rear chamber[25]. For retinal detachment, they made the retinal detached mould and printed it on the hard gelatine. For lens dislocation, they printed lenses not parallel to irises[25].

Jafri *et al*[51] made an eyeball simulator using a round plastic mould similar to the size of the eye. They poured the gelatine mixture and psyllium powder into the round plastic mould[51]. The lens appearance was made by a circumferential incision at a 15° angle with the tip of the blade facing the uppermost centre of the eyeball simulator[51]. A metal electrocardiograph lead was used to represent the optic nerve sheath (ONS), placed on the bottom of the eyeball simulator[51]. For retinal detachment, an incision using a size 15 scalpel was made in the posterior portion of the eyeball simulator[51]. For vitreous haemorrhage, a pocket was made by using an 18-gauge needle in the eyeball simulator, and hyperechoic fluid such as glue or casing plaster dissolved in water were injected into the pocket of the eyeball simulator[51]. For retrobulbar haemorrhage, the structure filled with fluid was placed under the posterior portion of the eyeball simulator[51]. Of course, it was possible to represent ocular foreign bodies by inserting various materials such as plastic or metal materials into the model as well[51].

Murphy *et al*[15] focused on creating an ocular simulator to represent ONS. To represent ONS, a 7 cm clear vinyl tube with a similar width to the optic nerve and a stylet of an 18-guage needle with a metal tip were used[15]. Eyeballs were represented by using a 40 mm diameter ping-pong ball filled with water[15]. To make the eyeball simulator, the ONS simulator was inserted in a 473.176 mL plastic cup through a round hole in the middle of the bottom (created using a drill), and then the surrounding material mentioned above was poured into the plastic cup at the level of the metal tip[15]. After hardening the surrounding materials in the plastic cup, the ping-pong ball filled with water was placed on the ONS simulator, and then the surrounding materials were poured into the plastic cup on top of the ping-pong ball[15].

Others - fracture, regional nerve block, and soft tissue abscess

Musculoskeletal ultrasounds are useful tools to diagnose skin infections and fractures, as are other imaging modalities such as plain radiography, computed tomography, and magnetic resonance imaging[3,7]. Ultrasounds in particular are superior in situations where other modalities are not suitable or accessible[3,7]. Physical examination is limited when it comes to distinguishing between soft tissue abscess and cellulitis[18,53]. POCUS has been reported to be a powerful diagnosis tool to diagnose soft tissue abscess or cellulitis, as well as help make treatment decisions[18,49,53]. POCUS is useful when it comes to regional nerve blocks in emergency departments, including forearm nerve blocks, brachial plexus blocks, serratus anterior plane blocks, and fascia iliaca compartment blocks[31]. In this section, we described the simulators related to musculoskeletal ultrasounds, including fractures, regional nerve blocks, and soft tissue abscesses.

Fracture: A paediatric skull fracture simulator has been introduced by Soucy *et al*[27]. Coconuts were used to represent paediatric skulls[27]. A coconut was cut into puzzle-like pieces, similar to suture lines and skull fractures. The motorized saw has been reported to be the best cutting tool[27]. The fixation among coconut pieces was done by applying the epoxy gel to the inner surface of the coconut pieces, in order to maintain the echogenic properties of the coconut and the suture line[27]. To waterproof the coconut simulator, a waterproof shellac was applied in two thin coats[27]. To stabilize the simulator, two 1.5 cm long pieces of round wooden dowels were attached to the convexity of the simulator, 1 cm from the midsagittal suture on each side[27]. To make soft tissue that is similar to the human cranium, the coconut simulator was submerged in a round bowl filled with a sugar-free gelatine and Metamucil (P and G) solution several times[27]. The completed skull fracture simulator looked like a lollipop, and was able to represent sonographic suture lines and fracture lines[27].

Regional nerve blocks: The nerve block simulators were made by various materials to simulate nerves such as metal rods[54], wooden dowels[55], electrical wire[55], shoelaces[17], yarns[31], Computer Aided Translation 5 Ethernet cables[56], spaghetti noodles[57], and straw embedded hot-dogs[39]. Sparks *et al*[56] made a nerve block simulator using pressure-injected ultrasound gel with a Computer Aided Translation 5 Ethernet cable representing a nerve. This was a good simulator, which produced the "donut sign" of hypoechoic fluid around the nerve, but due to the metallic properties, posterior shadowing appeared[56]. Micheller *et al*[57] used a long tubular balloon (28.5 cm × 0.9 cm in dimension, commonly used for balloon animals) filled with water and five pieces of flour spaghetti noodles presenting the femoral nerves. The regular-thickness spaghetti noodles created the "honeycomb" appearance that is typical in sonographic findings of large nerves[57]. The visualized hydrodissection could be confirmed in this simulator, but after three or four blockade attempts, it gradually lost hydrodissection confirmation[57]. Naraghi *et al*[31] introduced meat glue (transglutaminase) as a binding component to create fascial planes, in order to represent hydrodissection, by injecting fluid through a needle. To substitute the role of the fascia, the meat glue was sprinkled between a pork tenderloin that was cut into the required muscle shape[31]. Chunky yarn soaked in ultrasound gel was used as nerves[31]. Several strands of yarn could be twisted together for representing thicker nerves[31]. In addition, thin size straws filled with ultrasound gel that were occluded on both ends with chewing gum were used to represent the interscalene brachial plexus[31]. Situ-LaCasse *et al*[58] used a nerve simulator that was created by inserting angel hair pasta into long balloons and filling them with a dash of water to educate medical students in ultrasound-guided peripheral nerve block procedures. Previous research models had the disadvantage of having posterior shadowing, so it was hard to confirm the needle tip behind "the nerve"[39]. Rathbun *et al*[39] created a realistic nerve block simulator with minimal posterior acoustic shadowing compared to previous simulators. The authors used a gelatine-Metamucil mixture and a hot dog embedded with a straw in the core[39]. The centre of the hot dog with a straw represented a nerve[39]. They could simulate various nerve target models by adjusting the depth of the surrounding tissue, done by regulating the amount of the mixture used per layer, and the size of the nerves could be varied using different straw sizes[39]. However, it was difficult to confirm the perinerve infiltration or hydrodissection, since most of the injectate proceeded retrogradely along the path of the needle[39].

Soft tissue abscesses: The simulators for soft tissue abscess have been made using various liquids such as ketchup[18], lotion[18], mayonnaise[18], candies with liquid centres[18], honey[18], ultrasound gel[18,49], mustard[18], lubricating jelly[18], water[35], tapioca with olive oil[53], vanilla pudding with olive oil[53], and salad dressing[18] in cystic like materials such as pipette bulbs sealed using kitchen clips[23], or balloons[35,53]. Ultrasound gel has been reported to have the best performance in terms of sonographic appearance and injection into surrounding materials, as well as drainage using syringes[18,49]. The surrounding materials used in soft tissue abscess were as follows; SPAM®[49], 10% ballistic gelatine[35], and gelatine with sugar-free Metamucil[18,23,53].

RECOMMENDATIONS OF THE AUTHORS

Each way of producing the simulator has both advantages and disadvantages. Hence, our recommendation on a single method may not be appropriate. In addition, the purpose and circumstances may be different for each institute. The surrounding material recommendation maybe an exception that is based on the review and the authors' experience, which is the closest in human tissue that has a similar sonographic appearance and resistance. In addition, limited studies have used a specific target simulator. It is difficult to recommend one method since all methods have advantages and are similar to real ones. It is best to choose a specific target simulator depending on the structure they wish to focus on. Using hand ultrasound, which is the easiest approach, a dummy that is very similar to real and a pericardiocentesis model that uses a rib cage and mannequin have been developed.

Based on the current review and our experience, we would like to recommend the below simulation models. It is important to add colors to make the models more real, but from an educational point of view, using a transparent simulator to learn the relative positions of the objects and where the ultrasound probe should be placed is more important. We thought that training using transparent simulators would be more helpful to novices who are unfamiliar with ultrasound and that colored simulators would be of great help in the subsequent steps. To increase the best ultrasound appearance, we recommend the following additives: the gelatin and Metamucil mixture[18] (12:4 tablespoons) and the PVC mixture model[19] [9:1:2 ratio (PVC polymer to softener to mineral oil)]. We also recommend the modified PVC polymer model in terms of mimicking the skin resistance. If the PVC mixture ratio is practically complicated, we also recommend using hydrocolloid dressing materials (DuoDERMR CGF® dressings; ConvaTec, Skillman, NJ, United States) to secure the skin resistance or Schmidt Sports PHYSIO TAPE (THERABAND, Akron, OH, United States), which also has the effect of increasing realness[23] with the gelatin and Metamucil mixture[18] (12:4 tablespoons). Table 3 shows the advantages or disadvantages of the surrounding materials. For specific simulation models, we recommend using hand ultrasound with a dressing material form as a practical way of familiarizing the trainee with the basic sonographic appearance and physiology of the lungs[16,45]. For the pericardial model, we recommend the mannequin (Young *et al*[38]'s method), which is a compilation of the previous methods. For mimicking the orbit, different recommendations may be provided depending on the tissue that was focused to visualize. Various types of materials have been used in several studies to represent vessels. It is our opinion that for most cases, veins may be best represented by balloons and arteries may be best represented by silicon or latex pipes. Although innovative, 3D printing models do not seem practical so far. Finally, we wish to point out that the aforementioned models have their own strongpoints, and the recommendations provided are only based on our opinion.

CONCLUSION

Inexpensive and easily made simulators for education on POCUS provide sonographic appearances and resistance similar to human tissue. There were various recipes for making simulators; however, the materials used were similar. These materials were readily available, and the methods of making the simulators were simple. However, one thing to keep in mind is that injuries such as burns can occur in the process of making simulators, particularly during boiling or melting processes using stoves. The sonographic appearance of the easily made simulators that introduced in this review article might not be completely similar to human tissue. However, since the primary goal in procedural education is target acquisition, coordination between targets and needles, and needle finding, the sonographic appearance of these simulators did not affect the utility of the models in achieving those goals. In terms of resistance and sonographic appearance of the simulators, the gelatine and Metamucil mixtures and polyvinyl chloride mixtures appear to be most similar to the characteristics of actual human tissue. They get the spotlight of being a high-performance material.

There are some limitations in this review article. We did not describe the validation methods used to investigate the educational effects, and we did not insert the figures that introduced the creation processes of the simulators due to space constraints. We hope that this review article provides guidance when searching for specific simulators. If the descriptions of the processes to make the simulators were insufficient, it would be helpful to refer to the figures in the original articles.

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