TURKISH JOURNAL OF EMERGENCY MEDICINE

Original Article

Comparing commercial versus low-cost gelatinous phantoms for ultrasound-guided needle tracking: A randomized crossover trial, among emergency medicine residents

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Access this article online

Quick Response Code:

Website:
https://turkjemergmed.com/

DOI:
10.4103/tjem.tjem_206_23

Submitted: 16-09-2023
Revised: 20-01-2024
Accepted: 23-01-2024
Published: 04-04-2024

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Abstract:

OBJECTIVES: The objective of this study was to devise a low-cost indigenous gelatin-based vascular phantom and to compare this newly constructed phantom with a commercially available phantom.

METHODS: This was a randomized crossover study conducted at a tertiary care hospital of India. The aim of the study was to develop a prototype low-cost gelatin-based vascular phantom and compare it with a commercially available phantom. Gelatin, psyllium husk, corn starch, antiseptic liquid, food-coloring agent, latex balloons, and metallic containers were used to prepare the gelatin phantom. The newly prepared gelatin model was labeled "Model A" and the commercially available gelatin model was labeled "Model B." Emergency medicine residents ($n = 34$) who routinely perform ultrasound (USG)-guided invasive procedures were asked to demonstrate USG-guided in-plane and out-of-plane approach of needle-tracking in both the models and fill out a questionnaire on a Likert scale (1–5). An independent supervisor assessed the image quality.

RESULTS: The cost of our phantom was USD 6–8 (vs. USD 1000–1200 for commercial phantom). The participants rated the ease of performance and tissue resemblance as 4 (interquartile range [IQR]: 4–5) for both the models "A" and "B." The supervisor rated the overall performance as 4 (IQR: 3–4) for both the models. In all the parameters assessed, model A was noninferior to model B.

CONCLUSION: The indigenously developed vascular phantom was noninferior to the commercially available phantom in terms of tissue resemblance and overall performance. The cost involved was a fraction of that incurred with the currently available commercial model. The authors feel that gelatin-based models can be easily prepared in resource-constraint settings which may be used for USG-guided training and medical education in low- and middle-income countries.

Keywords:

Gelatin, low- and middle-income countries, needle tracking, phantom, ultrasound

Introduction

Needle tracking (NT) is an integral part of ultrasound (USG)-guided procedures in emergency or intensive care unit settings. The utilization of USG-guided NT has proven to decrease complications, such as hematoma formation, arterial puncture,

How to cite this article: Shrimal P, Thakur N, Gopinath B, Mishra PR, Rajalekshmi R, Bhoi S, *et al*. Comparing commercial versus low-cost gelatinous phantoms for ultrasound-guided needle tracking: A randomized crossover trial, among emergency medicine residents. Turk J Emerg Med 2024;24:103-10.

Box-ED Section

What is already known on the study topic?

- Needle tracking (NT) is an integral part of USG-guided procedures in the emergency department. It has proven to decrease the complications and increase the success rates of these procedures. Several commercially available phantoms are available in the market to enable the practice of ultrasound (USG)-guided NT.

What is the conflict on the issue? Has it importance for readers?

- Although there are several commercially available phantoms available in the market to practice USG-guided NT, the cost and limited availability of these phantoms have posed significant barriers for many academic institutions, particularly those in low- and middle-income countries.

How is this study structured?

- This was a randomized, crossover, double blinded study that included the data from 34 participants. The first phase of the study was to develop a prototype low-cost gelatin-based vascular phantom and the second phase was to compare it with a commercially available phantom.

What does this study tell us?

- This study tells us that gelatin-based vascular access phantoms can be made easily within a short span of time. The cost incurred is much less compared to the commercially available phantoms. These models are comparable in texture and performance to the commercial phantoms.

and pneumothorax, associated with various procedures including paracentesis, thoracocentesis, regional anesthesia, and central vein cannulations.[1-3] It increases the success rate while simultaneously, reducing the number of attempts and saving time.[2] Although USG can be taught on live patients and volunteers, USG-guided invasive procedures, such as giving nerve blocks and inserting central lines require expertise and practice. These procedures demand adequate experience in "tracking the needle" during the procedure. Adequate NT significantly increases the chances of a successful procedure while simultaneously decreasing the likelihood of complications.

Several commercially available models referred to as phantoms are available in the market and are being utilized for training in USG-guided NT procedures.[4] A phantom can be defined as a designed medium (other than live human tissue) that can be utilized for education and training. An ideal phantom should mimic the acoustic and sonographic appearance of human tissue to provide a realistic feel for beginners. However, the cost and limited availability of these phantom models have posed significant barriers for many academic institutions, particularly those in low-to middle-income countries (LMICs), hindering the widespread dissemination of knowledge on USG-guided procedures.[5] Although USG machines are now available in many teaching hospitals, their utilization in the emergency department (ED) has been low due to the lack of training.[6] Consequently, procedures, such as central line insertions are still being done blindly at most of the centers, leading to decreased success rates and increased risk of complications.

Hence, the investigators aimed to develop, devise, and assess low-cost gelatin models with a future goal of disseminating the model and information for wider usability, including medical education and training. The objective of the study was to develop a prototype low-cost gelatin-based vascular phantom model for USG-guided NT and to compare the ease and accuracy of NT using the newly developed model to a commercially available phantom model, considered as the gold standard.

Methods

Settings and design

This randomized, crossover, double-blinded study was conducted in the Department of Emergency Medicine at a Tertiary Care Hospital in North India which has a robust USG teaching program. The study was approved by the ethics committee of our institute vide, reference number IEC-924/04.09.2020, RP-33/2020 (dated November 26, 2020, All India Institute of Medical Sciences). Due to the COVID-19 pandemic and various unavoidable factors, the study was carried out over 8 months, from August 2021 to March 2022, with intermittent delays and interruptions.

The study methodology was divided into two parts:

- Part 1: Preparation of gelatin-based vascular phantom model
- Part 2: Comparison of the newly prepared model with a commercially available gelatin model (randomized crossover double blinded).

Part 1: Preparation of gelatin-based phantom model

Materials and equipment used: Commercial use gelatin, psyllium husk, corn starch, antiseptic liquid, food coloring agent, 30 cm latex long balloons, measuring jar, weighing scale, big size spoon, 25 cm × 12.5 cm metallic containers, scientific thermometer, electric drill, and refrigerator were used during this step. The shape and dimensions of the metallic container selected were such that it simulated the dimensions of the commercially available model.

Method for preparation of phantom

Step 1 (preparing the container)

A 25 cm × 12.5 cm metallic container was taken and circular holes were made on both the short sides of the container with the help of an electric drill to make space for the passage of inflated balloons. Two balloons were taken and inflated with the help of tap water and inserted in metal containers through the holes drilled maintaining adequate tension; the open ends were tied using a simple surgeon's knot [Figure 1a]. All four holes were sealed with the help of candle wax [Figure 1b].

Step 2 (preparing the mixture)

Multiple attempts were given to construct the gelatin phantom using different concentrations of constituents till a final desired product was obtained. The method which deemed the best in terms of consistency and durability as per the authors is described: 1000 mL of lukewarm water was taken in a 1.5 L volume jar. Around 150 g of commercial gelatin was added to a pan and lukewarm water was added to it in small aliquots and the contents were stirred with the help of a big spoon to avoid clumping until the mixture appeared homogenous [Figure 2a]. Any froth or bubbles formed were allowed to settle or were removed manually [Figure 2b]. About 20 g of cornstarch and 10 g of psyllium husk were then added to the above mixture to obtain a uniform consistency and to mimic the human tissue. After that, 10 mL of an antiseptic liquid and 5 mL of a food-coloring agent were added and stirred well. Any froth or bubbles formed were allowed to settle or were removed manually [Figure 2c].

Step 3 (mixing)

The mixture thus prepared was poured into the metallic container with balloons ensuring that the balloons were about 2–3 cm below the surface [Figure 2d]. The sides of the container were checked for leaks, if any. The container with the mixture was then left at the room temperature for 5–6 h for adequate solidification [Figure 2e and f]. Keeping the mixture in a refrigerator for 1–2 h helped with faster solidification.

Part 2: Comparison of the newly prepared gelatin model with a commercially available model

This part of the study aimed to assess and to compare the newly prepared gelatin model with a commercially available phantom model. We have used the commercially available Blue Phantom® as the gold standard which is commonly used for USG NT training. We used the BPO100 model two vessel subtype (Price USD 800–1000).[7]

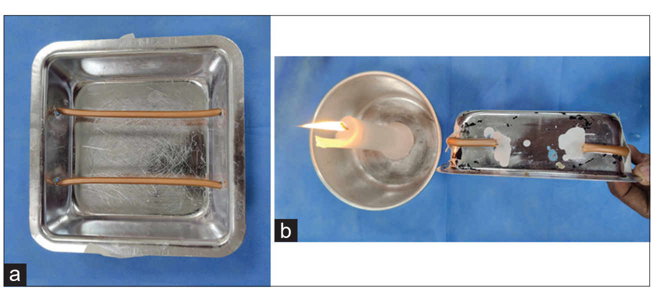

Figure 1: Preparation of the mold. (a) Inflated balloons fixed inside the metal container through drilled holes for vascular access phantom. (b) The ends of the container sealed with candle wax

Participants, randomization, and sample size

Sample size

For this cross over trial, considering noninferiority margin of – 0.8, expected difference between model A and model B group 0 and standard deviation (SD) of 1.07 with power of 90% and alpha 0.05, we get a sample size of 16 in each arm. We randomized 34 participants into two groups with 17 in each arm. In one arm (arm AB), participants conducted USG scans on a gelatin phantom (model A), initially, and subsequently, they performed scans on a commercial phantom (model B). In the other arm (arm BA), participants conducted USG scans on the commercial phantom first, followed by the scans on the gelatin phantom.

Emergency medicine residents who routinely perform USG-guided NT procedures such as central vein cannulation and nerve blocks were recruited in the study after taking informed consent. A total of 34 residents with different years of training were recruited. Block randomization of blocks of 6 and 4 was used using online available commercial software (sealedenvelope.com). Randomized sequence (arm AB or arm BA) was written in a paper and kept inside a dark brown envelope and arranged in order of block randomization. The consecutive envelope was opened when a resident was available to be recruited in the study. The resident would perform NT in the order mentioned in the randomization sequence (arm AB: Model A followed by model B, and arm BA-model B followed by model A) this way every resident performed NT on both the phantoms. There was an independent supervisor who noted the quality and characteristics of the image acquired by the participants. The independent supervisor was an emergency medicine consultant, serving as the lead for ED USG and was also blinded to the models.

Conduct of the comparison study

The study was conducted in the departmental teaching room, equipped with facilities for simulations and didactic lectures, featuring projector, and LED screen. Two stations were set up for conducting this part of the study. For both stations, Sonosite USG machine (Sonosite Edge II) and its linear probe were used. The gelatin phantom prepared was labeled "A" and the commercial phantom was labeled "B." Both models were of the same dimensions and covered by the same-colored polythene sheet to ensure blinding of participants and the supervisor. The models were indistinguishable based on the external appearance after being covered with the

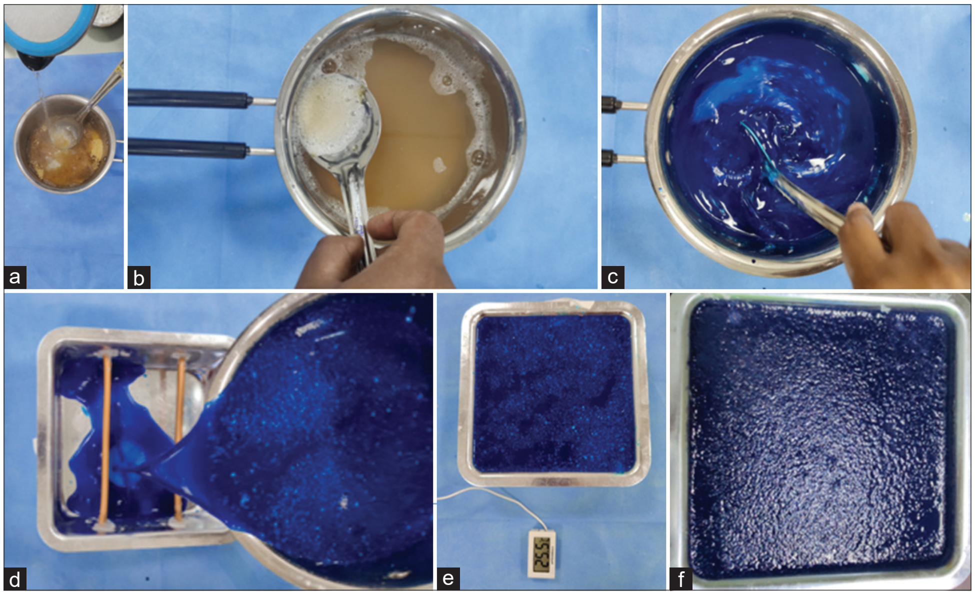

Figure 2: Preparation and settlement of the mixture. (a) Pouring lukewarm water into the gelatin. (b) Removing the superficial bubbles. (c) Adding rest of the constituents and stirring the mixture until homogenous appearance is achieved. (d) Pouring the freshly prepared mixture into the container. (e) Allowing the mixture to settle at the room temperature. (f) Final appearance of the phantom after settling

polyethylene sheet. Adequate jelly was used to ensure the complete removal of air pockets. Each participant was asked to demonstrate the two techniques of NT at the two stations – (1) In-plane, in which needle tip placed in-line to USG probe [Figure 3a and b] and (2) Out-of-plane, in which needle tip placed perpendicular to USG probe approach [Figure 3c and d]. Subsequently, they were asked to fill out a questionnaire comprising of basic knowledge and performance characteristics. The independent supervisor assessed the image acquisition characteristics (image clarity, resolution, artifact, and overall performance) in both the planes (based on the visualization of the needle tip, ability to aspirate, number of attempts, etc.) and graded the participants on a Likert scale of 1–5 (1-worst and 5-best). The performance and acquisition characteristics parameters were determined based on the study conducted by Abraham *et al*.[8] The questionnaire handed out to the participants had a series of questions on demographic characteristics, basic knowledge, and performance characteristics graded on a Likert scale of 1–5 (1-worst and 5-best). The statistician analyzing the data was also blinded as data were provided in labeled form "A" and "B" for the two phantoms.

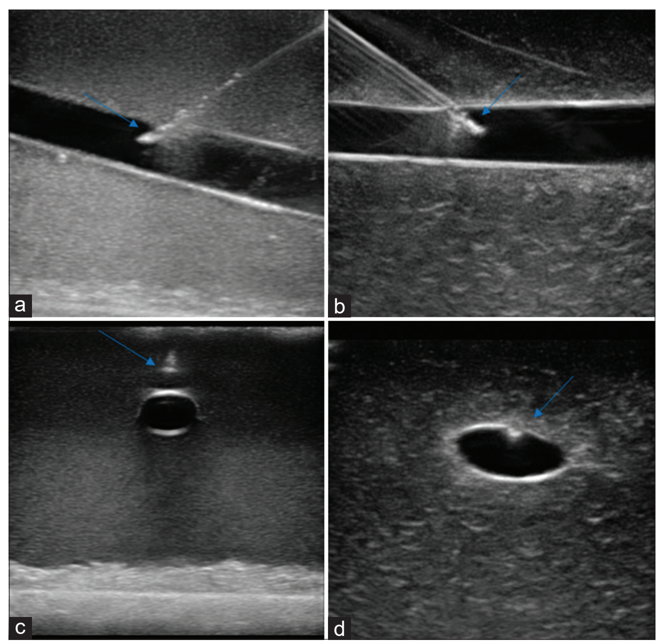

Figure 3: Appearance of needle tracking in freshly prepared low-cost phantom versus the blue phantom. (a) Needle tracking in the long axis in indigenous low-cost model (blue arrow tip corresponds to the needle tip). (b) Needle tracking in the long axis in the traditional blue phantom (blue arrow tip corresponds to the needle tip). (c) Needle tracking in the short axis in indigenous low-cost model (blue arrow tip corresponds to the needle tip). (d) Needle tracking in the short axis in the traditional blue phantom (blue arrow tip corresponds to the needle tip)

Data analysis and interpretation

Statistical software, namely Statistical Package for the Social Sciences, SPSS (International Business Machines Statistical Package for the Social Sciences, IBM Corp. Released 2013, Version 22.0. Armonk, NY, USA: IBM Corp) was used for the analysis of the data. Microsoft Word and Microsoft Excel (2013 version) were used to enter the data and generate graphs, tables, and charts. Numerical variables are expressed as median (interquartile range [IQR]) and mean ± SD. The categorical variables are expressed as frequency and percentages. Wilcoxon–signed rank test was used to compare the two models. The statistical analysis was based on an intention-to-treat analysis.

The cost of preparation of a single model was estimated on the basis of total cost of the project divided by the number of models made. The number of man-hours was calculated based on the number of persons involved to make the phantom multiplied by the number of hours required to make a single phantom.

Results

Demographics and baseline knowledge of the participants

Most participants were aged 25–30 years (n = 27), with 82.4% males (n = 28) and 17.6% females (n = 6). The majority were academic junior residents (66.7%) while the rest were senior residents. Junior residents are trainee doctors studying a 3-year postgraduate program in emergency medicine. Senior residents are those who have completed their training and are now working as registrars in the department. Regarding USG training, 82.4% had prior experience with USG-guided procedures and 58.8% received training on simulation models. All participants had observed a minimum of 10 and performed more than five USG-guided vascular procedures. Among those without training, 84.6% cited nonavailability of vascular access models in their previous institutions. All the demographics and baseline characteristics among the two arms were similar with no statistical difference [Table 1].

Model comparison

Performance characteristics and image acquisition characteristics of the models

Table 2 represents the performance characteristics ratings of both model A and model B as assessed by the performers. The median rating for both models across all performance aspects was 4, with an IQR of 4–5. The P values were nonsignificant, ranging from 0.08 to 0.8.

Table 3 summarizes the image acquisition characteristics of both model A and model B as evaluated by the supervisor. The median rating for both models across all image acquisition characteristics was 4, with an IQR of 4–5. The P values were nonsignificant, ranging from 0.42 to 0.89.

A detailed crossover analysis of the two arms is provided in Supplementary Table 1. No statistically significant differences were found between the two arms in the period effect and cross effect for all the parameters. In addition, the lower confidence interval does not cross the noninferiority margin of <–0.8 in any parameter. Therefore, model A is deemed noninferior to model B in all the parameters evaluated [Table 4].

The cost incurred to make a single phantom was USD 6–8 and number of man-hours required to make a single phantom was 4 man-hours (2 person × 2 h).

Discussion

Point-of-care sonography plays a vital role in emergency medical care, and NT is integral to procedures such as vascular access, nerve blocks, and guided interventions. However, in LMIC, the availability of commercially available phantoms is limited due to the associated costs. In this study, we aimed to develop a gelatin-based vascular access phantom model at a significantly lower cost compared to commercial alternatives.

Our indigenously developed model demonstrated a cost advantage, with an estimated cost of approximately Rs. 500–650 per model (USD 6–8), compared to Rs. 80,000–100,000 (USD 1000–1200) for commercially available gelatin-based phantoms. While previous studies have explored low-cost phantom models for vascular access, only few have compared them with commercial phantoms.[4,8,9] In a study conducted by Abraham *et al*.,[8] there was a statistically significant difference between an indigenously developed model and a commercial phantom with respect to resemblance to human tissue on tactile feedback and ease to perform the procedure. However, both models did not show a statistically significant difference in terms of ease of use, visual resemblance to human tissue, needle visualization, and artifacts on ultrasonography display. In our study also, there were no statistically significant differences between the two models in any domain.

Various materials have been used in previous studies to mimic blood vessels, such as latex balloons, latex gloves, Foley's catheters, latex tubings, and plastic tubes.[10-16] In our study, we opted for long latex balloons instead of rubber tubing as we found that rubber and latex tubing gave an acoustic shadowing which adversely affected USG image quality. The manner in which tubing was attached to the container has shown variations in studies done earlier. In one study, the rubber tubing was attached to the bottom and top of the container with the help of tape.[17] However, in our study, we drilled holes in the containers and fixed the tubes outside the container using a knot and sealed with candle wax to provide better strength and ease in doing needle puncture. This also allowed for multiple punctures on the same model and easy replacement of the tubes.

There have been studies using various primary materials to construct the phantom, such as gelatin, glycerin, gel, and agar.[10,11,13,15-19] However, the authors used commercial gelatin for making the phantom as they felt that it gave the best tissue-like consistency. A study compared six unique phantom models: Amini Ballistics, Morrow Ballistics, University of California San Diego gelatin, Rippey Chicken, Nolting Spam, and Johnson Tofu. The Rippey model (chicken breast) scored

Table 1: Demographics and baseline characteristics of the participants

Basic knowledge	Arm AB, *n* (%)	Arm BA, *n* (%)	Total participants (*n*)
Age group (years)			
25–30	13 (48.15)	14 (51.85)	27
31–35	4 (57.14)	3 (42.86)	7
Gender			
Male	15 (53.57)	13 (46.43)	28
Female	2 (33.33)	4 (66.66)	6
Medical experience			
Junior residents	10 (45.45)	12 (54.54)	22
Senior residents (post 3 years of junior resident training)	7 (58.33)	5 (41.66)	12
Training on USG-guided procedures			
Yes	14 (50)	14 (50)	28
No	3 (50)	3 (50)	6
Years of EM training/practicing point-of-care sonography (years)			
<1	4 (50)	4 (50)	8
1–2	2 (50)	2 (50)	4
2–3	5 (45.45)	6 (54.54)	11
3–4	4 (66.66)	2 (33.33)	6
>5	2 (40)	3 (60)	5
Number of performed USG-guided vascular procedures			
10–20 times	3 (60)	2 (40)	5
20–50 times	4 (66.66)	2 (33.33)	6
50–100 times	6 (42.86)	8 (57.14)	14
>100 times	4 (44.44)	5 (55.55)	9
Training on simulation models			
Yes	11 (55)	9 (45)	20
No	6 (42.86)	8 (57.14)	14
Awareness of commercially available vascular access phantoms			
Yes	13 (48.15)	14 (51.85)	27
No	4 (57.14)	3 (42.86)	7

USG: Ultrasonography, EM: Emergency medicine

Table 2: Performance characteristics of the two models (as rated by the performers)

	Model A		Model B		*P*	*Z* score
	Mean±SD	Median (IQR)	Mean±SD	Median (IQR)		
Ease of performing*	4.35±0.48	4 (4–5)	4.15±0.61	4 (4–5)	0.08	1.69
Accuracy of performing*	4.24±0.60	4 (4–5)	4.29±0.67	4 (4–5)	0.47	−0.70
Texture resemblance to human tissue*	3.85±0.78	4 (3–4)	3.58±0.86	4 (3–4)	0.12	1.5
Ease of learning*	4.00±0.66	4 (4–4)	4.03±0.72	4 (3–5)	0.80	−0.24

*Likert Scale was used for scoring. SD: Standard deviation, IQR: Interquartile range

Table 3: Image acquisition characteristics of the two models (as judged by the supervisor)

	Model A		Model B		*P*	*Z* score
	Mean±SD	Median (IQR)	Mean±SD	Median (IQR)		
Appearance of artifacts*	4.09±0.75	4 (3.75–5)	4.21±0.64	4 (4–5)	0.42	−0.79
Visualization of needle in-plane*	4.21±0.64	4 (4–5)	4.24±0.75	4 (4–5)	0.87	−0.15
Visualization of needle out-of-plane*	4.21±0.72	4 (4–5)	4.18±0.68	4 (4–5)	0.89	−0.13
Visualization of vessels*	4.24±0.55	4 (4–5)	4.12±0.65	4 (4–5)	0.57	0.56

*Likert Scale was used for scoring. SD: Standard deviation, IQR: Interquartile range

highest for each primary objective; however, it had a much shorter shelf life.[5] The shelf-life of the phantom prepared by us was estimated to be around 7 days if stored in a refrigerator at 8°C–10°C (high temperature reduced shelf life). We feel that our model provides excellent cost-effectiveness when used over shorter periods of time such as USG simulation courses and skill development-training workshops. This model may not be suitable for simulation labs with regular long-term use due to its relatively short shelf life.

In terms of usability, our phantom required balloon replacement after 15–20 pricks, but the hardened gelatin provided tamponade until that point, preventing water

Table 4: Cross-over analysis to compare the individual characteristics between Models A and B

	Effect size	95% CI	*P*
Ease of performing	0.4	−0.17–0.81	0.09
Accuracy of performance	−0.23	−0.51–0.04	0.16
Texture resemblance	−0.35	−0.74–−0.06	0.14
Ease of learning	−0.05	−0.48–0.37	0.83
Appearance of artifacts	−0.23	−0.68–0.21	0.38
Visualization in inplane	−0.11	−0.60–0.37	0.696
Visualization in out plane	−0.003	−0.49–0.49	0.999
Visualization of vessels	−0.18	−0.27–0.64	0·58

CI: Confidence interval

leakage. Multiple pricks sometimes left track marks but allowing the phantom to settle for about 3–4 h resulted in the disappearance of these marks. Some authors in earlier studies have also recommended re-heating the phantom in a microwave for few seconds until track marks disappear.[19] However, the latex balloons used in our model were not microwave safe, and hence, we did not practice the same.

All the participants in our study had done some USG-guided invasive vascular access procedure in past (61.7% of the participants had done it more than 50 times). However, 41.1% of participants had never received any formal training on similar simulation models before doing it on real patients. The main reason was the nonavailability of such models (84.6%) at their previous hospitals due to their expensive cost. The authors feel that practicing invasive procedures on live patients without any formal training on artificial models is associated with increased chances of complications.

Although we developed a vascular access model in the present study, we feel that the model's adaptability suggests potential applications in other procedures, such as "nerve block" phantom prepared by using a copper wire instead of rubber balloons or a "foreign body" phantom by placing glass or wood pieces in the gelatin mixture.

Limitations

Several limitations should be considered. First, our study did not compare different composition models, which could be a potential area for future research. Second, standardization in noncommercial settings can be challenging, leading to variations in phantom construction and potential discrepancies in results. Finally, the relatively shorter shelf life of the low-cost phantom limits its long-term use in simulation labs.

Conclusion

The indigenously developed vascular access model showed comparable performance and was noninferior to the commercially available phantom in terms of performance and image acquisition characteristics. Gelatin-based models can be easily prepared at a very low cost and utilized for teaching and training of students on USG-guided procedures in LMIC where cost constraints limit access to commercial alternatives.

Acknowledgment

The authors would like to thank Dr. Amit Mehndiratta, Associate Professor, Department of Bio-medical engineering, AIIMS, New Delhi for his valuable inputs during designing the project. The authors would also like to acknowledge the efforts of Dr. Ashish Suri, Assistant professor, Department of Biostatistics, AIIMS, Delhi with respect to the analysis of the data and providing valuable statistical inputs.

Author contribution statement

- PRM – conceptualization (equal); methodology (lead); writing original draft (equal); formal analysis (equal); resources (equal); funding acquisition (lead)
- PS – Methodology; validation; writing original draft (equal); formal analysis (equal); investigation (lead)
- NT – Conceptualization (equal); methodology; investigation; resources (equal)
- JN – Validation (equal); supervision (lead); project administration
- SB – conceptualization (equal); methodology; investigation; supervision; project administration (lead)
- PA – Methodology; resources (equal); supervision; project administration
- BG – writing – review and editing (equal)
- RR – writing – review and editing (equal)
- ADU – Statistical analysis (equal).

Conflicts of interest

None declared.

Ethical approval

The study was approved by the ethics committee of our institute vide. Reference number AIIMS IEC-924/04.09.2020, RP-33/2020 (dated November 26, 2020), All India Institute of Medical Sciences, New Delhi, India.

Funding

This study was financially supported by AIIMS, New Delhi [Early career Intramural research grant].

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Supplementary Table 1: Cross-over analysis of the two groups

Variable/group	Arm AB		Arm BA		Effect size (95% CI); *P*	Period effect	Carry over effect
	Mean±SD	Median (IQR)	Mean±SD	Median (IQR)			
Ease of performing							
Gelatin phantom (Model A)	4.4±0.51	4 (4–5)	4.2±0.43	4 (4–5)	0.4 (−0.17–0.81); 0.090	0.216	0.127
Commercial phantom (Model B)	4.0±0.65	4 (4–5)	4.2±0.56	4 (4–5)			
Accuracy of performance							
Gelatin phantom (Model A)	4.2±0.56	4 (4–5)	4.1±0.72	4 (4–5)	−0.23 (−0.51–0.04); 0.16	0.791	0.455
Commercial phantom (Model B)	4.2±0.66	4 (4–5)	4.4±0.61	4 (4–5)			
Texture resemblance							
Gelatin phantom (Model A)	3.9±0.89	4 (3–4)	3.4±0.87	4 (3–4)	−0.35 (−0.74−−0.06); 0.14	0.090	0.185
Commercial phantom (Model B)	3.8±0.63	4 (3–4)	3.8±71	4 (3–4)			
Ease of learning							
Gelatin phantom (Model A)	4.0±0.68	4 (4–4)	3.9±0.65	4 (3–5)	−0.05 (−0.48, 0.37); 0·83	0.623	0.857
Commercial phantom (Model B)	4.0±0.74	4 (4–4)	4.0±0.73	4 (3–5)			
Appearance of artifacts							
Gelatin phantom (Model A)	4.1±0.78	4 (3.75–5)	3.9±0.65	4 (4–5)	−0.23 (−0.68–0.21); 0.38	0.809	0.495
Commercial phantom (Model B)	4.1±0.60	4 (3.75–5)	4.2±0.68	4 (4–5)			
Visualization in in plane							
Gelatin phantom (Model A)	4.2±0.56	4 (4–5)	4.1±0.72	4 (4–5)	−0.11 (−0.60–0.37); 0.696	0.808	0.624
Commercial phantom (Model B)	4.3±0.70	4 (4–5)	4.1±0.80	4 (4–5)			
Visualization in out plane							
Gelatin phantom (Model A)	4.3±0.70	4 (4–5)	4.0±0.74	4 (4–5)	−0.003 (−0.49–0.49); 0.999	0.222	0.054
Commercial phantom (Model B)	4.0±0.70	4 (4–5)	4.1±0.62	4 (4–5)			
Visualization of vessels							
Gelatin phantom (Model A)	4.3±0.70	4 (4–5)	4.2±0.74	4 (4–5)	−0.18 (−0.27–0.64); 0·58	0.576	0.677
Commercial phantom (Model B)	4.1±0.70	4 (4–5)	4.3±0.62	4 (4–5)			

IQR: Interquartile range, SD: Standard deviation, CI: Confidence interval