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'WATER PHANTOM': AN EFFECTIVE TRAINING TOOL FOR SPINE ULTRASOUND! SIMULATION BASED MEDICAL EDUCATION

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ABSTRACT

Background: Knowing sonoanatomy of lumbar spine improves success of central neuraxial blockade in patients with difficult spine. Also, in pain medicine, ultrasound guided spine interventions is upcoming modality for management; but still there is lack of understanding of spine sonoanatomy as compared to peripheral region. **Aim:** To evaluate the use of 'water phantom' of spine as a training tool for identification of spine structures under ultrasound. **Methods:** We formulated 'water phantom' by immersing model of lumbosacral spine in water. Twenty subjects were given a lecture with ultrasound images of spine. They were given Ultrasound hands on training on the model. They were assessed for the time taken to identify spine structures (spinous process, laminae, facet joint, transverse process, caudal epidural space) on volunteer before (Group B) and after (Group A) hands on training on the model. **Results:** The time taken (in seconds) to identify spinous process (43.50), laminae(32.60 ± 15.81), facet joint (29), transverse process (21.50), caudal epidural space short axis (39), caudal epidural space long axis (22.60 ± 9.26) before 'Hands on' training on the model was significantly higher than time taken to identify each structure after training i.e. spinous process (12.50), laminae (13.70 ± 7.24), facet joint (10), transverse process (10.00), caudal epidural space short axis (10.50),caudal epidural space long axis (7.80 ± 3.83). Nobody could identify Sacroiliac joint before hands on training. **Conclusion:** We conclude that 'water phantom' can be effectively used as a training tool for identification of spine structures under ultrasound.

KEYWORDS : Water phantom, ultrasound, simulation, epidural space, facet joint

INTRODUCTION

Ultrasound assessment of the lumbar spine improves the success of spinal and epidural anaesthesia, especially for patients with underlying difficult anatomy, obesity, difficult positioning etc and it is also useful in pain intervention procedures related to spine. Several studies have shown the effectiveness of phantoms for improving the proficiency of novices[1] The ideal phantom is similar to human tissue, is readily available and inexpensive, can be used repeatedly, provides tactile feedback, will hold a needle in place, does not generate needle tracks, and is not a health hazard.

Simulation-based healthcare education has great potential for use throughout the healthcare education continuum[2]. The 'water-based spine phantom' that we use is based on a model previously described by Manoj M Karmakar in 2009.[3] Advantages of this model are that it is inexpensive, easy to assemble and can be used repeatedly without it deteriorating or decomposing like animal tissue based phantoms. Also, water is anechoic and gives a black background in a sonogram against which the hyperechoic reflections of the bone are clearly visualized. There are articles describing the uses and pitfalls of phantoms that have been described or commercially produced[4]. But there is no study published which quantitatively measures the effectiveness of this model as a training tool, hence we did this study.

Aim of our study was to observe and evaluate the use of 'water based spine model' as a training tool for identification of spine structures under ultrasound. Primary objective of our study was to formulate the 'water based spine phantom' for ultrasound scanning of spine and to identify the spine structures on volunteer before and after hands on training on water phantom. Secondary objective was to assess the time taken to identify the spine structures on ultrasound before and after 'hands on' training on water phantom.

METHODS

This prospective study was conducted at tertiary care hospital from September 2021 to March 2022 after institutional ethics committee approval and registration in clinical trial registry of India with CTRI number CTRI/2021/09/036906. After obtaining informed consent from all subjects and volunteer in a language best understood by them, a total of 20 study subjects (anaesthesia residents 2nd year, 3rd year) who have got basic orientation and knowledge of ultrasound scanning technique were included in the study. A volunteer was selected with normal spine, without scar or previous surgery. His consent was taken. Formulation of Water based spine phantom (Image 1) – Artificial lumbosacral spine model was kept in plastic rectangular container with spinous processes facing the roof, which was then filled with water until the bone model is completely immersed in water so that 2 cm of water is above the tip of the spinous processes. Container was then covered with nontransparent plastic wrap over which ultrasound probe could be placed and moved to scan.

Image 1: Ultrasound Image Of Spinous Process

All subjects were given a lecture on anatomy of spine along with ultrasound images of different structures of spine. After shifting to procedure room for scanning, volunteer was given prone position. A subject by using low frequency curvilinear transducer probe and linear transducer probe (for Caudal epidural space); tried to identify spinous process(Image 1), laminae, facet joint, transverse process, caudal epidural space, sacro-iliac joint on the back of the volunteer. Subjects scanned the volunteer and tried to identify different spine structures. Time noted by the observer who is not the primary investigator i.e. Group B- Observations before hands on training on Spine model. Hands on training given to all subjects on 'water based spine model'. Training was given in batches so each subject could get enough time to scan on model. Subjects again scanned the volunteer and tried to identify the spine structures. Time noted i.e. Group A- Observations after hands on training on Spine model. Time difference in both Group B and Group A was analyzed

Statistical Analysis

Collected data were coded and entered in Microsoft Excel Sheet. Data analysis was performed by using SPSS (Statistical Package for Social Sciences) version 28.0. The results were presented in tabular and graphical format. For Quantitative data Mean, SD, Median were calculated by paired t test and Wilcoxon sign rank test. For Qualitative data various rates, ratios and percentages were calculated. P value <0.05 was considered as significant

RESULTS

There was no similar study published which quantitatively measures the usefulness of water based spine model for ultrasound training. Considering 10 students per year for anaesthesia in our Institute, we have taken 20 subjects as our sample size as 2nd n 3rd year postgraduate students. They scanned volunteer's spine before (Group B) and after (Group A) 'Hands on' training on water based spine model.

As shown in table 1, Group B comprises of time taken (in seconds) to identify spinous process (43.50), laminae(32.60 ± 15.81), facet joint (29), transverse process (21.50), caudal epidural space short axis scan (39),caudal epidural space long axis scan (22.60 ± 9.26) 'before' hands on training. Out of 20 subjects nobody could identify Sacroiliac joint before hands on training. After hands on training, time taken (in seconds) to identify spinous process (12.50), laminae (13.70 ± 7.24), facet joint (10), transverse process (10.00), caudal epidural space short axis scan (10.50), caudal epidural space long axis scan (7.80 ± 3.83) was noted as Group A. After hands on training all subjects were able to identify sacroiliac joint on volunteer.

Table 1: Statistical Analysis Of Time Taken To Identify Each Spine Structure Under Ultrasound Before And After Hands On Training On Water Model

Structure seen	Before	After	t-value	p-value
Paired test	Time in seconds (Mean ± SD)			
Laminae	32.60 ± 15.81	13.70 ± 7.24	4.87	<0.001
Caudal epidural space Long axis	22.60 ± 9.26	7.80 ± 3.83	6.35	<0.001
Wilcoxon sign rank test	Time in seconds (Median)			
Spinous process	43.50	12.50		<0.001
Facet joint	29.00	10.00		<0.001
Transverse process	21.50	10.00		<0.001
Caudal epidural space Short axis	39.00	10.50		<0.001

Group B and Group A observations when compared, we found that the time taken to identify all the structures after hands on training on the spine model i.e. Group A was significantly lower than Group B (as shown in figure 1,2).

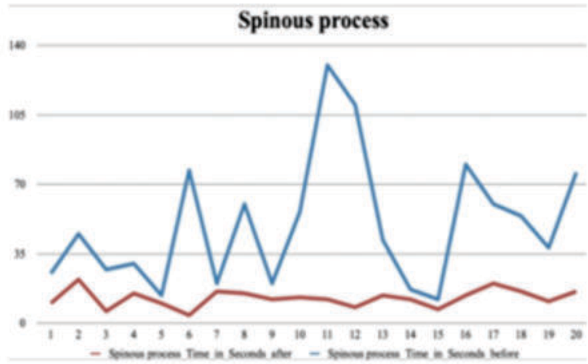

Figure 1: X-axis: Number Of Observers. Y-axis: Time In Seconds In Time Taken To Identify Spinous Process After Hands On Training On Water Spine Phantom

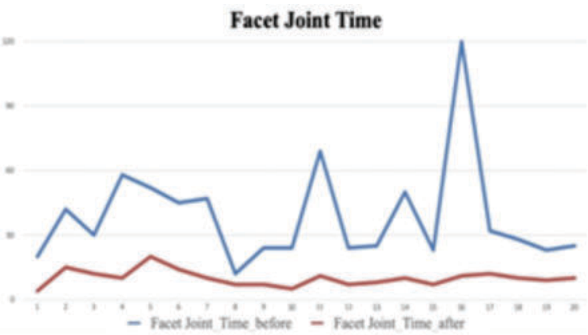

Figure 2: X-axis: Number Of Observers. Y-axis: Time In Seconds In Time Taken To Identify Facet Joint After Hands On Training On Water Spine Phantom

DISCUSSION

The concept of 'Water based spine phantom' was first described by Manoj K Karmakar in 2009 in which they prepared the model by immersing a lumbosacral spine model with the spinous processes directed towards the ceiling, in a water bath so that 1-2 cm of water is above the tip of the spinous processes[3]. We formulated our water spine model based on the same concept. Young Hoon Kim[1] demonstrated the comparisons of characteristics between different ultrasound phantom models like Water, Agar/Gelatin/Guar Gum-based phantom, Blue phantom, Meat phantom, Cadaver in which he observed that Water makes the background hypo-echoic, allowing easy visualization of the target and needle. Water phantoms are readily available, inexpensive, and reusable. In our study we confirm that because of hypo-echogenicity of water, visualization of target structure was clear, training duration was less and their understanding of each structure was better. Also, Reusability of water phantom made it possible to take training in batches. Kim also mentioned that water phantom does not provide tactile feedback, since water cannot hold the needle in place. In our study, we are using this model only to teach identification of structures and not a needle placement. Hocking G et al[4] in their review article described the uses and pitfalls of phantoms that have been described or commercially produced. It states that water is anechoic, making all needles highly visible, but does not fix the needle to allow practice placement. Michalek P et al[5] demonstrated an ultrasound-guided infraorbital nerve block using skull model immersed in a water bath and suggested that infraorbital foramen is easily located using ultrasound and an ultrasound-guided infraorbital nerve block is feasible using the model. Water phantom might not be useful in teaching needle placement; but it's low cost and reusability makes it one of the best simulator for students to learn ultrasound imaging. Simulator is an effective educational tool for acquiring knowledge and skills, gaining hands-on experience through repetitive practice without harm to patients, and receiving individualized feedback[6]. Also, in novices, skill attrition can occur rapidly after gaining initial proficiency in Ultrasound guided regional anaesthesia (UGRA).[7] Level of confidence increases after repeated practice on the phantom. In our study we emphasize on the importance of using water based spine phantom as it's easy to make and is reproducible for repeated practice. This model is ideal simulator for regional anaesthesia and pain medicine curriculum. A simulation-based UGRA curriculum can enhance learning of anatomy and sonoanatomy, facilitate acquisition of UGRA technical and non-technical skills, and provide recurrent training outside of the clinical setting[8]. Richardson et al[9] made Gelatin-Based Phantom for Head and Neck Fine-Needle Aspiration. Though these phantoms are low-cost; they have a limited shelf life, as the gelatin, fruit, and pig laryngotracheal complex naturally decompose and provide growth media for bacteria. If stored in a refrigerator, models can be preserved and used for up to two weeks. Bellingham GA et al[10] also produced gelatin based phantom which is cost effective but perishable. In our model, as we are using only water it is inexpensive as well as long lasting. Water can be removed and be added again before next teaching session. Also, phantoms like agar based, gelatin based need expertise and knowledge of various materials, refrigeration etc. but water based model is very easy to make. Also, simulation based training needs repeated sessions for practice which can be easily done with water phantom.

Limitations of our study are, though water based spine model is very beneficial in terms of identification of different structures under ultrasound and understanding sonoanatomy, but there is lack of tactile feedback. Needle holding is difficult to practice. Also, our sample size is small, can be considered as a pilot study and more studies can be done in larger sample size.

CONCLUSION

'Water-based spine model' is very easy to make, inexpensive, reusable, easily reproducible and an effective training tool for hands-on training to identify spine structures under ultrasound and to have better understanding of central neuraxial sonoanatomy. It helps to improve the slope of learning curve and we recommend it as an ideal simulator to be included in regional anaesthesia and pain medicine curriculum.

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