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Role of TAP Block Blue Phantom in Assessment and Quality Improvement of the Anaesthesia Department – A Prospective Study

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Abstract

Introduction: Ultrasound guided regional anaesthesia is a growing area of interest from the clinical as well as research point of view. Availability of Blue Phantom Mannequin to practice ultrasound guided regional anaesthesia offers a great advantage to trainees in achieving success. It contributes significantly towards the medical training and education of individuals. We considered the use of this technology to facilitate the performance of regional anaesthesia by practising anaesthesiologists.

Methods: Prospective, comparative study conducted among working anaesthesia consultants and trainees. A pre-teaching assessment was obtained from the participants which was followed by training and practice. At the end of this, a post-training assessment was carried out.

Results: Of the 25 participants, 13 (52.0%) had less than 24 months of experience and 12 (48.0%) had an experience of more than 24 months. Probe stability and needle visualization differed significantly in the pre and post training sessions ($p=0.001$). Distribution of target reached and obtaining image optimization also differed significantly in the pre and post teaching sessions ($p= 0.014$ and 0.001 respectively). Identification of structures differed significantly at pre teaching and post teaching sessions ($p=0.001$).

Conclusion: Study concludes that TAP Block blue phantom is beneficial in improving the skill set of all the participants. Inexperienced candidates with less than 24 months experience rapidly mastered basic ultrasound skills, allowing them to successfully perform an interventional procedure. We recommend simulation training for quality improvement of anaesthesia department. Further educational efforts may be directed at validating the efficacy of TAP block blue phantom simulation training to enhance technical skills and reduce performance times.

Keywords: TAP block, Blue Phantom, Simulation

Introduction

Ultrasound guided regional anaesthesia is a growing area of interest from the clinical as well as research point of view. Availability of Blue Phantom Mannequin to practice ultrasound guided regional anaesthesia offers a great advantage to trainees in achieving success. It contributes significantly towards the medical training and education of individuals. We considered the use of this technology to facilitate the performance of regional anaesthesia by practising anaesthesiologists.

Early "tissue mimicking phantoms" were designed for the calibration and testing of diagnostic ultrasound machines where accurate representation of the sonographic characteristics of human tissue was paramount. This involved controlling the acoustic impedance and attenuation properties of the desired material. [3] Numerous interventional phantoms have been described. Water baths were useful during initial studies to define ideal images and confirm relevant sonoanatomy, such as with spinal phantoms. Unfortunately, these convenient perfect waterbath images do not translate well into clinical practice.

Gelatin phantoms can be constructed in layers to allow the addition of simple or complex targets. The relatively

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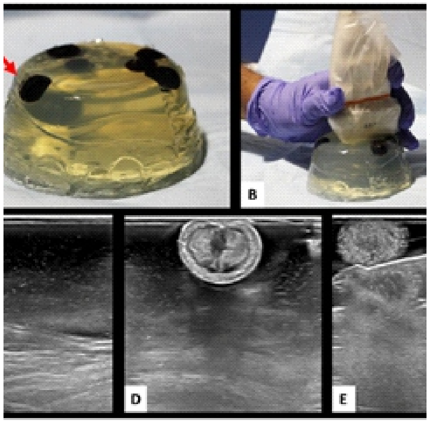

Figure 1: Gelatin phantom. Knox gelatin phantom biopsy simulation. Knox gelatin breast phantom (a and b) phantom with embedded blueberries (red arrow) to simulate breast lesion was tested for ultrasound image quality. Ultrasound images (c and d) demonstrate adequate ultrasound penetration and target lesion visibility. However, images with Celero 12-gauge device (e) are slightly obscured by air related artifact from the biopsy device

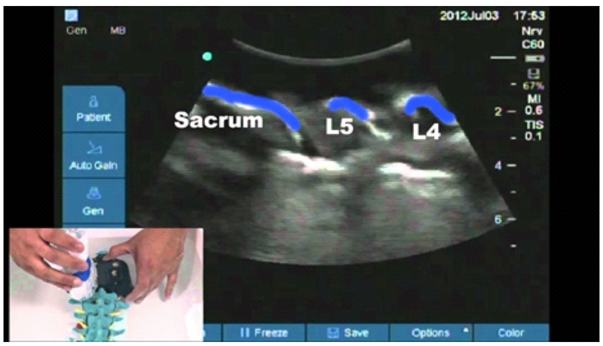

Figure 2: Water bath. Lumbar spine in water bath visualised with ultrasound


Figure 3: The Blue Phantom. The TAP Block Ultrasound Training Model.

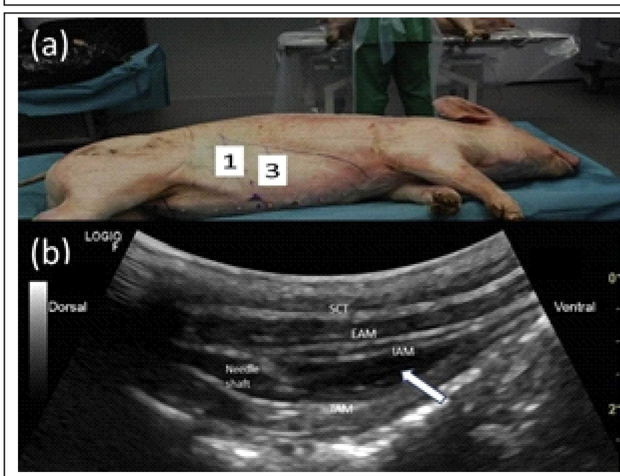

Figure 4: The meat phantom. It can be used for ultrasound guided TAP block needle guidance simulation.

anechoic and transparent background of agar or gelatin enhances needle visibility, which may assist with early learner confidence. Some tactile needle feedback allows for practice of needle guidance.

Meat phantoms are cheap and provide a more realistic simulation of needle guidance in actual clinical practice. The background, needle visibility, and tactile feedback are closer to those of human tissue than the low-fidelity phantoms. Unembalmed cadavers are probably the closest phantom media to live human tissue.

The patented "Blue Phantom" (Blue Phantom, Seattle, Wash) is constructed from an elastomeric rubber. Gelatin and Blue Phantoms behave similarly to water baths, but they also provide a degree of texture that both fixes the needle in its path and gives some element of "feel" as the needle is inserted. Needle visibility is high, which makes skill acquisition easier but can lead to false confidence in regard to clinical ability. They are useful in the early stages of learning needle guidance, before progressing to harder targets or meat phantoms.

With an advancement in ultrasound technology, TAP blocks have now become technically easier and safer to perform. The transversus abdominis plane (TAP) block was first introduced by Rafi [1] in 2001 as a landmark-guided technique via the triangle of Petit to achieve a field block. It involves injecting a local anaesthetic solution into a plane between the internal oblique muscle and transversus abdominis muscle (Figure 1). Since the thoracolumbar nerves originating from the T6 to L1 spinal roots run in this plane and supply sensory nerves to the anterolateral abdominal wall [2], the local anaesthetic spread in this plane can block the neural afferent and provide analgesia to the anterolateral abdominal wall.

Challenges of tap block training on patients include: Abdominal movement with respiration, abdominal movement with peristalsis, stress related with patient's hemodynamics, limited time frame.

"Simulation is a situation in which a particular set of conditions is created artificially in order to study or experience something that could exist in reality" [4].

A few advantages of simulation are:

i) Simulation provides a safe and supportive educational climate [5].

ii) Unlike patients, simulators do not become embarrassed or stressed.

iii) Has a predictable behaviour.

iv) Availability at any time to fit curricular needs.

v) Allow standardized experience for all trainees.

vi) Can be used repeatedly with fidelity and reproducibility [6] [7].

The four major categories of skill sets associated with proficiency are:

1) Understanding device operations,
2) Image optimization,
3) image interpretation and
4) visualization of needle insertion and injection of the local anaesthetic solution.

Of these, image optimization and image interpretation can be practised on oneself, Visualization of needle insertion and injection of local anaesthetic solution can be practised using simulators and phantoms.[8]

The hypothesis of this study is that Blue Phantom Simulation Training improves skill set.

Methods and Materials

This was a Prospective, comparative study conducted among working anaesthesia consultants and trainees in the department of Anaesthesiology at a tertiary care hospital. Practicing anaesthesiologists willing to participate were included in the study after obtaining a written informed consent. Ethical approval was obtained from the Institutional Ethics Committee before commencing the study.

Preteaching Assessment:

Evaluation was commenced by explaining the overview of the study to the participating candidate and obtaining a signed written consent. Candidates were asked to make themselves comfortable and perform lateral tap block on phantom. During this pre teaching session, the candidates were allowed to choose the probe and to make necessary ultrasonography machine setting changes in order to obtain an optimized image. Knowledge regarding tap block was accessed based on questions as per study proforma. Questions like "what is tap block, anatomy of anterior abdominal wall, indications of TAP block" were asked. Simultaneously, the procedure time (starting from needle entry of skin to reaching the target) was noted with the needle puncture count, no of redirection to reach target. Orientation of the candidate towards ultrasonography was also tested based on candidates' practice related to ergonomics (screen orientation to the patient), selection of transducer probe, selection of appropriate depth, gain and focus to get optimized image, application of colour Doppler to rule out vascular structures in the path [8].

Training and Practice:

Candidates were oriented with the ultrasonography machine by explaining knobology, ergonomics, and how to optimize the image using PART (Pressure, Alignment, Rotation, Tilt) Maneuver [8]. The anatomy of TAP block, that is, anterior abdominal wall was explained and discussed in detail including muscles involved, its origin and insertion, nerve supply. Its indications and functional anatomy were taught. Sonoanatomy and artifacts were discussed in order to achieve a complete orientation of tap block. The candidate was then allowed to practice needling on phantom in order to excel confidence while performing the TAP block. This was conducted over a period of 1 hour. Following this, a post teaching session was conducted.

Post Teaching Assessment:

Complete assessment was repeated after the teaching session in order to assess candidates' understanding of the topic which included all the parameters included in the pre teaching session. Candidate was asked about the anatomy of the anterior abdominal wall, its nerve supply, TAP block and its indications. While performing block on the mannequin, all the readings were recorded which included procedure time (starting from needle entry of skin to reaching the target), number of needle punctures, number of redirections, use of media while performing ultrasonography scanning, image optimization with the help of proper setting of gain and depth.

Statistical Methods:

The data on categorical variables is shown as n (% of cases) and the data on continuous variables is presented as mean and standard deviation (SD) or median (min –max). The inter-group statistical comparison of distribution of categorical variables is tested using Chi-Square test or Fisher's exact probability test if more than 20% cells have expected frequency less than 5. The inter-group statistical comparison of means of normally distributed continuous variables is done using independent sample t test. The paired comparisons (pre vs post) of distribution of means of continuous variables is done using paired t test. The paired comparisons (pre vs post) of distribution of categorical variables is done using Wilcoxon's signed rank test. The underlying normality assumption is tested before subjecting the study variables to t test. In the absence of normality, the data is subjected to appropriate non-parametric tests. All results are shown in tabular as well as graphical format to visualize the statistically significant difference more clearly. In the entire study, the p-values less than 0.05 is considered to be statistically significant. All hypotheses are formulated using two tailed alternatives against each null hypothesis (hypothesis of no difference). The entire data is statistically analysed using Statistical Package for Social Sciences (SPSS ver 22.0, IBM Corporation, USA) for MS Windows [17, 18, 19].

Results

A total of 25 participants were included in this study. Of the 25 participants, 13 (52.0%) had less than 24 months of experience and 12 (48.0%) had an experience of more than 24 months. The median experience level was 18.0 months (1.0 – 300.0 months). Probe stability was assessed and differed significantly at pre teaching and post teaching sessions (P=0.001) (Table 1). There was significant difference in the needle visualization at pre teaching and post teaching sessions (P=0.001) (Table 2). Distribution of target reached differed significantly at pre teaching and post teaching sessions, with all participants having reached the target at the post teaching sessions (P=0.014) (Table 3). Obtaining image optimization differed significantly at pre teaching and post teaching sessions with 20 (80%) having image optimization in the post teaching sessions (P=0.001). Identification of structures differed significantly at pre teaching and post teaching sessions with only 1 (4.00%) participant having poor identification of structures (P=0.001) (Table 4). The median procedure time, the median number of punctures and the median number of redirections were significantly reduced at the post teaching session compared to pre teaching session. Distribution of average (median) score of cognitive parameters such as physical demand was significantly higher in group of participants with experience below 24 months compared to group of participants with experience more than 24 months (Table 5, 6, 7). Average (median) score of cognitive parameters such as physical demand is significantly higher in group of participants with experience below 24 months compared to group of participants with experience more than 24 months (P=0.032) (Table 8).

Of the 25 participants, 4 (16.0%) selected curvilinear probe and 21 (84.0%) selected linear probe in the pre teaching session. None of the participants selected a curvilinear probe in the post teaching session. The type of probe selected differed significantly at pre teaching and post teaching sessions (P= 0.046). Of the total participants, 8 (32.0%) did not use any media, 9 (36.0%) used normal saline and 8 (32.0%) used Jelly at the pre teaching session. At the post teaching session none used no media, 15 (60.0%) used normal saline and 10 (40.0%) used jelly. The type of media used differed significantly at pre teaching and post teaching sessions (P=0.008). Of the total participants, 12 (48.0%) had no skin contact and 13 (52.0%) had skin contact at the pre teaching session. At the post teaching session, only 2 (8.0%) did not have skin contact and 23 (92.0%) had skin contact. This differed significantly at pre teaching and post teaching sessions (P=0.001). Of 25 participants, 22 (88.0%) did not look for the tram sign and 3 (12.0%) looked out for the tram sign at the pre teaching session. At the post teaching session, only 4 (16.0%) did not look out for the tram sign. This differed significantly at the pre teaching and post teaching

Table 1: Distribution of probe stability pre and post teaching.

	Pre (n=25)		Post (n=25)		P-value
Probe stability	no of participants	% participants	no of participants	% participants	
No	13	52	2	8	0.001***
Yes	12	48	23	92	
Total	**25**	**100**	**25**	**100**	

P-value by Wilcoxon's signed rank test. P-value<0.05 is considered to be statistically significant. ***P-value<0.001.

Table 2: Distribution of needle visualization pre and post teaching.

	Pre (n=25)		Post (n=25)		P-value
Needle visualisation	no of participants	% participants	no of participants	% participants	
Poor	16	64	2	8	0.001***
Good	6	24	18	72	
Excellent	3	12	5	20	
Total	**25**	**100**	**25**	**100**	

P-value by Wilcoxon's signed rank test. P-value<0.05 is considered to be statistically significant.

Table 3: Distribution of target reached pre and post teaching.

	Pre (n=25)		Post (n=25)		P-value
Target reached	no of participants	% participants	no of participants	% participants	
No	**6**	**24**	**0**	**0**	**0.014***
Yes	**19**	**76**	**25**	**100**	
Total	**25**	**100**	**25**	**100**	

P-value by Wilcoxon's signed rank test. P-value<0.05 is considered to be statistically significant. *P-value<0.05.

Table 4: Distribution of identification of structures pre and post teaching.

	Pre (n=25)		Post (n=25)		P-value
	Median	Min – Max	Median	Min – Max	
Procedure time (min)	1.97	0.32 – 5.90	0.98	0.13 – 2.75	0.001***

P-value by Wilcoxon's signed rank test. P-value<0.05 is considered to be statistically significant. ***P-value<0.001.

Table 5: Distribution of median procedure time pre and post teaching.

	Pre (n=25)		Post (n=25)		P-value
	Median	Min – Max	Median	Min – Max	
Procedure time (min)	1.97	0.32 – 5.90	0.98	0.13 – 2.75	0.001***

P-value by Wilcoxon's signed rank test. P-value<0.05 is considered to be statistically significant. ***P-value<0.001.

Table 6: Distribution of median no. of punctures pre and post teaching.

	Pre (n=25)		Post (n=25)		P-value
	Median	Min – Max	Median	Min – Max	
No. of punctures	4	1 – 11	2	1 – 5	0.001***

P-value by Wilcoxon's signed rank test. P-value<0.05 is considered to be statistically significant. ***P-value<0.001.

Table 7: Distribution of median no. of redirections pre and post teaching.

	Pre (n=25)		Post (n=25)		P-value
	Median	Min – Max	Median	Min – Max	
No. of redirections	3	1 – 12	2	1 – 6	0.001***

P-value by Wilcoxon's signed rank test. P-value<0.05 is considered to be statistically significant. ***P-value<0.001.

Table 8: Distribution of average (median) cognitive feedback data according to duration of experience.

	Duration of experience				
	<24 Months (n=13)		≥24 Months (n=12)		
Parameter	Median	Min – Max	Median	Min – Max	P-value
Mental demand	5	2 – 6	2.5	1 – 6	0.090NS
Physical demand	5	1 – 7	1.5	1 – 6	0.032*
Temporal demand	3	2 – 6	2	1 – 6	0.202NS
Performance	7	2 – 9	6.5	1 – 8	0.457NS
Effort	5	1 – 9	2.5	1 – 7	0.259NS
Frustration level	2	0 – 5	1.5	0 – 6	0.716NS

P-value by Mann-Whitney U test. P-value<0.05 is considered to be statistically significant. *P-value<0.05, NS - Statistically non-significant.

sessions (P=0.001).

All the participants selected a 10 cm needle in both pre and post teaching sessions. Only 1 (4.0%) participant did not follow the ergonomics in the pre teaching sessions. At the post teaching session, all followed the ergonomics aspects. Understanding of the participants regarding the ergonomics did not differ significantly at pre teaching and post teaching sessions. The operator position was assessed and did not differ significantly at pre teaching and post teaching sessions. Of 25 participants, 1 (4.0%) did not have any change in needle angle and 24 (96.0%) had the change in the needle angle. At the post teaching session, none had any change in the needle angle. Distribution of change in needle angle did not differ significantly at pre teaching and post teaching sessions. Average (median) score of cognitive parameters such as mental demand, temporal demand, performance, effort and frustration did not differ significantly between group of participants with experience below 24 months and group of participants with experience more than 24 months.

Discussion

The results of our study show that TAP Block blue phantom is beneficial in improving the skill set of all the participants. Inexperienced candidates with less than 24 months experience rapidly mastered basic ultrasound skills, allowing them to successfully perform an interventional procedure.

The most difficult challenges that arise for an anaesthesia practitioner performing UGRA (ultrasound guided regional anaesthesia) include availability of an ultrasound machine, prolonged block performance time, fear of adverse events and inadequate skill to perform UGRA [8]. Simulation contributes significantly by providing a hands on experience, immediate feedback on performance, and allows repetition with no harm to patients [9]. It also provides realistic experiences in managing common and rare situations, errors can be allowed to occur and can even be corrected [9]. Repetitive practice in a controlled, simulated environment has been shown to improve the performance in clinical settings [10].

The different simulators available for training in ultrasound guided procedures include Blue Phantom, Gelatin based model, Agar based, Tofu based, Premisorb based, Silicon based, Cadavers, Turkey and chicken breast model, Porcine shoulder, Leg of Lamb with metal rod, computer [11]. Amongst these, Blue phantom simulator carries advantages of being portable, realistic, no infection issues, large scanning surface, long shelf life, reusable properties [12].

In this learning students acquire different motor skills and pass through distinct behavioural stages. Educational literature describes development of motor skills across many domains. The behaviour exhibited by student can be used to assess the level of motor skill learning [13]. Performance improves with practice and is described by a robust relationship which is valid across different activities including sports, music [14]. Novices require discrete step wise approach in contrast to experts. Cognitive task analysis tools break down complex skills into individual processes and decisions to facilitate teaching. These cognitive task analysis tools can be used to examine individual tasks involved in procedures [15, 16].

Limitations

The cognitive load perceived by the participants during performance of the TAP block is compared using a blue phantom. This data needs to be compared with the cognitive load perceived during performance of TAP block on real patients. In real patients who are spontaneously breathing or are ventilated, the respiratory excursions and bowel peristalsis pose an added challenge to performance of TAP block. Hence, a further study is warranted in this aspect.

Secondly, the long term impact on the learning curve from this simulation training is not studied. A follow up and summative assessment of the participants over a period of 1, 6 and 12 months after the simulation training will be helpful.

Thirdly, the tissue feel of the blue phantom in terms of consistency and resistance is different from real patient tissue. A Thiel embalmed cadaver brings in tissue realism as compared to a blue phantom. The cadaver can be ventilated if required. But the downside is limited availability, high maintenance cost and infection control concerns especially in current pandemic situation. A low cost and portable blue phantom may be considered in the face of above constraints.

Conclusion

Study concludes that TAP Block blue phantom is beneficial in improving the skill set of all the participants. Inexperienced candidates with less than 24 months experience rapidly mastered basic ultrasound skills, allowing them to successfully perform an interventional procedure. We recommend simulation training for quality improvement of anaesthesia department. Further educational efforts may be directed at validating the efficacy of TAP block blue phantom simulation training to enhance technical skills and reduce performance times.

Declaration of patient consent: The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given his consent for his images and other clinical information to be reported in the Journal. The patient understands that his name and initials will not be published, and due efforts will be made to conceal his identity, but anonymity cannot be guaranteed.
Conflict of interest: Nil **Source of support:** None

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