Original Article

Validation of a Part-Task Trainer to Facilitate the Fifth-Year Medical Student in Practice of Abdominal Paracentesis and Improving Skill Retention after Hands-On Structured Workshop Setting

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Objective: To validate an internally developed part-task trainer for training abdominal paracentesis (AP) to fifth-year medical students (MS), and to evaluate participant confidence level and perceived benefit compared between before and after a hands-on AP workshop among MS.

Materials and Methods: This cross-sectional study was conducted at Siriraj Hospital between February 1, 2018 and June 30, 2019. The model was designed to closely simulate the important characteristics of the abdomen so that trainees could learn and practice shifting dullness examination and AP. The target of evaluation was that 80% of participants would rate the model as good to very good. MS completed both the pre- and post-structured abdominal AP self-evaluation with 0 to 10 for each item.

Results: The model was validated by 15 residents and 41 MS. Almost all participants rated the model as good to very good for 'simulated human abdomen' and 'ability to perform the process', with a range of 85.7% to 100%. Among the 177 MS evaluations, both pre- and post-workshop, the median confidence in 'performing the procedure' was significantly increased from pre-workshop (5.0) to post-workshop (8.0) ($p<0.001$). The inexperienced group improved their level of confidence significantly more than the experienced group ($p<0.001$). Competency examination revealed that 99.2% of assessed MS had skill retention.

Conclusion: The evaluated model was shown to be a valid tool for teaching and practicing AP. A hands-on structured workshop using this model is effective for improving MS performance in AP.

Keywords: Abdominal model; Abdominal paracentesis; Part-task trainer; Abdominal paracentesis workshop

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Abdominal paracentesis (AP) is a common procedure in clinical practice to obtain and determine the etiology of ascites[1], and to evacuate ascites to relieve patient symptom[1]. The Thai Medical Council has, therefore, required that Thai medical students (MS) perform AP as a requirement for graduation from medical school[2]. Competency in a procedure is best achieved via practice in human patients in real-world clinical practice[3,4]; however, patient safety is a concern in an instructional setting. Complications associated with AP, including bleeding[5] and puncture of abdominal organs, are rare[6]. However, they can occur, and the results can be severe and even fatal. Alternatively, simulation-based medical education facilitates the acquisition of clinical skills with no risk to patient safety[7,8]. AP with ultrasound guidance to detect ascites and to identify the landmark for puncture may reduce the risk of complication, which

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is why this enhanced treatment modality was recently recommended by the Society of Hospital Medicine in the USA[9]. Ultrasonography benefits AP in some situations such as in patients with small or loculated ascites. However, ultrasound is not available in all clinics in Thailand. Furthermore, ultrasound skills and frequent practice are needed. A finding of shifting dullness on physical examination may still be suitable for indicating the landmark for puncture in AP[10] in general practice in Thailand, because a moderate volume of free abdominal fluid can be detected by this method[10].

Siriraj Hospital of the Faculty of Medicine Siriraj Hospital, Mahidol University is Thailand's largest university-based medical center and medical school. A hands-on, structured AP workshop using a part-task trainer was organized for all fifth-year MS in March 2018. The medical degree training program in Thailand is a six-year course. A good quality and affordable model for AP is required in medical schools, especially in developing countries. Therefore, the aim of the present study was to validate an internally developed part-task trainer for training AP to MS, and to evaluate participant confidence level and perceived benefit compared between before and after a hands-on AP workshop among MS.

Materials and Methods

The present study was a cross-sectional study, conducted at Siriraj Hospital between February 1, 2018 and June 30, 2019. The protocol for the present study was approved by the Siriraj Institutional Review Board (COA no. Si 732/2017). Written informed consents were obtained from all participants included in the validation study. The workshop evaluation was collected from the normal class evaluation completed by workshop participants. The present study complied with the principles set forth in the 1964 Declaration of Helsinki and all its subsequent amendments.

Characteristics of the internally developed abdomen model

The abdominal model was designed to be a part-task trainer for use in teaching AP to MS. The design objectives were set by SN, which is a gastroenterologist, and PC, which is an internist, both with 10 years of AP experience. The agreed upon objectives included 1) the model would provide a simulated anatomic setting so that AP could be performed similar to how it would be performed in a real human patient, 2) examination for shifting dullness could be performed to detect if abdominal fluid was present, 3) the model could accommodate continuous performance of AP. The model was designed and developed by NP.

The final model is a simulation of an adult abdomen. Its dimensions are 35.5 cm in width × 40.5 cm in length × 23 cm in height, and its weight without fluid and with fluid is 8.9 kg and 11.5 kg, respectively. It is made of rubber, silicone, and polyester resin. The components of the model include simulated shape, synthetic skin, and abdominal sac. The system is designed to keep the abdominal sac continuously filled with the same volume of fluid during the use of the model.

Evaluation questionnaire for validation

The questionnaire was divided into two parts, a quality, and an assessment of perceived increase in experience and confidence with a range of 1 for not at all to 5 for very much. The questionnaire details are shown in Table 1 and 2. The content validity of each question was evaluated by three instructors using the index of item-objective congruence (IOC) with a range of –1 to +1[11]. Thirteen items had very good validation (IOC 1), six items had good validation (IOC 0.67), and one item had poor validation (IOC 0.33). The poor item was changed from model's color to model's skin color. The aim of validation was that 80% of evaluators would rate all assessments as good to very good.

Participants and validation process

To ensure the model suitability, three gastroenterologists with experience in teaching AP for at least five years evaluated the model as good to very good in almost all items of the questionnaire, which was the same content as in Table 1 and 2. Then, three MS and three medical residents rated almost all items as good to very good. Neither issue adversely affected the process nor the outcome, therefore, the model was judged to be acceptable as a part-task trainer.

Forty-seven MS during the 2017 academic year were invited to participate in the final validation process. After learning with computer-assisted instruction (CAI) of AP, the MS practiced AP and evaluated the model. Additionally, two gastroenterologists independently observed the MS practicing AP with the model and evaluated whether the MS could perform AP correctly as yes, no, or not done, according to the checklist, and whether the model was suitable for performing each process as yes, no, or not done. Fifteen medical residents

Table 1. Simulated human characteristic assessment of the internally developed abdominal model by the 5th-year medical students and medical residents

Items	Quality-rating scale; n (%)					
	5th-year medical students (n=41)			Medical residents (n=15)		
	Fair	Good	Very good	Fair	Good	Very good
Anatomical shape	3 (7.3)	21 (51.2)	17 (41.5)	2 (13.3)	10 (66.7)	3 (20.0)
Adult size	2 (4.9)	19 (46.3)	20 (48.8)	1 (6.7)	6 (40.0)	8 (53.3)
Anatomy for placing the hand for percussion	1 (2.5)	14 (35.0)	25 (62.5)	0 (0.0)	11 (73.3)	4 (26.7)
Skin color	4* (9.8)	13 (31.7)	24 (58.5)	2 (14.3)	9 (64.3)	3 (21.4)
Skin texture	9* (21.9)	22 (53.7)	10 (24.4)	5 (33.3)	8 (53.3)	2 (13.3)
Turning the model from/to supine and on the side	1 (2.4)	20 (48.8)	20 (48.8)	1 (6.7)	9 (60.0)	5 (33.3)

* One participant rated as poor

Participant rating by 5-option Likert scale (1=very poor, 2=poor, 3=fair, 4=good, 5=very good)

Table 2. Assessment of the internally developed abdominal model for abdominal paracentesis process by the 5th-year medical students and medical residents

Items	Quality-rating scale; n (%)					
	5th-year medical students (n=41)			Medical residents (n=15)		
	Fair	Good	Very good	Fair	Good	Very good
Tympanic sound if percussion at umbilical area*	2†# (5.1)	14 (35.9)	23 (59.0)	0 (0.0)	10 (66.7)	5 (33.3)
Dullness sound if percussion at flank area‡	2 (4.9)	16 (39.0)	23 (56.1)	1 (6.7)	7 (46.7)	7 (46.7)
Differentiate sound between tympany and dullness	2@ (5.4)	15 (40.5)	20 (54.1)	3† (21.4)	9 (64.3)	2 (14.3)
Changed sound from tympany to dullness§	0 (0.0)	13 (31.7)	28 (68.3)	1 (6.7)	8 (53.3)	6 (40.0)
Changed sound from dullness to tympany**	0 (0.0)	15 (36.6)	26 (63.4)	1 (6.7)	7 (46.7)	7 (46.7)
Identify the landmark for needle insertion	1 (2.4)	15 (36.6)	25 (61.0)	2 (13.3)	7 (46.7)	6 (40.0)
Needle insertion from skin to abdominal cavity	4† (9.8)	18 (43.9)	19 (46.3)	3 (20.0)	9 (60.0)	3 (20.0)
Obtain fluid when needle in abdominal cavity	1 (2.4)	15 (36.6)	25 (61.0)	1 (6.7)	6 (40.0)	8 (53.3)
Withdraw needle from the model	2 (4.9)	17 (41.4)	22 (53.7)	1 (6.7)	9 (60.0)	5 (33.3)
Convenience	1 (2.4)	16 (39.0)	24 (58.6)	1 (6.7)	10 (66.7)	4 (26.7)
Safety	0 (0.0)	7 (17.1)	34 (82.9)	0 (0.0)	5 (33.3)	10 (66.7)

There were few missing data in 2 items (# 2 missing data, @ 4 missing data)

* Model in supine position, † One participant rated as poor, ‡ Model in side position, § If performing percussion at the point of transitional zone from the umbilicus to the flanks in the supine position, ** If performing percussion when the model is positioned on the side at the point of transition from tympany to dullness in the supine position

Participant rating by 5-option Likert scale (1=very poor, 2=poor, 3=fair, 4=good, 5=very good)

were also invited to participate in the final validation process.

AP workshop and evaluation, and competency evaluation

All MS entered an 8-week rotation in the Department of Medicine for a total of seven groups during each year. They attended a single AP workshop at the beginning of the rotations and completed the self-evaluation questionnaire that was made anonymous since the 2018 academic year. The 60-minute workshop included CAI of general knowledge and performing AP on our model. Each workshop comprised approximately 40 MS, and all participants would individually practice their skills on the model under supervision of the instructor. Sufficient time was allowed for trainees to perform tapping or ask questions, as desired. The pre-workshop survey comprised of eight items and included knowledge relating to AP in choosing the right answer, and confidence in performing AP using 0 for not at all to 10 for very much. The perceived benefit level from attending the workshop using 0 for not at all to 10 for very much, was included in the post-workshop evaluation. MS who completed both the pre- and post-workshop evaluations were included for analysis.

One of the procedural skills, either AP, lumbar puncture, or thoracentesis, was randomly selected to be evaluated in a competency objective structured

Table 3. Pre- and post-abdominal paracentesis workshop self-evaluation by medical students

Items	Pre-workshop (n=177)	Post-workshop (n=177)	p-value
Perceiving known landmark; n (%)	137/174 (78.7)	174/174 (100)	<0.0001*#
Correctly identify landmark; n (%)	96/140 (68.6)	135/170 (79.4)	0.029*#
Known indication; n (%)	135/171 (78.9)	174/174 (100)	<0.0001*#
Confidence; median (IQR)			
All participants	5.0 (2.5, 7.0)	8.0 (7.0, 9.0)	<0.001*†
Naïve	2.0 (0, 5)	7.0 (6, 8)‡	<0.001*†
Only observed	4.0 (1, 5)	8.0 (7, 8)‡	<0.001*†
Experienced	6.0 (5, 7)	8.0 (7, 9)	<0.001*†
Perceived benefit; mean±SD			0.670§
Naïve	NA	8.4±1.7	
Only observed	NA	8.7±1.3	
Experienced	NA	8.6±1.5	

IQR=interquartile range; SD=standard deviation; NA=not applicable

‡ The median increased confidence after the workshop was significantly higher when comparing to the experienced group with p<0.001

* p<0.05 indicates statistical significance (# chi-square test, † Wilcoxon signed-rank test, § Kruskal-Wallis test)

clinical examination (OSCE) at the end of the rotation. The AP examination was assessed by other instructors using a standard checklist that evaluated the AP process, including landmark of needle aspiration by performing shifting dullness, attaining fluid, and sterile technique. The passing score of this OSCE station was 65%.

Statistical analysis

The authors estimated that 80% of MS would rate the part-task trainer as good to very good with a 5% error. Therefore, a sample of 43 MS was required. Convenience sampling was employed for 15 medical residents for a target value.

Comparison of categorical variables was conducted using Pearson's chi-square test. Mann-Whitney U test or Wilcoxon signed-rank test was used to compare continuous variables between the two groups, and the Kruskal-Wallis test was used to compare continuous variables among the three groups. All comparisons were made for available data with no imputation made for missing data. Values with a p-value of less than 0.05 were considered statistically significant. Statistical analyses were conducted using PASW Statistics for Windows, version 18.0 (SPSS Inc., Chicago, IL, USA).

Results

Validation study

Forty-one MS participated with few missing data. Twenty-three (59%) of those MS had prior experience in AP in real patients. Fifteen residents were enrolled. The model's assessment by the MS and residents is shown in Table 1 and 2. The following comments were received from the study participants: 'the synthetic skin is more resistant than human skin' (seven MS and three residents) and 'good quality synthetic skin for multiple punctures without needle mark' (three MS and two residents).

Under the observation of two instructors, all MS correctly performed all AP processes, and the model was suitable for practicing AP in all steps, including placing the hand for percussion, turning the model between lying on the back and on the side, performing shifting dullness, identifying landmark for puncture, and performing puncture, obtaining fluid if the needle was in the right position, withdrawing the needle, and differentiating tympany from dullness sound when percussion was performed at the right place. Moreover, the model could be practiced continuously among workshop participants with no visible needle mark at synthetic skin.

Confidence level in practicing AP, benefit of workshop, and result of competency evaluation

One hundred seventy-seven MS completed both the pre- and post-workshop evaluations with few missing data. Of the 173 MS that answered the experience item on the questionnaire, 24 (13.8%) MS were naïve, having never performed or observed AP, 81 (46.8%) previously only observed, and 68 (39.3%) reported having prior AP experience in real patients. The benefit of AP workshop is shown on Table 3.

Regarding competency OSCE examination, AP was assessed three of seven times using the same model during the 2018 academic year. Of the 118

MS examinations, the median and mean score was 90 (IQR 80 to 100) and 88±10.6, respectively. Only one MS failed with a score of 55%.

Discussion

The present study showed the authors' internally developed abdominal model to be a valid tool for teaching AP, and for performing shifting dullness in a large group of MS. Moreover, it was validated among personnel representing a wide range of experience in AP from beginner to expert, in both learners and teachers. Previously, Mesquita, et al. developed a low-cost model that was reported to be successful in training AP to MS[12]; however, Mesquita's model could not be turned over and assessed for level of fluid. Furthermore, the Mesquita's model was suitable only for a small group. Moreover, similar to the authors' previous knee model[13], this model used self-healing synthetic skin that can be punctured at least 100 times without puncture mark visibility after needle withdrawal. This important feature ensures that each successive student uses the appropriate landmarks to identify the puncture site.

A good hands-on structured workshop should include both high-quality content and a high-quality model. In the present study, CAI was used to deliver general knowledge about AP and how to perform AP. Moreover, a gastroenterologist observed all MS to ensure that they correctly performed every AP process. The confidence level of a procedure could be viewed as a surrogate marker of competency for doing such a procedure[14]. MS practiced AP with the authors' model and reported increased confidence and benefit from participation in the hands-on workshop, which was similarly reported by Tejos et al[15]. Learning a procedure via only observation may not increase learner confidence. After the hands-on workshop, the inexperienced groups in the present study had a significantly higher increase in confidence in AP than the experienced group, and the levels of confidence were then comparable among the three groups. Therefore, the hands-on workshop demonstrated educational benefit with no risk to real patient safety. Perceived benefit was rated as high among all MS regardless of AP experience level, and the ratings were similar among the three experience level groups. Moreover, the skills learned during the workshop were shown to be sustained for at least a short period as assessed by the competency examination.

Weaknesses of the present study abdominal model were identified. First, the synthetic skin and abdominal sac were both found to be more resistant to needle puncture than human tissue; however, both were still rated as acceptable by most raters and neither obstructed nor prevented any part of any process. Second, the model was heavy, but the weight of the model did not impair any aspect of the training process. The authors plan to improve the synthetic skin and the abdominal sac, and to lighten the weight of the abdominal model in the future.

Conclusion

The authors' internally developed part-task trainer was shown to be a valid tool for teaching and practicing AP. A hands-on structured workshop using CAI and the model is a successful model for improving performance and confidence in performing the procedure among MS. In its current form, this model should be considered a suitable tool for AP training and practice. However, additional enhancements, such as modification of the skin texture, will further enhance the similarity between the present study internally developed abdominal model and the human abdomen.

What is already known on this topic?

A paracentesis simulation workshop was shown to be successful for improving MS performance after training; however, retention time was unknown.

What this study adds?

An internally developed abdominal model on which shifting dullness could be performed is a suitable tool for teaching and practicing AP. The AP skill gained from a hands-on structured workshop are retained for at least a few months.

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Conflicts of interest

All authors declare no personal or professional conflicts of interest relating to any aspect of this study.

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