# Comparative Accuracy of Ultrasound and Physical Examination Conducted by Clinical Year Medical Students in Diagnosing Ascites

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***Background:*** Accurate diagnosis of ascites is crucial before abdominal paracentesis can be performed. Physical examination alone can be inaccurate and lead to incorrect clinical decision making.

***Objective:*** We aimed to evaluate and compare the accuracy of physical examination and ultrasound conducted by clinical year medical students after short ultrasound training session.

***Materials and Methods:*** This was a prospective quasi-experimental study conducted from January 2020 to April 2020. The sample consisted of 18 clinical-year medical students at Srinagarind Hospital Emergency Department. Ultrasound training (intervention) was provided by one specialist in emergency ultrasound. Five volunteer patients were evaluated for ascites using two modalities (physical examination [PE; pre-intervention] and ultrasound [post-intervention]). Participants then responded to a questionnaire constructed to evaluate the relative ease of use of each modality as well as students' confidence and satisfaction. Data were compared using the McNemar test, and $p<0.05$ was considered statistically significant.

***Results:*** Eighteen medical students were included. Participants were able to diagnose ascites in the five patient volunteers using PE with a sensitivity of 74.2%, specificity of 94.4%, positive predictive value (PPV) of 95.2%, and negative predictive value (NPV) of 70.8%. Subsequent ultrasound examination yielded a sensitivity of 90.7%, specificity of 97.2%, PPV of 98%, and NPV of 87.5%. Use of ultrasound increased diagnostic accuracy from 82.2% to 93.3% and yielded higher mean ease and satisfaction scores. However, the average confidence score was lower and time required to perform the procedure was longer.

***Conclusion:*** Medical students were able learn to use an ultrasound device after a short training session with an expert. Ultrasound yielded higher diagnostic accuracy for ascites. Future studies should be conducted regarding the inclusion of ultrasound training programs in medical education curricula.

***Keywords:*** Ultrasound, Ascites, Emergency medicine, Medical curriculum

Two key components in clinical diagnosis are history taking and physical examination. Nonetheless, both have limitations, particularly in complicated patients such as those with minimal ascites or obesity, in whom physical examination alone can be inaccurate[1,2]. However, ultrasound can improve the effectiveness of physical examination, even when performed by medical students[3]. This makes it a useful tool in identifying ascites that can be employed at the bedside by a clinician, allowing for early diagnosis and proper management[3-5].

In the past decade, ultrasound has been implemented in the curricula of many medical schools. However, not all medical students have the opportunity to explore this useful tool, due to various limitations such as lack of access to equipment and its operator dependency, which necessitates training by a specialist[6,7]. Because of these limitations, few undergraduate students in Thailand are able to receive ultrasound training.

The main objective in this study was to compare the accuracy of physical and ultrasound-assisted examination in diagnosing ascites when conducted by clinical-year medical students after a short ultrasound training course.

## Materials and Methods
### Study design

This was a prospective, single-center, quasi-experimental study at a tertiary university hospital in Thailand. Ethics approval was provided by the Khon Kaen

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University Ethics Committee for Human Research and registered with the Thai Clinical Trials Registry (HE621314).

### Participants

Medical students at the Khon Kaen University Faculty of Medicine were enrolled in this study using a random sampling method. The sample consisted of 18 fourth-, fifth-, and sixth-year students (6 students each), none of whom had any previous knowledge of ultrasound. No monetary incentive was provided, and students did not receive academic credit for participating in the study. Written informed consent was obtained from each participant prior to enrollment.

### Patients

A total of five consecutive, eligible patients were recruited from a hepatology clinic and emergency department affiliated with the university. Informed written consent was obtained and a small monetary honorarium was provided for all participating patients. Three of the patients had ascites to varying degrees, and two had no ascites (as confirmed by CT within one month of the study), one with BMI ≥25 and one with BMI 18.5 to 24.9.

### Sample size calculation

The sample size for analysis by multilevel mixed-effects logistic regression was determined based on a study by Arora[8]. We hypothesized that the accuracy of ultrasound would be 0.8 and that of physical examination would be 0.3. The power analysis was determined using an alpha of 0.05 and power of 0.8. Based on this, we estimated that five patients would be required and that ultrasound should be conducted 90 times. We thus determined that a total of 18 medical students should be enrolled.

### Study intervention

All participants were medical students in their clinical years who had already completed an introductory clinical sciences class that provided basic physical examination training including abdominal examination to detect ascites.

We conducted this study at the university's Skill Lab Unit. At the start of this study, all students gave each volunteer patients a physical examination for ascites (pre-intervention). After that, we provided a point-of-care ultrasound course (intervention) taught by a specialist in emergency ultrasound. The course consisted of a 30-minute didactic section and 30-minute hands-on section. Students were taught about probe orientation, image optimization using depth and gain, and FAST examination to detect ascites.

After the training session, each student examined the same volunteer patients, this time using ultrasound to detect ascites (post-intervention). Following the study, students completed a questionnaire regarding the ease of use of each modality, as well as their confidence and satisfaction with each procedure using a 5-point Likert scale.

The evaluation was conducted by one examiner

who had no previous association with the students or the mentor. Data were recorded as the presence or absence of ascites and the time required to complete diagnosis.

### Ultrasound equipment

This study was conducted using the Butterfly IQ handheld ultrasound machine (2D array, 9,000 micro-machined sensors, USA). All images were obtained in B mode and no color Doppler.

### Statistical analysis

Quantitative data are presented as mean ± standard deviation and qualitative data as proportion and percentage. Differences in pre- and post-intervention were compared using an exact McNemar test. A two-tailed $p<0.05$ was considered statistically significant. All data analysis was performed using Stata version 10 (StataCorp, College Station, TX).

### Results

In total, 18 clinical medical students participated. The average age was 22.5±1.29 years, and 66.7% (n = 12) were male. Five volunteer patients were enrolled, three with ascites and two with no ascites confirmed by CT. Pre-intervention diagnosis yielded a sensitivity of 74.2%, specificity of 94.4%, positive predictive value (PPV) of 95.2%, and negative predictive value (NPV) of 70.8%, whereas post-intervention, sensitivity was 90.7%, specificity was 97.2%, PPV was 98%, and NPV was 87.5% (Table 1). The diagnostic odds ratio of ultrasound was 3.26 (95% CI 1.167, 9.106). Sensitivity, specificity, PPV, NPV by clinical year are shown in Table 1.

Students were able to correctly diagnose the patient with minimal ascites by ultrasound at a rate of 77.78%, but only at a rate of 38.89% by physical examination. There were no statistically significant differences between pre- and post- intervention diagnosis in the other four patients (Table 2).

The mean duration of physical examination was 3.86 minutes, while that of ultrasound examination was 7.50 minutes (Table 3). The mean time required to complete ultrasound examination was longest in the fourth-year medical students and shortest in the sixth-year students.

Participants rated ultrasound examination higher than physical examination in terms of ease (median 3.39 pre-intervention versus median 3.61 post-intervention) and satisfaction (median 4.22 pre-intervention versus median 4.50 post-intervention), but these differences were not statistically significant. The sixth-year students gave the highest satisfaction scores (Table 4).

### Discussion

Diagnosis of ascites is challenging, especially in patients with minimal ascites or obesity. In this study, we examined the reliability, validity, and key-performance-indices (duration, ease, confidence, and satisfaction) of ultrasound diagnosis conducted by medical students after a formal lecture

**Table 1.** Sensitivity, specificity, PPV, and NPV pre- and post-intervention

| Statistical analysis | Physical examination (Pre-intervention) (%) (95%CI) | Ultrasound (Post-intervention) (%) (95% CI) | p-value |
|---|---|---|---|
| Sensitivity | 74.2 (60.3, 85) | 90.7 (79.7, 96.9) | 0.012* |
| 4th year | 66.7 (41, 86.7) | 88.9 (65.3, 98.6) | 0.125 |
| 5th year | 61.1 (35.7, 82.7) | 83.3 (58.6, 96.4) | 0.218 |
| 6th year | 94.4 (72.7, 99.9) | 100 (81.5, 100) | 1.000 |
| Specificity | 94.4 (81.3, 99.3) | 97.2 (85.5, 99.9) | 1.000 |
| 4th year | 100 (73.5, 100) | 100 (73.5, 100) | 1.000 |
| 5th year | 83.3 (51.6, 97.9) | 91.7 (61.5, 99.8) | 1.000 |
| 6th year | 100 (73.5, 100) | 100 (73.5, 100) | 1.000 |
| PPV | 95.2 (83.8, 99.4) | 98 (89.4, 99.9) | 0.453 |
| 4th year | 100 (73.5, 100) | 100 (79.4, 100) | 1.000 |
| 5th year | 84.6 (54.6, 98.1) | 93.8 (69.8, 99.8) | 0.418 |
| 6th year | 100 (80.5, 100) | 100 (81.5, 100) | 1.000 |
| NPV | 70.8 (55.9, 83) | 87.5 (73.2, 95.8) | 0.058 |
| 4th year | 66.7 (41, 86.7) | 85.7 (57.2, 98.2) | 0.218 |
| 5th year | 58.8 (32.9, 81.6) | 78.6 (49.2, 95.3) | 0.241 |
| 6th year | 92.3 (64, 99.8) | 100 (73.5, 100) | 1.000 |
| Accuracy | 82.2 | 93.33 | 0.024* |

* Statistically significant

**Table 2.** Accurate diagnosis pre- and post-intervention in different volunteer patients

| Patient number | Accurate diagnosis | | p-value |
|---|---|---|---|
| | Physical examination (Pre-intervention) total (n =18), n (%) | Ultrasound (Post-intervention) total (n =18), n (%) | |
| No. 1 (massive ascites) | 17 (94.44) | 18 (100) | 1.000 |
| No. 2 (moderate ascites) | 16 (88.89) | 17 (94.44) | 1.000 |
| No. 3 (minimal ascites) | 7 (38.89) | 14 (77.78) | 0.016* |
| No. 4 (BMI 18.5 to 24.9, no ascites) | 16 (88.89) | 17 (94.44) | 1.000 |
| No. 5 (BMI ≥25, no ascites) | 18 (100) | 18 (100) | 1.000 |

* Statistically significant

and workshop. Ultrasound has been adopted in the detection of ascites in many qualified medical training centers and has been shown to improve diagnostic accuracy, especially when compared with physical examination (PE)[9-12]. We found that the diagnostic accuracy of ultrasound was about three times higher than that of PE. Ultrasound also yielded greater sensitivity, specificity, and PPV[3,9]. These results contrast those of a study by Arora et al, in which ultrasound was not found to be superior to PE[13].

We included five patients in this study with various ascites statuses (massive, moderate, minimal ascites and 2 controls: BMI 18.5 to 24.9 and BMI ≥25), and found that ultrasound examination yielded significantly higher diagnostic accuracy in patients who had minimal ascites than physical examination (38.89% vs. 77.78%, p 0.016). However, there were no statistically significant differences in other patients. These findings are consistent with those of a study of Goldberg et al, which found that examination by

**Table 3.** Time to diagnosis pre- and post-intervention by year of study

| | Duration time to diagnosis | | p-value |
|---|---|---|---|
| | Physical examination (Pre-intervention) mean ± SD (minute) | Ultrasound (Post-intervention) Mean ± SD (minute) | |
| Average time | 3.86±1.02 | 7.50±4.10 | 0.001* |
| 4th year | 4.50±0.86 | 12.35±1.71 | 0.001* |
| 5th year | 3.80±1.01 | 6.97±1.73 | 0.014* |
| 6th year | 3.28±0.93 | 3.18±0.61 | 0.825 |

* Statistically significant

**Table 4.** Questionnaire scores pre- and post-intervention

| Questionnaire | Score | | 95% CI |
|---|---|---|---|
| | Physical examination (pre-intervention) mean ± SD | Ultrasound (post-intervention) mean ± SD | |
| The ease of use of each modality in detecting ascites (total score = 5) | | | |
| Average score | 3.39±0.78 | 3.61±0.61 | -0.749, 0.305 |
| 4th year | 3±0.89 | 3.5±0.55 | -1.600, 0.600 |
| 5th year | 3.83±0.75 | 3.33±0.52 | -0.600, 1.600 |
| 6th year | 3.33±0.52 | 4±0.63 | -1.523, 0.190 |
| Confidence in detecting ascites using each modality (total score = 5) | | | |
| Average score | 3.72±0.67 | 3.5±0.71 | -0.331, 0.776 |
| 4th year | 3.67±0.52 | 3.33±0.82 | -0.937, 1.604 |
| 5th year | 3.83±0.98 | 3.17±0.75 | -0.767, 2.100 |
| 6th year | 3.67±0.52 | 4 | -0.875, 0.208 |
| Satisfaction with each modality in detecting ascites (total score = 5) | | | |
| Average score | 4.22±0.73 | 4.50±0.86 | -0.811, 0.256 |
| 4th year | 4.33±0.52 | 4.67±0.52 | -0.875, 0.208 |
| 5th year | 4±1.10 | 3.83±1.17 | -1.640, 1.974 |
| 6th year | 4.33±0.52 | 5 | -1.208, -0.124* |

* Statistically significant

ultrasound was able to detect ascites in cadavers at a volume as low as 100 ml[14].

The average time required to perform ultrasound was significantly longer than for PE (7.5 minutes vs. 3.86 minutes, p 0.001). This may have been due to students' lack of experience with ultrasound and the greater number of steps required. The main obstacles observed were difficulties with probe orientation and identifying potential spaces in different patients, especially the splenorenal recess. However, average time decreased by year of study, which indirectly implies that greater experience with ultrasound could reduce the length of time required to complete the procedure.

Based on students' responses to the questionnaire, satisfaction with ultrasound over PE was significantly greater in the sixth-year students. After the post-intervention examination, medical students rated ultrasound as higher in all areas covered by the questionnaire, which is consistent with previous findings[15-21].

## Conclusion

This study found that ultrasound could improve medical students' accuracy and satisfaction in the diagnosis of ascites after just a short lecture and workshop. This suggests that ultrasound training should be implemented earlier as a part of medical students' curricula in order to increase their competency.

## What is already known on this topic?

Recent studies have found ultrasound can help clinicians in the diagnosis of some diseases. Although medical curricula in developed countries include formal ultrasound training, such training is just beginning to be implemented in Thailand.

## What this study adds?

This study showed the diagnostic performance of ultrasound for ascites when performed by novice medical students after a short formal training session taught by an expert.

## Acknowledgement

## Conflicts of interest

The authors declare no conflict of interest.

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