

Confidence Level and Ability of Medical Students to Identify Abdominal Structures After Integrated Ultrasound Sessions



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ABSTRACT

Purpose Determine the confidence level and ability of first year medical students to identify abdominal structures using a wireless portable ultrasound scanner.

Methods The students were assessed for their confidence and ability to perform abdominal ultrasound. The 5-point Likert survey included questions on their perception about ultrasound as a resource for learning anatomy, physical examination skills, and the quality of the pre-session instructions. Data was also recorded by the faculty about the students' ultrasound skills and confidence. Goodman and Kruskal's gamma was used to demonstrate an association between the students' ability to identify the structures and the self-reported student confidence level.

Results Most of the students had confidence and were able to identify the liver, kidney, and urinary bladder, while almost half of them needed faculty help them to identify the inferior vena cava and aorta. The spleen and gall bladder were the most difficult to locate even for the very confident students. The perception of supervising faculty was that the confidence level was low in most of the students and only 13–20% of students felt “very confident” about performing ultrasound. Almost 37% needed encouragement and support and almost 10% of the students were not willing to try to locate difficult organs. Some students started locating the ureteric jet and portal vein. Most of the students agreed that ultrasound is an excellent resource for learning anatomy and physical examination skills. All students suggested having more ultrasound sessions.

Conclusion Most of the students feel confident about performing ultrasound and they perceive that ultrasound can enhance their basic sciences and physical examination skills.

Background

Ultrasound has become an important diagnostic modality, and some medical schools have incorporated ultrasound into their curriculum. The living anatomy supplements the traditional cadaver-based and cross-sectional anatomy [1]. Ultrasound has also been shown to aid in the understanding of the physiology and pathophysiology of organs [2]. Some medical schools incorporate ultrasound into the curriculum to improve medical students' diagnostic accuracy. Studies have shown that point-of-care ultrasound im-

proves the diagnostic accuracy of medical students [3, 4], though it is dependent on student training [5]. We developed an undergraduate medical education curriculum based on the premise that ultrasound training on point-of-care ultrasound would supplement physical examination skills. We have successfully completed the first year of our curriculum, which is system-based and driven by clinical cases and incorporates a team-based active-learning teaching pedagogy. Based on the principles of point-of-care ultrasound as used in many medical specialty residencies [6], we implement-

ed hands-on ultrasound sessions in our system-based curriculum. Ultrasound session learning outcomes were thematically integrated with the clinical cases of the week to promote integrated learning of basic sciences with clinical skills. There are already many renowned medical schools that incorporate ultrasound into their review of anatomy in year 1 and review of physical examinations in year 2 [7, 8]. The literature from these innovative curriculums demonstrates that the integrated ultrasound curriculum is well-received by medical students as a valuable teaching tool that enhances their medical education [9, 10]. The instructors who are teaching organ structures and relationship to function in anatomy and physiology courses consider ultrasound an exciting addition [11]. The evidence of hands-on training with hand-held ultrasound devices is promising, especially with regard to integrated courses of anatomy and physiology during the pre-clerkship years [12]. Additionally, increasing ultrasound training as an adjunct to basic physical examination skills has been demonstrated to improve student learning and physical examination accuracy [13]. This current evolution of ultrasound proficiency among medical students has great potential to improve learning: to evaluate, diagnose, and treat patients with better patient outcomes.

The objective of this study was to determine the confidence level and ability of first-year medical students with respect to identifying abdominal structures using a wireless portable ultrasound scanner on a standardized patient.

Methods

During the clinical skills sessions within the gastrointestinal and renal system courses, first-year medical students conducted an ultrasound practice session on standardized patients using portable wireless scanners. The students were asked to review online modules before the sessions. Online modules were curated from multiple resources: Society of Ultrasound in Medical Education, American Institute of Ultrasound in Medicine portal, and trained onboard faculty. The study was approved by the appropriate institutional review board at our university.

Assessment of student confidence

Following the sessions, students completed an anonymous 5-point Likert questionnaire. The 5-point Likert scale ranged from not confident [1] to very confident [5] and assessed students' confidence in the following competency domains:

- Ability to identify major abdominal organs using hands-on wireless ultrasound scanners
- Physical examination skills after the hands-on ultrasound sessions

In the same survey, students were asked about their perception of the ultrasound sessions. The following statements were asked, with students answering on a 5-point Likert scale from "strongly disagree" to "strongly agree."

- Ultrasound in the basic sciences curriculum is an excellent resource.
- The ultrasound session helped improve understanding of anatomy.

- The amount of instruction provided prior to performing the ultrasound session was adequate.
- It would be useful to have more ultrasound sessions.

Assessment of student ability

Data on faculty perception of the students' confidence and skills with respect to performing abdominal ultrasound to locate and identify specific structures was also collected.

The students' ability to identify anatomical structures using a portable ultrasound scanner was observed by experienced faculty and assessed using the following 3-point scale: could not locate [1], able to locate with help [2], located without help [3]. The faculty were also asked to rate the students' apparent confidence in their ability to identify each structure using a 3-point scale: not confident [1], moderately confident [2], very confident [3].

Statistical analysis

Goodman and Kruskal's gamma was used to demonstrate an association between the students' ability to identify the structures and the self-reported student confidence level. One-sample Chi-squared (χ^2) analysis was performed to determine the independence of the student confidence level and the faculty-observed and assessed ability to identify each structure. Goodman and Kruskal's gamma was used to determine the association between self-reported student confidence ("After participating in the ultrasound practice session, how confident are you about identifying major anatomical organs using ultrasound?") and the student's ability to identify each structure. This is a non-parametric statistical procedure used to measure the strength and direction of association between two ordinal variables.

Results

25 first-year students responded to the survey regarding their confidence with respect to performing ultrasound and their perception regarding the ultrasound sessions, after participation in the integrated ultrasound session.

As shown in ► **Table 1**, 72% of the students identified the liver and kidney independently using the scanner without faculty help. 68% were able to identify the urinary bladder without faculty help, while 44 and 52% were able to identify the inferior vena cava and aorta without faculty help, respectively. However, a significantly smaller number of students were able to identify the spleen (28%) and gallbladder (4%) without faculty assistance. A significant association between the students' ability to identify the structures and the self-reported student confidence level for 4 (liver, spleen, Aorta, IVC) of the 7 anatomical structures ($G = 0.619-0.707$, $p < 0.05$) was demonstrated.

Regarding the faculty perception of student confidence with respect to performing ultrasound independently and locating the abdominal viscera, the supervising faculty observed that most of the students (70–80%) were either "not confident" or "moderately confident" about performing abdominal ultrasound and locating the major organs. Only 13–20% of students felt "very confident" about performing the scan and locating the abdominal organs. As shown in ► **Table 2** (1st column), 80% of students felt

► **Table 1** Student perception of organ identification using ultrasound.

Organs	Student ultrasound skill	Count	Valid N %	Standard of valid N % error
Liver	Yes, without faculty help (3)	18	72.0%	± 9.0 %
	Yes, with faculty help (2)	7	<u>28.0%</u>	± 9.0 %
	No (1)	0	<u>0.0%</u>	–
Gall bladder	Yes, without faculty help (3)	1	<u>4.0%</u>	± 3.9 %
	Yes, with faculty help (2)	23	92.0%	± 5.4 %
	No (1)	1	<u>4.0%</u>	± 3.9 %
Spleen	Yes, without faculty help (3)	7	<u>28.0%</u>	± 9.0 %
	Yes, with faculty help (2)	17	68.0%	± 9.3 %
	No (1)	1	<u>4.0%</u>	± 3.9 %
IVC	Yes, without faculty help (3)	11	44.0%	± 9.9 %
	Yes, with faculty help (2)	12	48.0%	± 10.0 %
	No (1)	2	<u>8.0%</u>	± 5.4 %
Aorta	Yes, without faculty help (3)	13	52.0%	± 10.0 %
			44.0%	± 9.9 %
	No (1)		<u>4.0%</u>	± 3.9 %
Kidneys	Yes, without faculty help (3)	18	72.0%	± 9.0 %
	Yes, with faculty help (2)	7	<u>28.0%</u>	± 9.0 %
	No (1)	0	<u>0.0%</u>	–
Urinary bladder	Yes, without faculty help (3)	17	68.0%	9.3 %
	Yes, with faculty help (2)	8	<u>32.0%</u>	9.3 %
	No (1)	0	<u>0.0%</u>	–

* Bolded numbers are statistically significantly higher than underlined numbers within each anatomical structure.

“not confident” or “moderately confident” about locating the liver and 20% felt “very confident” about identifying the liver.

Supervising faculty also recorded student performance and their ability to locate the organs. As shown in ► **Table 2** (2nd column), for liver ultrasound, 53% of students were able to conduct ultrasound of the right upper quadrant and identify the liver without any help. The remaining 37% required a little encouragement and help from the supervising faculty to perform a decent ultrasound scan with identification of the liver. 10% of students did not try and gave up on locating the liver. Interestingly, the faculty observed that the group of students who showed no confidence were able to locate organs after some encouragement, while some of the “very confident” students had to seek faculty help or could not perform a complete scan with organ identification. Nonetheless, this was an insignificant number among the “very confident” students.

For ultrasound of the gallbladder, only 13% of students were “very confident,” which was much lower than for the liver. However, there was a high number of “not confident” students. During the ultrasound scan, only 10% located the gallbladder by themselves while 33% had to ask for faculty help. More than half of the students (56%) could not locate the gallbladder. With regard to the hepatorenal pouch, only 20% of students were very confident in

identifying Morrison’s space, and 87% had to seek faculty help during scanning. 77% were able to show the hepatorenal space, and the remaining 10% just stopped trying and preferred to see the scan being performed by their peers or faculty.

With the exception of the gallbladder, $\chi^2(4, N = 30) = 11.02$, $p = 0.03$, the right kidney and Morrison’s space, $\chi^2(4, N = 30) = 18.62$, $p < 0.01$, χ^2 analysis indicated that confidence and ability were independent of each other for each anatomical structure tested (► **Table 3**, χ^2 columns). Four of the ten tested structures indicated a significant correlation between student confidence and faculty assessment of ability (► **Table 3**, γ columns).

Interestingly, while students showed varying confidence levels with respect to being able to identify the urinary bladder, all of the students were able to locate it (with or without faculty help), but only 70% observed the ureteric jet on color Doppler. The rest of the students (30%) just observed their peers performing the ultrasound scan for the ureteric jet. However, this was not a learning outcome. No students were able to identify the pancreas on ultrasound without faculty help, including the “very confident” students.

The survey results (► **Table 4**) showed that approximately 6% of the students perceived themselves as “very confident” with respect to identifying major abdominal organs using ultrasound, while about 40% thought they were “mostly confident”, indicating the top two responses on the 5-point Likert confidence scale. Approximately 95% of the students agreed that integrated ultrasound sessions in the basic sciences curriculum is an excellent resource for learning anatomy and physical examination skills. Almost 89% of the students agreed that the ultrasound session helped improve their physical examination skills. Almost 78% of the students thought the pre-session modules that were provided prior to working with ultrasound scanners were adequate, and 100% of the students agreed that it would be useful to have more ultrasound sessions. The students’ comments were very positive about the sessions (► **Table 4**).

Discussion

Our study shows that there is a significant association between the students’ ability to identify structures and the self-reported student confidence level for 4 of the 7 anatomical structures for abdominal ultrasound that is consistent with other studies of medical students’ perception and confidence levels, along with the impact of faculty-assisted ultrasound education [7]. Ultrasound training of medical students should adhere to the evidence-based principles that support theoretical knowledge followed by hands-on training. On a similar note, we had our students learn from an online module for the theoretical knowledge that was followed by the hands-on training sessions [14].

Our students feel that more ultrasound sessions should be incorporated in year 1 and 2. This is consistent with the studies conducted at other established and renowned medical schools. Most of the results of these studies are in favor of creating a 4-year integrated ultrasound program with more exposure in years 1 and 2 [15]. Our students believed the ultrasound session helped improve their understanding of anatomy, which is similar to the findings in other studies [16].

► **Table 2** Faculty-perceived student confidence level and organ identification using ultrasound.

Organ	Student confidence level (SCL)			Organ location and identification (OLI)		
	Not confident	Moderately confident	Very confident	Could not locate	Able to locate with help	Located without help
Liver	15	9	6	3	11	16
	50.0%	30.0%	20.0%	10.0%	36.7%	53.3%
Gall bladder	17	9	4	17	10	3
	56.7%	30.0%	13.3%	56.7%	33.3%	10.0%
Pancreas	17	9	4	19	11	0
	56.7%	30.0%	13.3%	63.3%	36.7%	0.0%
Spleen	17	9	4	1	21	8
	56.7%	30.0%	13.3%	3.3%	70.0%	26.7%
Right kidney and Morrison space	17	7	6	3	23	4
	56.7%	23.3%	20.0%	10.0%	76.7%	13.3%
Left kidney	14	10	6	2	23	5
	46.7%	33.3%	20.0%	6.7%	76.7%	16.7%
Urinary bladder	13	11	6	0	17	13
	43.3%	36.7%	20.0%	0.0%	56.7%	43.3%
Ureteric jet on color Doppler	15	9	6	9	7	14
	50.0%	30.0%	20.0%	30.0%	23.3%	46.7%
Aorta and IVC	15	9	6	13	7	10
	50.0%	30.0%	20.0%	43.3%	23.3%	33.3%
Celiac trunk and SMA	15	9	6	13	7	10
	50.0%	30.0%	20.0%	43.3%	23.3%	33.3%

► **Table 3** Association between confidence and faculty-observed ability.

Anatomical organs	χ^2	df	sig	γ	sig
Liver	2.515	4	0.642	0.225	0.444
Gall bladder	11.022	4	0.026 *	0.556	0.053
Pancreas	2.952	2	0.229	0.489	0.102
Spleen	6.191	4	0.185	0.584	0.073
Right kidney and Morrison space	18.623	4	0.001 *	0.767	0.017 *
Left kidney	8.109	4	0.088	0.746	0.023 *
Urinary bladder	1.674	2	0.433	0.269	0.374
Ureteric jet on color Doppler	6.442	4	0.168	0.370	0.155
Aorta and IVC	9.071	4	0.059	0.600	0.006 *
Celiac trunk and SMA	9.071	4	0.059	0.600	0.006 *

We conducted a hands-on ultrasound experience of our students in a simulated environment on simulated patients. This approach of training before reaching a higher competence level on real patients is supported by experts in several studies [17]. Other studies have shown that with minimal instruction, students were able to locate and determine liver size [18]. Similar observations were made in our study where some motivated students went beyond the learning outcomes and started to measure the lobes of the liver with minimal

guidance. One of the benefits of skills in ultrasound for medical students and physicians is to help guide diagnosis and treatment for patients. For instance, in one study that tested the identification of cardiac abnormalities, first-year medical students using point-of-care ultrasound outperformed board-certified cardiologists who were solely using bedside cardiovascular physical examination [19]. We have a similar perception about confidence and ultrasound skills, especially among our students in the ultrasound interest group. Their

► **Table 4** Student ultrasound survey results.

After participating in the ultrasound practice session, how confident are you about identifying major abdominal organs using ultrasound?	Total N	18
	Valid N	18
	5 - Very confident	1 5.6%
	4	7 38.9%
	3	6 33.3%
	2	4 22.2%
	1 - Not at all confident	0 0.0%
	Mean	3.28
	Standard deviation	0.89
	Ultrasound in the basic sciences curriculum is an excellent resource.	Total N
Valid N		18
5 - Strongly agree		12 66.7%
4		5 27.8%
3 - Neutral		1 5.6%
2		0 0.0%
1 - Strongly disagree		0 0.0%
Mean		4.61
Standard deviation		0.61
The ultrasound practice session helped improve my physical examination skills by helping me gain a better understanding of anatomy and physiology.		Total N
	Valid N	18
	5 - Strongly agree	4 22.2%
	4	12 66.7%
	3 - Neutral	1 5.6%
	2	1 5.6%
	1 - Strongly disagree	0 0.0%
	Mean	4.06
	Standard deviation	0.73
	The amount of instruction provided prior to working with the ultrasound machine was adequate.	Total N
Valid N		18
5 - Strongly agree		2 11.1%

► **Table 4** Continued

	4	12
		66.7%
	3 - Neutral	2
		11.1%
	2	1
		5.6%
	1 - Strongly disagree	1
	5.6%	
	Mean	3.72
	Standard deviation	0.96
It would be useful to have more ultrasound sessions.	Total N	18
	Valid N	18
	Yes	18
		100.0%
	No	0
		0.0%

► **Table 5** Students' suggestions to improve the ultrasound practice session integrated with physical examination/clinical skills.

More instruction prior to the sessions would be helpful.
There is not much to add to the session. It was the perfect length of time with the perfect amount of resources.
This was a great tie-in between clinical skills and anatomy. Sample ultrasound images are very useful in helping us.
Identify the various anatomical structures and orientations.
The ultrasound sessions were well done.
Maybe more diagrams on the wall about what we are supposed to see.
I feel as though the session was extremely useful.
I enjoyed practicing on the patients, and I do not feel as though there is much to add to the session. It was the perfect length of time with the perfect amount of resources.

performance of ultrasound is better compared to many board-certified physicians, but the limitation is that they are only allowed to work with standardized patients who have no known disease or diagnosis. In one study, it was demonstrated that a medical student performing point-of-care ultrasound had a meaningful impact on the diagnosis and management of cases [20, 21]. This is also the perception of the faculty at our institution. Although these studies provide evidence to support the position that point-of-care ultrasound improves diagnostic accuracy [3], the results of other studies about enhanced learning of anatomy and physical examination skills with ultrasound training in undergraduate medical education are mixed and inconsistent [22].

There is a significant correlation between student confidence and faculty assessment of ability for four of the ten anatomical structures tested. This provides evidence that there may have been students who were overconfident in their ability to identify some organs on ultrasound. This may be explained by the lack of prior experience. In another study, a clinician's overconfidence was negatively correlated with prior experience [23]. To increase ultrasound experience and correct the discrepancies between overconfidence

and underconfidence with ability, additional ultrasound training in undergraduate medical education may prove useful.

One limitation of this study is that the reported data are subjective in nature and have inherent variability. In order to overcome this limitation, the ultrasound session was held over the course of a single day, students watched the pre-session module together, and faculty assessment of students was performed by a single trained physician. Another limitation is the decreased statistical power given the limited number of students participating. We hope to address this in the future as more sessions are held, and class sizes increase.

Through additional ultrasound sessions, we also hope to not only increase confidence in those who are less confident but also to increase student confidence in physical exam maneuvers [24, 25]. Anatomy, physical examination skills, and confidence in sonography can all be addressed through additional didactic and hand-on ultrasound sessions. Additionally, increasing student confidence in ultrasound has been shown to have a positive impact during residency, where residents with prior point-of-care ultrasound exposure outperformed those without when both groups took image interpretation tests [26].

The ultrasound sessions and overall student interest led to the creation of the student ultrasound interest group at our institution.

We are currently in the process of developing a formal curriculum based on required ultrasound competencies [27–29] for 4 years of medical school education (► **Table 5**).

Conclusion

Ultrasound training in medical schools enhances the learning of anatomy, physiology, pathophysiology, and physical examination skills. Although evidence in the literature to support the effectiveness of integrated ultrasound in undergraduate medical education is sparse, our study supports that student training can improve confidence about accurately performing ultrasound and improve the learning of anatomy and physical examination skills. That confidence will be immensely helpful as students prepare for clinical clerkships and residencies.

Conflict of Interest

The authors declare that they have no conflict of interest.

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