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ORIGINAL ARTICLE

Impact of point of care ultrasound rotation on single Saudi emergency medicine program

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ABSTRACT

Background: Emergency ultrasound has become an essential component of patient care and a mandatory skill for emergency medicine (EM) residents. Since 2001, major EM organizations have released guidelines mandating the integration of bedside ultrasonography into EM practice. This study aims to evaluate the ultrasound knowledge of emergency residents and their progress by conducting a survey before and after their emergency ultrasound (EUS) rotation.

Method: This longitudinal prospective study was conducted at King Abdulaziz Medical City in Riyadh, Saudi Arabia, to investigate the improvement in knowledge, interpretation accuracy, and clinical decision-making based on ultrasound findings. The study included first-year residents who joined the residency program in 2023. The research team collected data by administering a pre-test and post-test.

Results: We analyzed data from 12 residents. Half of them had received ultrasound training, and half of them used ultrasound on a daily basis. Regarding the perceived barriers to ultrasound training, the most commonly reported barriers were a lack of training (75.0%) and a lack of equipment (41.7%). All of the residents under the study anticipated the use of ultrasound in their clinical practice. The mean knowledge score of the pre-rotation period was 13.8 ± 2.6, whereas the mean post-rotation score was 17.3 ± 1.6. There was a significant increase in the knowledge score from the pre- to the post-rotation period ($p < 0.001$).

Conclusion: Our study has highlighted the significant benefits of the EUS rotation, including increased confidence in using ultrasound as a diagnostic tool and an enriched educational experience.

Keywords: Ultrasound knowledge, point of care ultrasonography, emergency medicine.

Introduction

Over the past two decades, ultrasound has been increasingly incorporated and has become an essential part of patient care and a mandatory skill to be achieved by emergency medicine (EM) residency graduates [1]. Since 2001, the leading organizations of EM, including the Society for Academic Emergency Medicine, the American College of Emergency Medicine, the Accreditation Council for Graduate Medical Education (ACGME), the Council of Emergency Medicine Residency Directors, and the American Board of Emergency Medicine have released guidelines that include bedside ultrasonography as one of the skills that must be integrated into the practice of EM [2]. However, it is unclear how standardized ultrasound training is in EM residency programs and the differences in their outcomes.

The data from a study that included all ACGME EM residency programs suggests that current continuing

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residency programs vary in the level and quality of ultrasound education. These results suggest that further guidelines may be warranted to standardize ultrasound training in all EM residency programs [3]. This has also been shown in a study that included 40% of ACGME EM residency programs, which showed discrepancies between different programs regarding the required number of scans, length of ultrasound rotation, and multiple other factors [1].

There is a significant variation in ultrasound training across EM residency programs. Consequently, there are differences in the outcomes, skill level, and knowledge of EM residents after undergoing ultrasound training. According to a study conducted in Saudi Arabia that included certified pediatric emergency physicians and fellows in pediatric emergency fellowships the most common barrier to not using ultrasound was limited training [4]. A study that evaluated the skills and knowledge of the EM residents after participating in a 2-week ultrasound training during their first ultrasound rotation revealed an improvement between pre-training and post-training scores and enhancements in their knowledge and skills [5]. In a similar study done to evaluate the impact of a 1-month emergency ultrasound (EUS) rotation, pre-tests and post-tests were conducted before and after the rotation. It showed that ultrasound knowledge and interpretation improved significantly; however, the clinical decision-making questions did not change significantly [6]. Furthermore, studies have shown that trainees who have additional proctored ultrasound hands-on instruction during an ultrasound course score higher compared to those who did not [7].

No studies have been found to assess the competency of ultrasound training in EM residency programs in Saudi Arabia. This study aims to assess the improvement of EM residents' ultrasound knowledge, interpretation accuracy, and clinical decision-making based on ultrasound findings by conducting a pre-test and post-test before and after completing a dedicated ultrasound rotation in the emergency department at King Abdulaziz Medical City, Riyadh, Saudi Arabia.

Subjects and Methods

This observational single-center longitudinal prospective study was conducted from January to May 2023. The study enrolled first-year EM residents, who underwent the ultrasound rotation during the study period. The total number of participants was 12 EM residents. The EUS rotation is part of the Saudi Emergency Medicine program curriculum at King Abdulaziz Medical City, Riyadh, Saudi Arabia, one of the largest EM training centers in the Kingdom of Saudi Arabia and the region. It receives and sees more than 170,000 per year and over 500 patients per day.

The EUS rotation is a 4-week rotation with six to eight supervised sessions. Each session is 4 hours long, providing hands-on instructions in the emergency department. It focuses on extended focused assessment with sonography for trauma of the aorta and deep venous thrombosis scans. Cardiac, lungs, biliary, renal, and first-trimester pregnancy scans are also included. Residents are encouraged to scan solo in the emergency department whenever possible. Each resident is required to perform 100 scans per month and is asked to save images and videos on a flash card for review.

Before participating in the EUS rotation, verbal consent was obtained from each participant. Residents were required to complete a pre-course knowledge test (Appendix A) consisting of 21 questions to measure their baseline ultrasound knowledge. The pre-test included ultrasound images and clinical scenarios. Additionally, residents were asked about their understanding of potential uses of ultrasound, whether they had ever received ultrasound training, how often and how comfortably they perform ultrasound, and whether there are any barriers to using ultrasound. At the end of the EUS rotation, residents were asked to complete the post-course test (Appendix B) which had a similar structure and content to the pre-course knowledge test. The pre- and post-course tests were adapted from previous research [8].

Normality testing was performed on the difference between pre- and post-rotation scores, and it showed non-significant p-value (Shapiro-Wilk test, $p = 0.362$), indicating a normally distributed variable. This was confirmed by the fact that the quantiles of the sample distribution aligned with those of the theoretical distribution (Figure 1). Numerical variables were expressed as mean ± SD, and categorical variables were presented as frequencies and percentages. We applied a paired-sample t-test to assess the changes in knowledge scores between pre- and post-rotation. Furthermore, an independent sample t-test was used to assess the statistical differences between residents' groups in terms of the difference in knowledge scores. McNemar test was used to assess the changes in dichotomous variables concerning residents' understanding and comfort levels toward the use of ultrasound in the pre- and post-

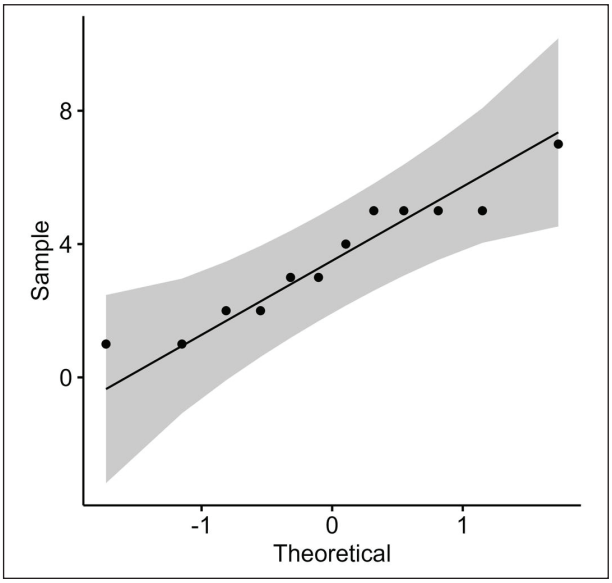

Figure 1. *QQ plot depicting the distribution of the difference between pre- and post-rotation knowledge scores.*

Table 1. *Practice and perceptions toward the use of point-of-care ultrasound among EM residents.*

Parameter	Category	*N* (%)
Ever received ultrasound training	No	6 (50.0%)
	Yes	6 (50.0%)
Description of the US training	Basic point of care ultrasound workshop	1 (20.0%)
	POCUS	1 (20.0%)
	Ultrasound workshops	1 (20.0%)
	US workshop in Princess Norah University 2021	1 (20.0%)
	We received training about efast and gyne US	1 (20.0%)
How often do you use point-of-care ultrasound?	Once a week	6 (50.0%)
	Daily	6 (50.0%)
Barriers	Broken machines	1 (8.3%)
	Lack of equipment	5 (41.7%)
	Not useful for my patients	2 (16.7%)
	Lack of training	9 (75.0%)
Do you anticipate utilizing point-of-care ultrasound in your clinical practice?	No	0 (0.0%)
	Yes	12 (100.0%)

rotation periods. A p-value of <0.05 indicates statistical significance.

Results

In the current study, we analyzed data from 12 residents. Half of them had received ultrasound training, and half of them used ultrasound on a daily basis. Regarding the perceived barriers to ultrasound training, the most commonly reported barriers were a lack of training (75.0%) and a lack of equipment (41.7%). All of the residents under the study anticipated the use of ultrasound in their clinical practice (Table 1).

Based on 21 questions administered in the pre- and post-rotation periods, the mean knowledge score for the pre-rotation period was 13.8 ± 2.6, whereas the mean post-rotation score was 17.3 ± 1.6 (Figure 2). There was a significant increase in the knowledge score from the pre- to the post-rotation period ($p < 0.001$).

The mean difference between pre- and post-rotation scores was 3.58 ± 1.88. There were no significant differences in the mean knowledge differences between residents' groups, including those who had received previous ultrasound training, those who used ultrasound frequently, those who reported barriers to ultrasound use, and those who anticipated the use of ultrasound in clinical practice (Table 2).

The analysis of the temporal changes in residents' understanding of ultrasound revealed no significant differences between the pre- and post-rotation periods.

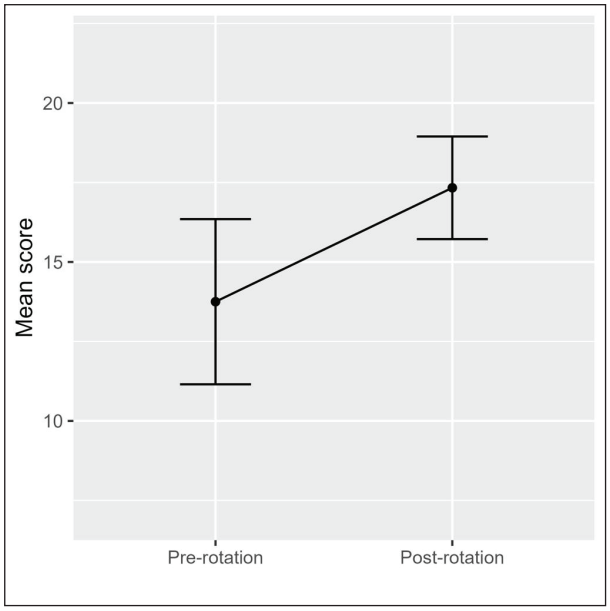

Figure 2. *The variation in the mean knowledge scores between pre- and post-rotation time.*

Table 2. *Group-based differences of the mean difference of knowledge scores.*

Parameter	Category	Mean ± SD	*p*-value
Have you ever received ANY ultrasound training:	No	3.50 ± 2.26	0.887
	Yes	3.67 ± 1.63	
How often do you use point-of-care ultrasound?	Once a week	3.83 ± 2.23	0.668
	Daily	3.33 ± 1.63	
Barriers - broken machines	No	3.45 ± 1.92	NA
	Yes	5.00 ± NA	
Barriers - lack of equipment	No	4.00 ± 2.24	0.345
	Yes	3.00 ± 1.22	
Barriers - not useful for my patients	No	3.90 ± 1.85	0.258
	Yes	2.00 ± 1.41	
Barriers - lack of training	No	3.67 ± 1.15	0.912
	Yes	3.56 ± 2.13	
Do you anticipate utilizing point-of-care ultrasound in your clinical practice?	No	NA ± NA	NA
	Yes	3.58 ± 1.88	

NA: computation of the p value was not possible because at least one comparative group had no cases or one case.

However, a significantly higher proportion of residents indicated that they were very comfortable using ultrasound after the rotation (66.7%) compared to pre-rotation (16.7%, $p = 0.041$).

Discussion

The aim of this study was to evaluate the impact of a dedicated ultrasound rotation on EM residents' knowledge and skills. Our results demonstrate a significant improvement in residents' knowledge from the pre- to the post-rotation period following ultrasound rotation, an observation that aligns with earlier studies.

Before the initiation of the ultrasound rotation, the residents' ultrasound knowledge and skills were found to be lacking, a finding that was observed in the results of some studies [9]. Similarly, a study was conducted to evaluate if medical students can learn and retain sonographic skills during a period of 2-4 weeks. The test scores were significantly better after enrollment in an EUS rotation [10]. Furthermore, it was noted that the mastering of ultrasound proficiency by these residents led to an increase in confidence in the application of these skills, which surely will positively influence patient care and outcomes, a notion supported by other studies [11].

Beyond skill acquisition, our study has shown that ultrasound rotation has boosted the confidence of EM residents in using ultrasound as a diagnostic tool by making them more comfortable with using it. Other studies have similar findings where they revealed that residents who completed ultrasound rotation reported increased confidence in their ability to use ultrasound for patient evaluation. This newfound confidence can translate into more rapid and accurate diagnoses, leading to improved patient outcomes [12]. This also can have an effect on their clinical management as it was found in a study where residents who participated in ultrasound rotation were more likely to change their clinical management based on ultrasound findings, resulting in more appropriate interventions and decreased time to definitive care [13].

While this study provides valuable insights, there are some limitations to this study. Due to our small sample size and lack of randomization, the results of the study are not generalizable.

Moreover, being conducted at a single center, the study's results cannot fully represent diverse contexts from other institutions as well. Self-reporting design of this study can potentially introduce bias, and a 4-week follow-up period does not allow for insights into durability of skill improvements. However, this study provides valuable insights, and its design allows for a comprehensive evaluation of changes over time.

Conclusion

EUS rotation has a substantial and positive impact on EM residents across multiple dimensions of their training and practice. Our study has highlighted the significant benefits of the EUS rotation, including increased confidence in using ultrasound as a diagnostic tool and an enriched educational experience.

EUS rotation provides residents with the hands-on experience needed to become proficient in image acquisition, interpretation, and clinical application of these findings. These skills are essential in the emergency department environment, where rapid and accurate diagnoses can directly influence patient outcomes.

Moreover, participation in EUS rotation empowers residents with the confidence to apply ultrasound as an integral part of their clinical practice, as shown in this study. This can lead to more efficient patient evaluations, quicker interventions, and ultimately better patient care.

Acknowledgment
The authors extend our heartfelt gratitude to Ryan Good for generously granting us permission to utilize the pre-course assessment and post-test assessment developed by their esteemed research [8].

List of Abbreviation

ACGME Accreditation Council for Graduate Medical Education
EM Emergency medicine
EUS Emergency ultrasound
KAMC King Abdulaziz medical city

Conflict of interests
The authors declare that there is no conflict of interest regarding the publication of this article.

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None.

Consent to participate
Written informed consent was obtained from all the participants.

Ethical approval
Ethical approval was granted by the Ethics Committee at King Abdullah International Medical Research Center, via reference/letter number: RYD-23-419812-42586 dated: 19 March 2023.

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Appendix A
Pre-course knowledge test

For data tracking please fill in the last 5 digits of your cell phone number: _____

A 14-year-old male presents to your ED with complaints of sudden onset of right-sided chest pain and difficulty breathing. You decide to use bedside ultrasound to evaluate the patient for pneumothorax (Questions 1 to 4).

1. What is the BEST probe to use for a pneumothorax evaluation?

   a) Linear probe

   b) Curvilinear probe

   c) Phased array probe

   d) Endocavitary probe

2. Choose the BEST location to scan for pneumothorax in a supine patient.

   a) Inferior to the xiphoid and directing it toward the patient's head

   b) Longitudinal position in the 3rd to 4th intercostal space at the midclavicular line

   c) Directly above the sternum

   d) Left of the sternum with the probe marker pointing to the patient's right shoulder

3. While scanning the patient looking for evidence of pneumothorax, which is the most helpful anatomical landmark that can be used to find the pleura?

   a) Rib shadows

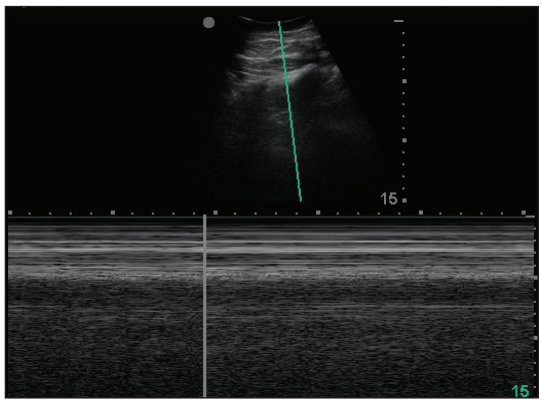
   b) Lung tissue

   c) Heart

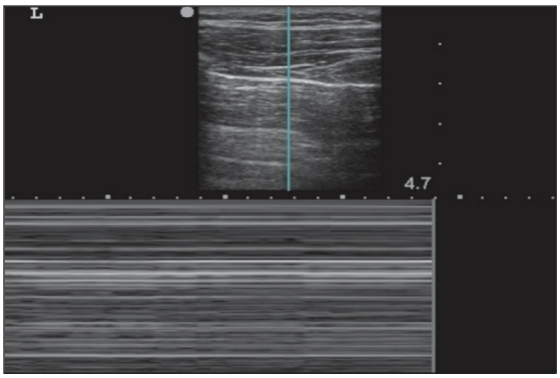
   d) Overlying soft tissues

4. During the scan, you found evidence of pneumothorax. Which of the following images indicate the presence of pneumothorax?

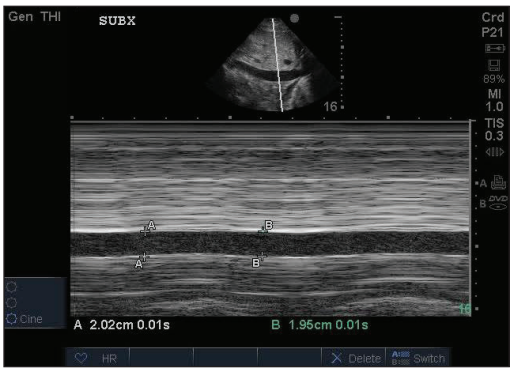
   a)



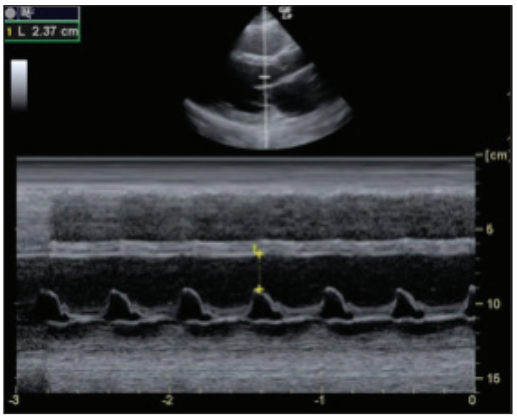
   b)



   c)



   d)



5. Which of the following option(s) are normal lung findings?

   a) Lung point

   b) Absence of lung sliding

   c) Presence of lung sliding

   d) B-lines

6. The following options are true about A-lines EXCEPT

   a) Horizontal, hyperechogenic lines representing reverberations of the pleural line

   b) It is a normal finding

   c) It indicates the presence of pneumothorax

   d) It is an artifact

7. Which of the following conditions can result in a false positive for pneumothorax on bedside lung ultrasound?

   a) Lung scarring

   b) Adhesions

   c) Pleurodesis

   d) All of the above

8. Which of the following can be seen on ultrasound in a patient with pneumothorax?

   a) B-lines

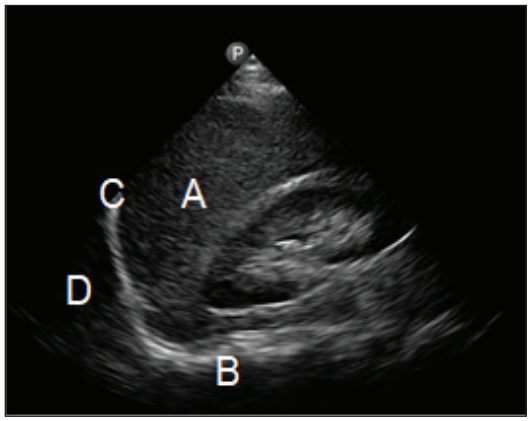
   b) A-lines

   c) "Barcode" sign

   d) "Seashore" sign

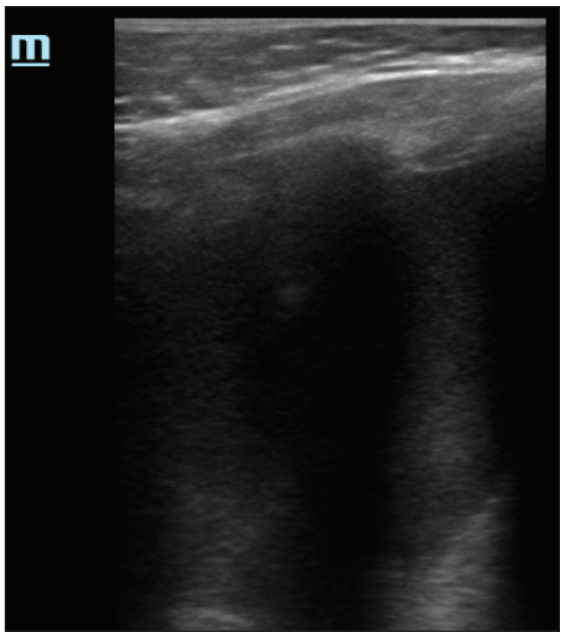
Please circle TRUE or FALSE for the questions below (Questions 9 and 10).

9. The following structures are labeled accurately. T or F



   A= mirror artifact, B= spine shadow, C= diaphragm, D= liver

10. The following image indicates the presence of pleural effusion. T or F



11. Which of the following is NOT a component of the echocardiogram exam?

    a) Apical 4-chamber

    b) Parasternal short axis

    c) Mid-axillary

    d) Sub-costal

12. Which of the following measures provides an estimate of a patient's volume status?

    a) IVC diameter > 1 cm

    b) IVC collapse during respiration

    c) IVC size relative to aorta

    d) b and c

    e) all of the above

13. Which of the following is an indication for performing bedside echocardiogram?

    a) Undifferentiated shock or hypotension

    b) Assessment of volume status

    c) Evaluation for pericardial effusion

    d) b and c

    e) All of the above

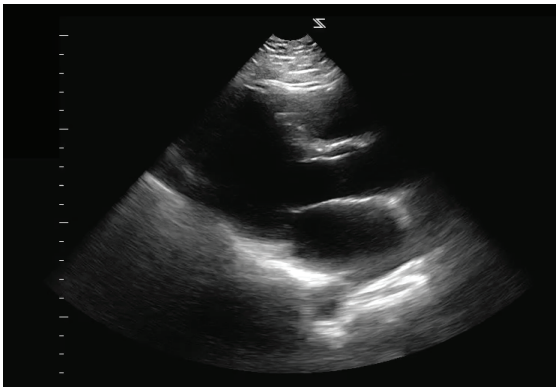
14. Which substance is the WORST for the transmission of ultrasound?

    a) Liquid

    b) Air

    c) Soft tissue

15. Which of the following correctly labels the anatomic structures seen in the parasternal long axis view?



    a) A = right ventricle, B = left ventricle, C = aortic valve, D = left atrium

    b) A = left ventricle, B = right ventricle, C = pulmonary valve, D = right atrium

    c) A = pericardial effusion, B = left ventricle, C = aortic valve, D = left atrium

    d) A = right ventricle, B = left ventricle, C = mitral valve, D = aortic valve

16. The E-point Septal Separation (EPSS) measurement is used to estimate:

    a) Volume status

    b) Pericardial effusion size

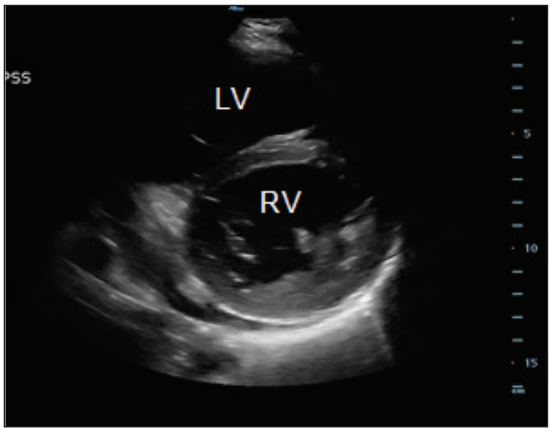
    c) Cardiac function

    d) Aortic valve function

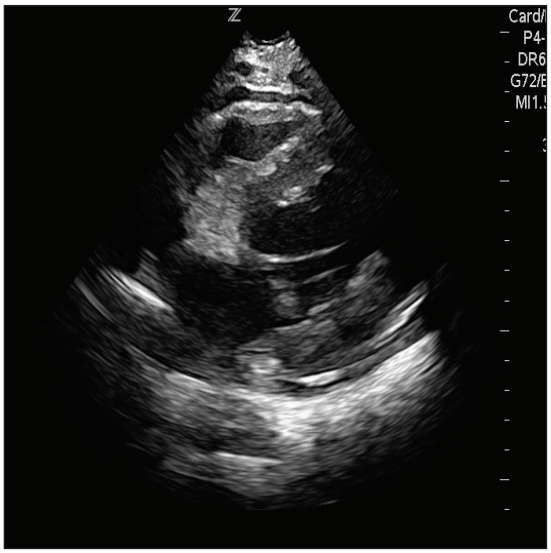
Please circle TRUE or FALSE for the questions below (Questions 17 to 20).

17. IVC collapsibility can be assessed in the transverse or longitudinal plane. T or F

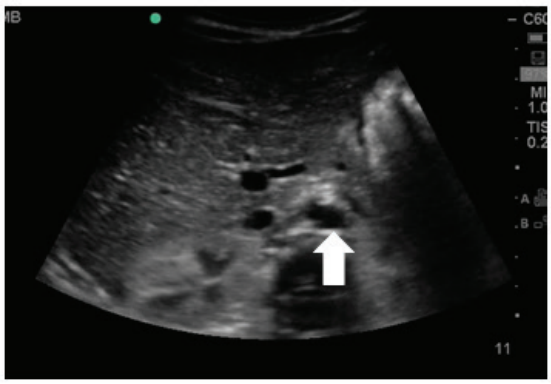
18. The anatomic structures in the following image taken from the parasternal short axis are labeled correctly: T or F



19. The following image indicates the presence of pericardial effusion. T or F



20. The WHITE arrow in the image below indicates the aorta. T or F



21. The following US image is obtained from which cardiac view?

    a) Parasternal long axis

    b) Parasternal short axis

    c) Apical four chamber

    d) Subcostal

22. Have you ever received ANY ultrasound training: Y N

    If yes, please describe: _____
    _____

23. How often do you use point-of-care ultrasound?

    1 – Never *2 – Once a year*

    3 – Once a month *4 – Once a week*

    5 – Daily

24. What barriers exist for your use of point-of-care ultrasound (choose all that apply)?

    a) lack of training

    b) lack of equipment

    c) not useful for my patients

    d) other: _____

25. How well do you understand the potential uses of point-of-care ultrasound?

    1 – Not at all *2 – Somewhat*

    3 – Neutral *4 – Very*

    5- Extremely

26. 26. How comfortable do you feel performing point-of-care ultrasound?

    1 – Not at all *2 – Somewhat*

    3 – Neutral *4 – Very*

    5- Extremely

Appendix B

Post-course knowledge test

For data tracking please fill in the last 5 digits of your cell phone number: _____

1. The following options are true about A-lines EXCEPT:

   a) Horizontal, hyperechogenic lines representing reverberations of the pleural line

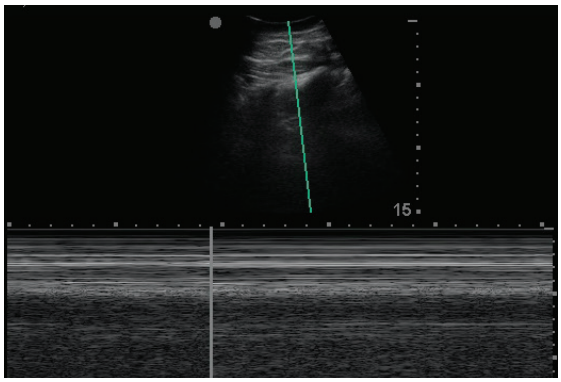
   b) It is a normal finding

   c) It indicates the presence of pneumothorax

   d) It is an artifact

Please circle TRUE or FALSE for the questions below (Questions 2 to 6):

2. The BEST location to scan for pneumothorax in a supine patient is at the left of the sternum with the probe marker pointing to the patient's right shoulder. T or F
3. The phased array probe is the BEST probe to use for a pneumothorax evaluation. T or F
4. The lung tissue is the most helpful anatomical landmark used to find the pleura. T or F
5. Presence of lung sliding is a normal lung finding. T or F
6. The image below indicates the presence of pneumothorax. T or F



7. Which of the following conditions can result in a false positive for pneumothorax on bedside lung ultrasound?

   a) Lung scarring

   b) Adhesions

   c) Pleurodesis

   d) All of the above

8. Which of the following can be seen on ultrasound in a patient with pneumothorax?

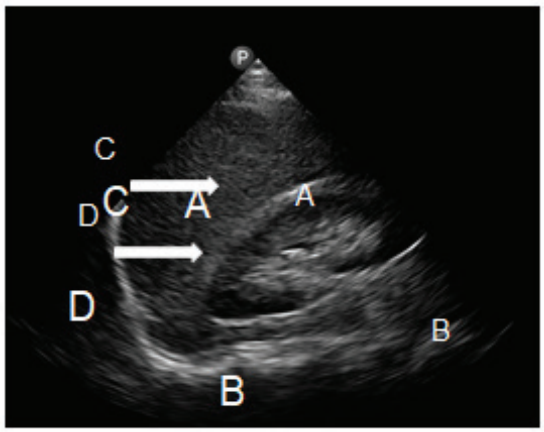
   a) B-lines

   b) A-lines

   c) "Barcode" sign

   d) "Seashore" sign

9. Identify the following anatomic structures:



   a) A= liver, B= spine shadow, C= diaphragm, D= mirror artifact

   b) A= spleen, B= spine shadow, C= mirror artifact, D= diaphragm

   c) A= liver, B= spine shadow, C= mirror artifact, D= diaphragm

   d) A= mirror artifact, B= spine shadow, C= diaphragm, D= liver

10. Which of the following image(s) indicate the presence of pleural effusion.

    Image A

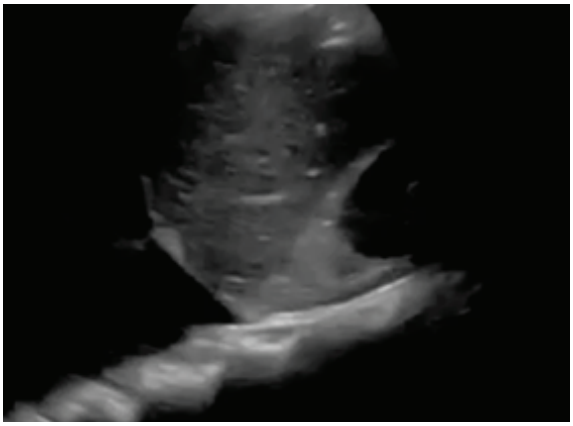


    Image B

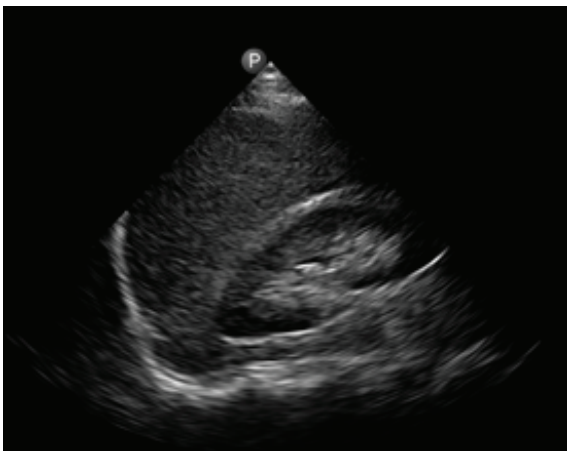
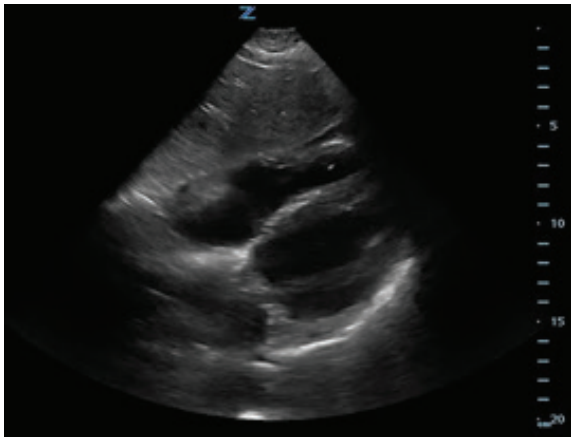


    Image C



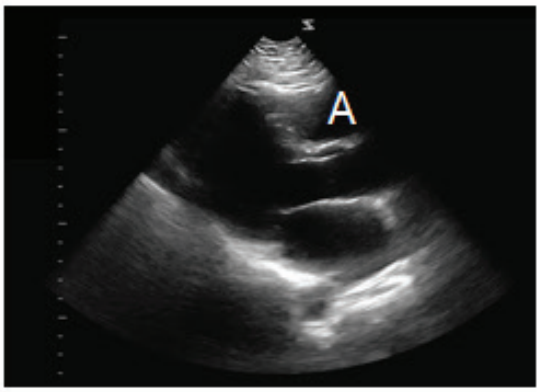
a) Images A and B

b) Images B and C

c) Image A

d) Image B

11. In the following image taken from the parasternal long axis, A represents:



a) Left ventricle

b) Right ventricle

c) Left atrium

d) Aortic outflow tract

12. Which of the following is/are a component of the echocardiogram exam?

a) Apical 4-chamber

b) Parasternal short axis

c) Sub-costal

d) All of the above

13. Which of the following is an indication for performing bedside echocardiogram?

a) Assessment of volume status

b) Undifferentiated shock or hypotension

c) Evaluation for pericardial effusion

d) a and b

e) All of the above

Please circle TRUE or FALSE for the questions below (Questions 14 to 17).

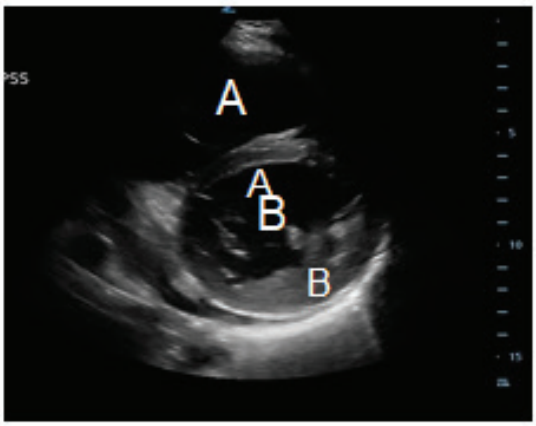
14. Air allows for optimal transmission of ultrasound. T or F

15. IVC collapsibility is assessed in the longitudinal plane. T or F

16. Volumes status can be assessed by comparing the diameter of the IVC to the diameter of the aorta. T or F

17. The following image indicates the presence of pericardial effusion. T or F

18. Identify the following anatomic structures seen in the parasternal short axis:



a) A = right ventricle, B = left ventricle

b) A = left ventricle, B = right ventricle

c) A = right atrium, B = right ventricle

d) A = left atrium, B = left ventricle

19. The EPSS measurement is used to estimate:

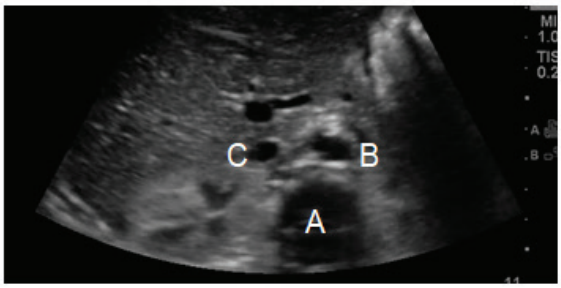
a) Volume status

b) Pericardial effusion size

c) Cardiac function

d) Aortic valve function

20. Identify the following anatomic structures:



a) A = aorta, B= IVC, C = hepatic vein

b) A = spine, B = aorta, C = IVC

c) A = IVC, B = aorta, C = hepatic artery

d) A = spine, B = IVC, C = aorta

21. The following US image is obtained from which cardiac view?

a) Parasternal long axis

b) Parasternal short axis

c) Apical four chamber

d) Subcostal

22. How well do you understand the potential uses of point-of-care ultrasound?

1 – Not at all *2 – Somewhat*

3 – Neutral *4 – Very*

5- Extremely

23. How comfortable do you feel performing point-of-care ultrasound?

1 – Not at all *2 – Somewhat*

3 – Neutral *4 – Very*

5- Extremely

24. Do you anticipate utilizing point-of-care ultrasound in your clinical practice: Y or N