Developing Preliminary Point-of-Care-Ultrasound Competency Guidelines for Internal Medicine at the UVA Hospital

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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Abstract

Point-of-care-ultrasound (POCUS) technology, including handheld models, are portable ultrasound devices. These devices are cost-effective and similarly capable to traditional models at capturing scans of the major body systems[1,2]. However, despite having been available for 20 years, POCUS has not been adopted into regular practice[3]. User-led interviews with physicians at the UVA hospital identified nine barriers to implementation across various specialties. The primary pain point was related to questions of liability. In particular, a lack of established education and training amongst all levels of physicians. This creates uncertainty in how to prove competency with the technology. The second round of survey-based interviews with physicians who teach ultrasound found that the use of didactic lectures, small group discussions, guided scans, unguided scans, and assessments were the optimal training methods for establishing competency. These methods relate to learning device physics and practicing image acquisition and interpretation. This project aims to design preliminary guidelines, in the form of a handbook, that includes set modules and checkpoints to follow. This collection of essential skills can be used to develop a more robust and standardized certification curriculum. Thus, eliminating the gray area that currently exists around the standards necessary for using POCUS in clinical practice. The final product will outline relevant information, associated teaching methods, and skill checkpoints (e.g. number of scans). It is presented using UI/UX design methods by incorporating the use of color and graphics in order to highlight the key points. The implementation of these guidelines was validated using a case study on how successful POCUS implementation in emergency medicine indicates success within internal medicine due to increased diagnostic accuracy of mutual disease states between the two departments[4]. Handheld ultrasounds have the potential to improve the diagnosis and treatment of patients if the barriers to implementation are addressed.

Keywords: Handheld ultrasound, Point-of-Care, POCUS, competency, liability, standardized training

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Background

Medical imaging technologies are an essential tool in medicine that allows a physician to view the internal structures of the human body for diagnosis, monitoring, or treatment[5]. As a result, the technologies are used by a wide variety of specialties to provide better care to patients. There are various types of technologies, each giving the physician different information about the area of the body being examined. These technologies are an essential component of medicine because of their diverse applications in helping patients. Ultrasound imaging is a popular non-invasive medical imaging technology because it provides real-time images with minimal risk[6]. Prior to the introduction of medical imaging technologies such as ultrasound, diagnostic information was obtained through impractical and invasive procedures[7]. Ultrasounds have a probe attachment with a layer of piezoelectric crystals that vibrate upon the application of voltage[8]. These vibrations produce high-frequency sound waves that can travel under human skin[8]. Once the waves impact internal tissue boundaries, the waves are reflected back to the transducer and recorded, which are used to create a two-dimensional image[8]. Ultrasound is a versatile tool as it can be used for imaging various regions in the body including the cardiovascular system, pulmonary system, abdominal area, soft tissues, and obstetric medicine[9]. Moreover, it is generally a painless procedure and causes no known harmful effects upon usage. However, the quality of the images obtained is directly impacted by the skill of the operator[10]. Additionally, the technology requires a particular medium to be placed between the ultrasound and the patient's skin as air acts as a barrier to the sound waves, which causes distortions in the images[11].

In general, ultrasound has several advantages over other imaging modalities including its size and cost. Traditional ultrasound systems are cart-based. The cart system can be bulky, tedious to move, and cost upwards of $50,000[2]. Point-of-Care-Ultrasound (POCUS) are handheld devices that use the same scientific premise and are capable of visualizing the same areas of the body as a traditional ultrasound. The only differences are the portability, as the devices are pocket-sized, and the ability for the probes to interface directly with small computers, phones, and tablets[2]. The starting point for these devices is only $2,500[2]. Implementation of POCUS into regular clinical practice has several significant benefits. First and foremost, the use of a visual aid during the diagnostic process gives physicians additional relevant information, which can allow for earlier diagnosis and intervention for patients[1].

Currently, only emergency medicine (EM) physicians have adopted POCUS into regular practice and have been doing so for over 10 years[12]. EM uses the device for diagnostic purposes, including scanning protocols for trauma and performing guided procedures[12]. Other specialties are currently lagging. These specialties have some physicians who have sought out POCUS certification and initiated programs within their departments; however, there is no official guidance at the board level. Recommendations on how to properly use that technology and what should be done to be certified are not currently available[13]. At UVA hospital, this is true as well. Outside of the emergency medicine department, POCUS's use is entirely dependent on the physician. These early adopters must seek out training to learn how to use the technology. Even then, neither the department nor hospital administration monitor what physicians are trained or how the technology is being used in an individual's clinical practice.

Internal medicine is one specialty that could benefit greatly from the implementation of POCUS. Internal medicine physicians, or internists, specialize in the treatment of illness throughout several systems in the body[14]. This includes diagnosis of complex illnesses or helping patients manage chronic conditions such as hypertension, lung disease, and more[15]. The American College of Physicians has released a formal statement acknowledging the important role POCUS can play in the field with promises for establishing clinical guidelines, an educational curriculum, and more for the future[16]. However, there is currently no concrete timeline for these guidelines so it is up to individual physicians to implement POCUS into practice. At UVA Health, ultrasound is part of the internal medicine curriculum, and residents are taught the basics of ultrasound devices, image acquisition, image interpretation, and usage for certain guided procedures. Point-of-care ultrasound usage, specifically the use of ultrasound where a patient is being treated, is used sporadically and handheld devices are used even less.

The hypothesis for this project is that by creating initial competency guidelines for the usage of the technology, with a focus on the ultrasound physics, image interpretation, and image acquisition principles, a foundational model for widespread implementation of POCUS can be developed that will incline more regular use of the device. This project has three key aims. The first is to obtain data on interest in POCUS usage in various subspecialties, determine the current barriers to implementation that exist at UVA, and investigate the common training methods and checkpoints for ultrasound competency. The second aim is to compile the relevant skills for internal medicine, establish the ideal teaching method for each skill, and create a pathway for proving competency. This will be the basis of the manual. The final aim is to create a prototype interface that presents the information in aim 2 engagingly and descriptively.

Material and Methods

Throughout this project, the materials used included prior literature on POCUS relating primarily to learning and teaching the technology, participant experiences obtained through stakeholder interviews, and the graphic design tool Canva for creating the final product using user interface (UI)/user experience(UX) design principles.

One of the primary methods for collecting data in this study was interviews. It was determined that this was an optimal method because identifying the problem and solving the problem begins with understanding the stakeholder's relevant experiences.[17] Two rounds of interviews were conducted to determine the current barriers to ultrasound implementation within various departments of the UVA hospital as well as the existing methods used for ultrasound certification for residents and attendings. The first round of interviews was user-led to allow each respondent to guide the conversation (see supplementary for common themes). Physicians were asked open-ended questions in two rounds. The first was more general questions focused on understanding the daily work-flows of physicians. These questions involved common patient populations, pain points in diagnosis, the role of imaging technology, as well as general questions on medical education. The second half of the interview was more targeted to POCUS as it was meant to gauge their knowledge and interest in the technology, and the potential barriers to widespread usage on an individual, department, or hospital-wide basis. The information on POCUS was more variable as the experience of the physician influenced how much information was provided. The goal of this interview round was to establish evidence that there is a general interest in using POCUS and also to understand the key barriers in order to devise a potential solution. This round was essential for problem definition and ideating potential solutions. The second round of interviews was survey-based and featured a structured list of questions that were asked to all interviewees in an effort to standardize the response categories across all interviews (see supplementary for questions). The target population was physicians who currently teach ultrasound education in their department. The goal of the second round of interviews was to understand the teaching methods that are commonly used in medical education for ultrasound imaging and what steps the ultrasound certification process consists of.

A secondary method that was implemented was literature reviews of the current POCUS training and certification guidelines released by various professional organizations (both in the United States and other countries) that successfully implemented the technology were compiled as well. This included organizations such as the American College of Physicians (ACP), the Society of Hospital Medicine (SHM), the American College of Emergency Physicians (ACEP), and Sonoguide[18–21].
The focus of this literature review was to understand what skills were essential, what key milestones had to be achieved, and how this information was successfully implemented into practice. This information contributed to the foundations of the handbook as well as a verification for the information learned in the second round of interviews. Additionally, due to time constraints, the final handbook could not be validated by implementing it into practice, so a case-study approach was used. The study was a translational study of how successful POCUS implementation in emergency medicine would indicate success in internal medicine as well[4]. The study was based on the premise that there are a high number of overlapping disease states within both the emergency medicine and internal medicine departments[4]. Obtaining data involved performing diagnostic procedures in various disease states to test the accuracy of POCUS in comparison to the conventional imaging modality[4]. The study was based on the premise that there are a high number of overlapping disease states within both the emergency medicine and internal medicine departments[4]. So, successful implementation within emergency medicine could have comparable outcomes for internal medicine. The analysis of the proven effects of POCUS implementation further verified that the device would have a positive effect on the internal medicine department.

The final method employed was the use of user experience and user interface design principles. It was essential to design a final product that was informative and conveyed all the essential information.

However, part of the project's aim was also to organize the information in a way that was easy to understand and engaging for the reader. Techniques such as colors, bolded fonts, and visual graphics were used to highlight the important information. The aim was to present the detailed information in an easy-to-grasp manner and the organizational techniques would keep the reader focused on important information. Color theory played a key role in making the handbook engaging[22,23]. By using bright, vibrant colors as the background for key points that were being made, the reader's attention was drawn right away to the main point. Aside from bright colors to lead the reader's eyes, the use of bolded sections of text were used to extract the main idea of a sentence and ensure that none of the information that needed to be taken in went unnoticed. Helpful graphics, including ultrasound images, were used to provide a visual aid for the reader and put some of the ideas in another context that could be understood.

Results

Identification of Pain Points at UVA Hospital

To explore the barriers of handheld ultrasound a decision matrix was established to quantitatively compare POCUS and traditional cart-based ultrasound (seen in table 1 below). The purpose of this comparison was to determine if the traditional model (cart-based) was significantly superior to handheld devices in any way. The decision matrix was divided into three main categories of comparison. Each feature was weighted on a scale of 1 to 3 with 3 being the most important. The categories were miscellaneous, ultrasound specifications, and usage. Differences between the handheld and traditional ultrasound devices can be seen in the box outlined in red.

Table 1. Decision matrix for the use of handheld ultrasound devices compared to traditional cart-based

	Handheld vs Cart Based Ultrasound Decision Matrix			
		Ratings		
	Criterion	**Weight**	**Handheld Ultrasound**	**Cart Based Ultrasound**
Misc.	Price	2	+	-
	Phone compatability	1	+	-
	Portability	3	+	-
U/S Specs	Interface with EMR	3	-	+
	Color Doppler	2	+	+
	Frequency Range up to 10 Mhz	3	+	+
Usage	Lungs	3	+	+
	Heart	3	+	+
	Liver	3	+	+
	Vasculature	3	+	+
	Abdomin	3	+	+
	Diagnostic capability	3	+	+
	Therapeutic Capability	3	+	+
Total +			32	29
Total -			3	6
Weighted Total Score			29	23

The miscellaneous category included aspects such as cost, compatibility with mobile devices, and portability. POCUS showed clear advantages over the cart-based devices in all three aspects. In terms of pricing, POCUS costs between $2,000 and $7,000 compared to $50,000 for a cart-based device[2]. The handheld POCUS devices are also significantly smaller, more portable, and are designed to interface with phones and tablets. The second category was ultrasound specifications and investigated each device's ability to interface with the electronic medical records (EMR) system, perform color doppler imaging, and allow for frequency ranges of up to 10 Mhz. Both devices offered color doppler and the proper frequency range, but POCUS cannot interact with the EMR. The inability to interface with the EMR is a large barrier because there is no way to store the images that are captured in a patient's file. Additionally, these images cannot be verified for quality assurance unless another physician is in the room. The third category that was evaluated was usage capabilities and focused on the structures of the body that can be imaged. Each device had the capability to major all of the major structures of the body, indicating that POCUS implementation would not result in a decrease in imaging potential.

After quantifying all of these factors, POCUS emerged as the optimal device with a weighted score of 29 as opposed to the traditional ultrasound score of 23. This decision matrix indicates that even though POCUS has a barrier in its lack of ability to interface with the EMR, the advantages of the device far outweigh the disadvantages, and implementation of the device will have an overall positive impact on ultrasound imaging within internal medicine. Thus, the qualities of the device are currently not the primary barrier to its implementation into regular usage in internal medicine.

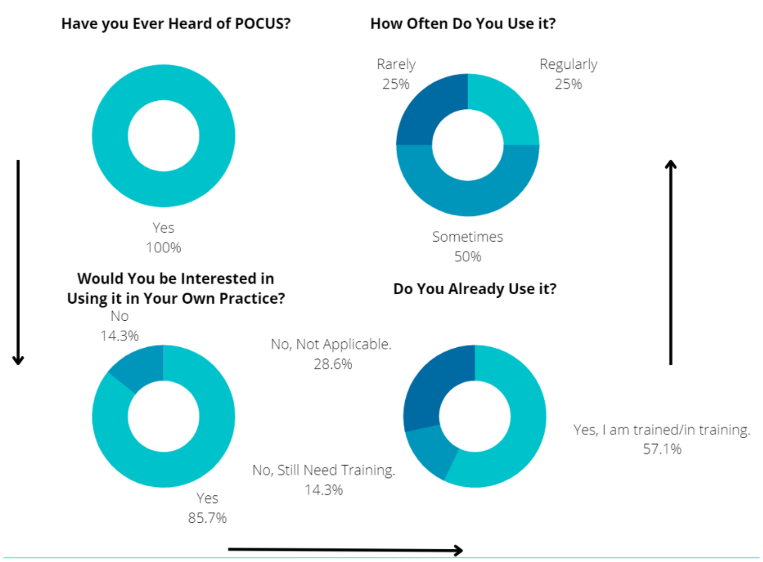

Fig.1. Summary of user-led interview data pertaining to the respondents experience and usage of handheld devices.

The next stage of analysis was to conduct interviews. These interviews were completed to understand the current usage at UVA hospital to gauge interest and more importantly to determine the barriers to the usage. In fig.1, pie charts were created of the answers to four questions asked relating to POCUS usage at UVA. As seen in fig.1, all of the respondents had heard of POCUS indicating that the technology is well-known within the medical field. One of the larger implications was that 57% of respondents stated that training was previously received training or in progress, and 14.3% were going to pursue training in the future. Of those who were trained to use the technology, 50% used it at least sometimes, while 25% used it often. Thus, it can be concluded that the majority of respondents had an interest in the technology and when properly trained, physicians will find a way to implement these new skills into regular practice in some way.

This data on usage is significant because it directly contradicts our hypothesis. Based on the literature, it was expected that physicians would have some knowledge of the technology and a combination of a general lack of training or interest would lead to limited usage was what; however, the opposite was true. This discrepancy can likely be attributed to the early adopter effect. In medicine, there are typically two groups when it comes to implementing new technology or skills, the early and the lagging. The early adoption group is the ones who champion these new skills by using them within a personal practice setting or leading the initiative for department-wide adoption. These physicians play an essential role in providing the proof of concept for why something is worthwhile. Proof of concept is essential in the official adoption of technology, like in the case of POCUS. A possible explanation for this high percentage of early adopters is that some of the respondents were at the recommendation of ones who had previous experience or interest in ultrasound devices. Additionally, since most were aware of the device from outside research, it is more understandable that training was sought to use the device in clinical practice.

The second portion of the interviews focused on understanding the barriers at UVA. Including ones the physicians had personally encountered, colleagues had indicated, or general barriers within the field as a whole. The barriers to POCUS usage were compiled in fig.2. The x-axis represents the number of times it was mentioned throughout all the interviews while the y-axis contained the name of the identified barrier.

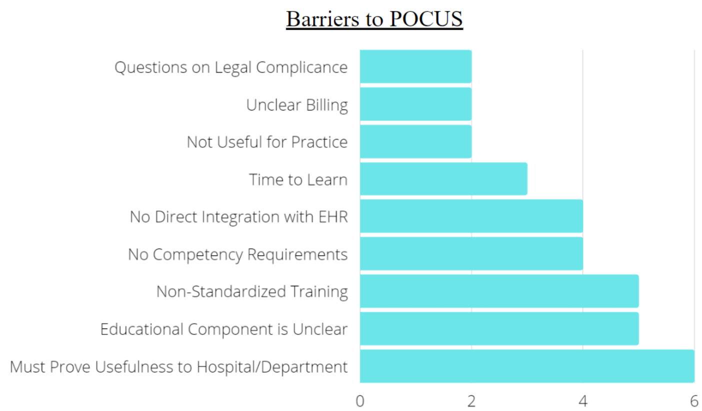

Fig.2. Respondent identified barriers to implementation of regular POCUS usage at UVA Hospital

The interviews identified nine common barriers with each having been identified by at least two respondents. Proof of concept was the most often identified barrier as all six respondents agreed it was the most pressing issue. This is expected as mentioned in the previous section, adoption of new technology requires a well-developed proof of concept of not only how the technology can be adopted but also what benefits it adds over the current methods. The next set of commonly identified barriers, identified by at least four respondents, included an undefined education curriculum, lack of standardized training, a lack of competency requirements, and handheld devices' lack of direct integration with the electronic medical records (EMR) system. These barriers can all be grouped under the theme of liability. With all those barriers in place, there are large questions on how someone is competent at the technology and not a danger when using it on a patient. Without a standard of competency, comprehensive training and educational curriculum cannot be successfully adopted. In the case of EMR integration, the problems were mentioned previously in the design matrix. The inability to upload the scans for verification or record-keeping has the potential for legal consequences.

The exploration of these barriers led to the problem statement that internal medicine physicians need clear competency guidelines for using POCUS in clinical practice. Competency guidelines address the current gray area around when the device can be used and how a physician can be properly trained to not be a liability.

Developing Competency Guidelines for POCUS in Internal Medicine

As mentioned previously, only emergency medicine has clear guidance and an established educational curriculum for teaching POCUS. As each department of the hospital uses ultrasound for different cases and procedures, the emergency medicine guidelines cannot be directly transferred into usage in other specialties. Because of this variability in use, training physicians in different departments will require different types of scans to practice, each with its checkpoints.

During the exhaustive literature review, common teaching methods for ultrasound curriculum were evaluated to establish the optimal methods for POCUS training[24]. The results of the literature review found that using didactic lectures, small group discussion, guided and unguided scans, and skills assessments were the most effective methods of teaching. Didactic lectures were found to be valuable for conveying introductory information such as device anatomy, common use cases, and how artifacts occur. Small group discussion was shown to be the most effective method for image interpretation practice. By breaking into small groups, ultrasound images could be displayed and discussed to identify structures of the body as well as abnormalities in the image. Guided scans and unguided scans served as the primary method for learning image acquisition. Guided scans were performed with a trained physician present to offer real-time feedback in terms of image quality and diagnostic accuracy. Unguided scans were performed upon proof of ability with guided scans. The images completed during the unguided scan section were submitted to faculty members to be reviewed and critiqued at a later date. Technical skills assessments were used to evaluate skills such as hand placement during procedures and general device knowledge.

To validate the effectiveness of these teaching methods, interviewees were asked if the methods were a part of the ultrasound curriculum. In figure 3, it can be seen that all of the respondents reported using most of the devices and a portion of them claimed to use all of the listed methods. It was also found that the majority of respondents believed that hands-on methods offered significant advantages over lecture-based lessons. This validation of the literature provided increased confidence in the methods being laid out in our handbook.

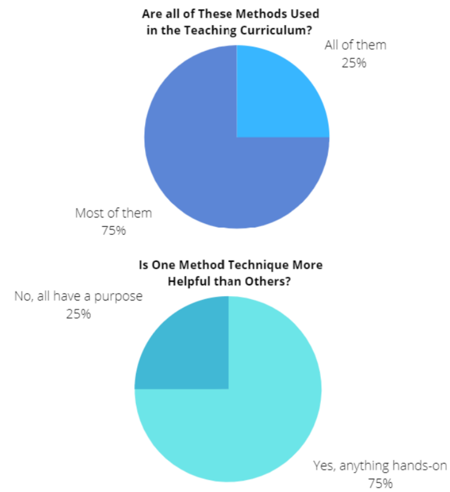

Fig.3. Responses to questions on if the methods identified in literature were used and whether one is more helpful than others.

Designing the Handbook

One of the major issues with current POCUS training guidelines is that the manuals are incredibly dense in content, but lacking in key specific details. Required skills are listed out, but the description of how to learn the skills or how in-depth to go is not provided. Additionally, when a quantitative requirement is provided, it is generalized to all skills regardless of the type of procedure. So, a more complex image acquisition requires the same number of practice scans as something simpler. Along with this, the guidelines are very bland and not engaging for the reader. These problems make the guidelines challenging to read and important information is not conveyed well. In the case of designing guidelines for a different specialty, it is tedious to read through so many different documents and efficiently identify the relevant information.

In the handbook, these issues were alleviated by cutting out unnecessary information and providing more in-depth descriptions of the important points. By doing this, the reader does not have to try and sift through a pile of text that doesn't have any significance to find the information needed. In addition to cutting out unnecessary text, the handbook pages were designed to be colorful and keep the reader engaged with aesthetically appealing page layouts. The implementation of these aesthetic aspects absorbs the reader's attention and creates an enjoyable learning environment as opposed to the current guidelines. Sample pages can be seen in supplementary fig.1.

The notable features are that the information has been divided into three beginning modules focused on ultrasound physics, image interpretation, and image acquisition. The relevant skills have been matched with the most relevant module. Each of these modules includes an outline of the most important information, the necessary number of quality scans that need to be completed to prove competency, and the relevant teaching methods that should be used to present the information. In addition, the modules highlight key points with the use of bold text and clear visuals. As seen in the supplementary fig.1. (A), an annotated visual of a POCUS device is displayed for the reader along with a breakdown of the important controls with a short description. The reader can quickly identify (in red) the controls and if desired can read the short description of each. Supplementary fig.1(D)-(F), contains the information for artifacts. In supplementary fig.1.(D), the optimal teaching methods for learning the skill are broken down and red text is used to highlight the important lessons. In supplementary fig.1.(D), common artifacts are listed along with example ultrasound images and definitions with key points in blue text. Supplementary fig.1.(F) also highlights how a user can adjust positioning to fix any artifacts that may appear during practice. The information is engaging by ensuring that various information presentation techniques are used. Each page has some slight differences that can draw the reader to the important information. There is a large amount of detail, but the viewer does not feel overwhelmed.

Validation

Due to lack of time, validation of the hypothesized handbook could not be determined with physician feedback. To make up for this, a validation study was conducted using a case study. This translational case study discussed how the trends of POCUS implementation in emergency medicine were also applicable to internal medicine. The study found that the majority of disease states between the emergency department and the internal medicine unit are the same[4]. In fact, the majority of patients in the emergency department are not critically ill and quite similar to those in internal medicine[4]. This equating of the two departments indicates that POCUS can be implemented successfully. One significant implication was that the implementation of POCUS led to increased diagnostic accuracy and more efficient result acquisition due to the physicians performing scans and interpreting the results instantaneously[4]. This is primarily because for many common disease states, POCUS is an optimal tool for diagnosis. The sensitivity and specificity of POCUS were above 0.75 for all the states as seen in figure 4.

Sensitivity and Specificity of POCUS for Various Conditions

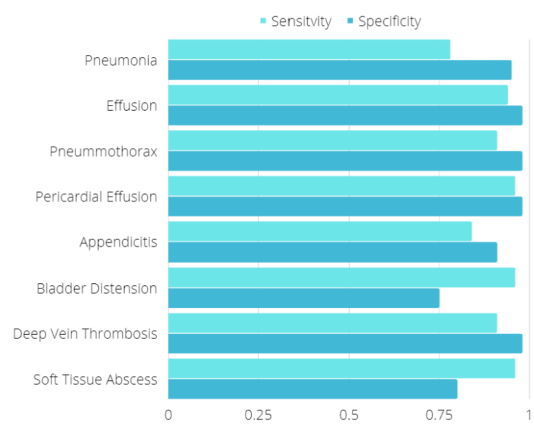

Fig.4. This figure depicts the sensitivity and specificity of POCUS in various disease states that are common in both emergency medicine and internal medicine. It was found that POCUS offered high sensitivity and specificity in each.

Discussion

Implications

The implications for these types of guidelines have an impact not only at the UVA Hospital but also in the field of internal medicine as a whole. At UVA, the establishment of the necessary skills and methods to become competent at each is the first step toward creating a comprehensive educational curriculum. A curriculum allows for the opportunity to test the competency guidelines in practice and determine the effectiveness or if there is a need for continued refinement. Once the curriculum is proven to effectively train residents in technology usage it can become the certification standard at the hospital for all future physicians who want to become proficient. Additionally, the internal medicine department at UVA already owns some handheld ultrasound devices that aren't regularly used due to a lack of physician training with the technology. By instituting guidelines and getting physicians properly trained, these devices will be put into use to help more patients. Aside from lack of training, physicians shy away from using the POCUS devices because there is a liability risk. If something were to go wrong because a physician's training is not standardized, like a diagnosis is not made properly due to operator error, a physician may face legal consequences. Upon receiving certification, this liability risk is minimized as the physicians will be properly licensed to use the technology within their practice.

On a national level, the successful implementation of these guidelines at UVA can be the basis for a national standard for certification. As POCUS gains more traction, educational institutions will be able to look at the established guidelines offered at UVA, that have been proven effective, and base their curriculum on the educational principles in place. Moreover, as more physicians across the country get certified to use the device, as well as success at the hospital level, this will lead to more definitive proof of concept. So, the lagging group of physicians will eventually adopt POCUS as well and eventually lead to significantly increased device usage. Overall, this will lead to improved diagnostic capabilities and better patient outcomes.

Limitations

The main limitation of this work is the sample size of both rounds of interviews. The first round of interviews included responses from six physicians and the second round included responses from four physicians. This low response rate was mostly due to time constraints of the project as well as poor response rates from physicians. Data was able to be collected from these sample sizes; however, the findings are not generalizable to the larger population due to their selective nature. To curb this limitation, more interviews are necessary to be conducted to add data and create more reliable findings. Additionally, the handbook has not yet been able to be tested by physicians, so the content and presentation may not address the problem well enough.

Conclusion

Point-of-Care Ultrasound shows major indications for improved diagnostic capabilities and improved patient outcomes. Various barriers to implementation were identified with the focus of this project being on how to address the lack of competency guidelines within the internal medicine department at UVA. A prototype handbook was created using UI/UX design principles that included three modules divided into ultrasound physics, image interpretation, and image acquisition. Each module includes the foundational knowledge and sets forth the proper steps that need to be taken to gain minimum competency with POCUS. The handbook is the necessary first step towards integrating handheld ultrasound into regular usage in internal medicine at UVA and eventually in the field as a whole. The work on this project focused on foundational educational elements, so there is still much work to be done. The modules that were created serve only for generalized ultrasound information, and for that reason, several things should be done moving forward to improve upon the initial design. This includes showing the guidelines to physicians, who teach ultrasound skills, for review of the content as well as the presentation of the information. This feedback would highlight any gaps in knowledge. Additionally, the guidelines should be expanded with more modules for specific disease states. The current modules introduce procedures and disease states but do not go into depth on how to identify them. After expanding on the handbook, it should be implemented into the residency curriculum for residents to get properly certified. In the long-term, the handbook can be iterated for other department needs. Future iterations of the handbook could use the same general structure and flow, but ensure the certification process is customized to the needs of the other specialties.

End Matter

Author Contributions and Notes

Stiglitz performed research on ultrasound physics (module 1) and UI/UX design principles. Porter performed research on image acquisition (module 2) and image interpretation (module 3). Porter and Stiglitz developed the questions for interviews, collected data, and performed analysis. Stiglitz and Porter both contributed to the handbook and wrote the paper.

The authors declare no conflict of interest.

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Supplementary

User-Led Interview Topics

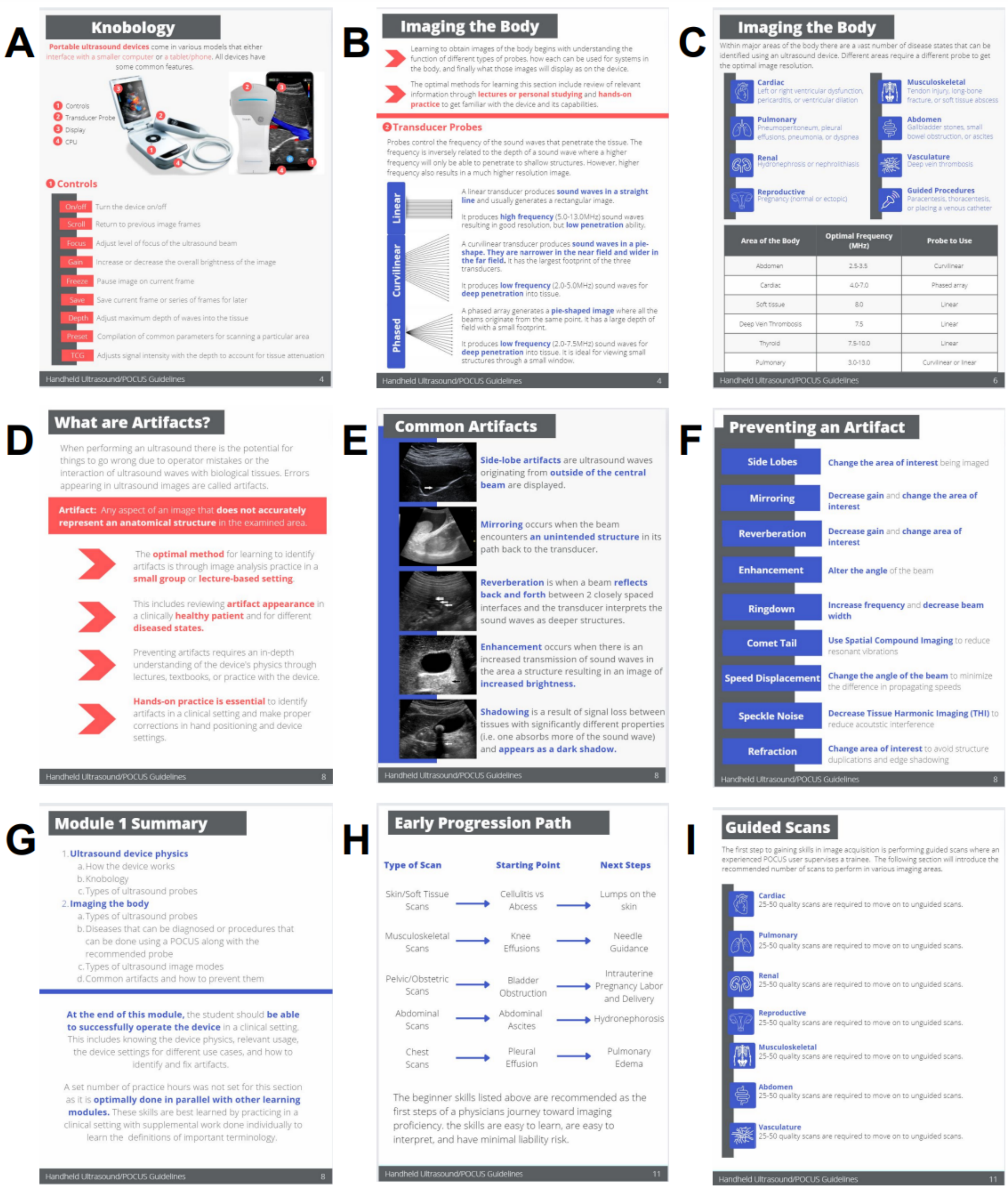
1. What is the typical patient population? What are some common qualities of these patients?
2. What is the day-to-day workflow?
3. What are some pain points in the diagnostic process?
4. How is imaging used?
5. How are new technologies (or protocols) implemented within the department? What are some pain points associated with that?
6. How are residents taught new skills?
7. Experience with POCUS
   a. Interest
   b. Previous experience
   c. Current usage (personal and in the department).

Survey-Based Interview Questions

1. Did you receive any training in ultrasound at any of the following phases of your career: (select all that apply)
   a. Medical School
   b. Residency
   c. Fellowship
   d. Post-fellowship
2. Does UVA med school do any ultrasound training currently? POCUS or otherwise?
   a. Yes
   b. No
3. Are all necessary ultrasound skills taught as part of the curriculum or are there cases where physicians can seek out training on additional skills?
   a. Yes - part of formal education
   b. No - attendings seek it out
4. If no to the above, Who did you have to report your certification to be able to use it in your practice? (select all that apply)
   a. Hospital
   b. Department
   c. American Board
   d. Other
5. What are some of the more common ultrasound uses? (short answer)
6. What is the foundation for learning in medical education? Is the primary focus repetition of procedures or is the focus more centered on an understanding of material and processes?
   a. Repetition
   b. Understanding
   c. Both
7. Is there an official assessment to determine competency within residency/medical school?
   a. Yes
   b. No
8. As part of the ultrasound educational curriculum, did any of the following play a role?

    a. Assessments
    b. Clinical skills (with patients)
    c. Clinical skills (no patients)
    d. Lectures
    e. Other
9. Of the above options, would you say that one is more impactful/effective than the others?
    a. Yes (provide method)
    b. No
10. For lectures, is this a general overview of the skills before practicing them later on?
    a. Yes - like an introduction
    b. No - not used
    c. No - used in some other way
11. Is there any discussion-based learning? Like being given a scan and having to determine what is wrong (not just performing the skill)
    a. Yes
    b. No
12. Were any of the following things used as part of the learning process:
    a. Guided Scans
    b. Perform scan and resident/attending will verify later
    c. Unguided scans - no resident/attending will review later
    d. Knowledge-based assessment
    e. Image interpretation
13. Who is in charge of teaching ultrasound skills (select all that apply)?
    a. Attending
    b. Senior resident
    c. Other
14. Is there a pass-fail aspect to the training?
    a. Yes
    b. No
15. Is there a set number or range of quality scans that must be completed for a student to be deemed competent at each skill?
    a. Yes
    b. No
16. What is that number or range? (short answer)
17. Is competency-based on the number of scans or the quality of scans? (short answer)
18. Are any types of knowledge-based assessments completed during training? (select one)
    a. Yes
    b. No
19. If someone fails the credentialing assessment, is there a remediation process? (select one)
    a. Yes
    b. No
20. What steps are needed to attempt the certification again?
    a. No delay
    b. Wait X amount of time
    c. Certain skills must be demonstrated
    d. Other
21. Are handheld ultrasound devices something common in your department? (select one)
    a. Yes
    b. No
    c. Depends on the physician
22. If yes, in what capacity? (Select all that apply)

    a. Diagnostic
    b. Therapeutic - mostly this one
    c. Other
23. Does certification for portable devices differ from more traditional models?
    a. Yes
    b. No
    c. Do not use portable devices
24. Upon receiving certification, are you free to perform scans within your practice or are there further steps that need to be completed? (select all that apply)
    a. Diagnostic
    b. Therapeutic Usage
    c. Guided Procedures
25. How do residents prove they aren't a liability? (select one)
    a. Have to have a certain number of exams checked off by the department
    b. Prove to the department
26. Do you have to renew your certification? (select one)
    a. Yes
    b. No
27. What are the steps to renewing your certification and/or maintaining your certification?
    a. Continually show evidence of usage in your practice (i.e. no officially test)
    b. Sit for a credentialing exam (as part of boards or something else)
    c. Attend a conference (or something) to demonstrate skill
    d. Other



Supplementary Fig.1. Excerpts from the Handbook on Point-of-Care Ultrasound Competency Guidelines. (A) A section dedicated to the device components and important controls. (B)-(C) Section on imaging the body using ultrasound including information on probe types and where the device can be used. (D)-(F) Section on teaching methods for artifacts, common ones, and preventative measures. (G) Summary of information contained in Module 1 on ultrasound physics. (H)-(I) Information on image acquisition found in Module 3 including the progression of skills and the number of skills required for competency.