	<p>were surveyed on their perceptions of the curriculum. Responses were correlated with specialty choice and clinical campus site. Results: Based on our survey (90% response rate), students felt US was useful for anatomical understanding and patient care. Overall, 93% of our respondents reviewed the curriculum favorably. Qualitative feedback was very positive with students desiring more ultrasound education and more required components, specifically in clinical rotations. Conclusions: Based on these results, some changes have already been implemented including decreased student to instructor ratios, more open scan time, and more required components. The breadth of formal assessment has increased. Multiple pilot programs for clinical rotations are being developed. There is an ongoing need for faculty development and continued assessment of US competency.</p>

SCHOLARONE™
Manuscripts

Author Manuscript

This is the author manuscript accepted for publication and has undergone full peer review but has not been through the copyediting, typesetting, pagination and proofreading process, which may lead to differences between this version and the [Version of record](#). Please cite this article as [doi:10.1002/jum.14662](#).

Longitudinal Ultrasound Curriculum Incorporation at West Virginia University School of Medicine: A Description and Graduating Students' Perceptions

Joseph Minardi, MD, Holly Ressetar, PhD, Theresa Foreman, MD, Kristen Craig, MD, Melinda Sharon, MPH, John Bassler, MS, Stephen Davis, MPA, MSW, Anthony Machi, MS2, Scott Cottrell, Ed.D, Nicolas Denne, MD, Norman Ferrari, MD, Kenneth Landreth, PhD, Bruce Palmer, Gregory Schaefer, DO, Robert Tallaksen, MD, David Wilks, MD, Dorian Williams, MD

Corresponding Author: Dr. Joseph Minardi

1 Medical Center Drive, Morgantown, WV 26506

Phone: 304-293-2436

Fax: 304-293-6702

Email: jminardi@hsc.wvu.edu

The abstract has been presented as an oral presentation at Learn Serve Lead 2016: The AAMC Annual Meeting in Seattle, WA, in November 2016.

None of the authors have any financial disclosures.

Keywords: Undergraduate; medical, education; longitudinal; curriculum; multidisciplinary

RUNNING HEAD: Longitudinal Ultrasound Curriculum at WVU SOM

Longitudinal Ultrasound Curriculum Incorporation at West Virginia University School of Medicine: A Description and Graduating Students' Perceptions**ABSTRACT**

Objectives: Ultrasound (US) is a clinical tool being incorporated in multiple medical specialties with evidence of improved patient care and cost. Some schools have begun implementing US curricula. We hope to build upon that foundation and provide another potential framework of incorporation. There are several barriers including curricular space, equipment and physical space, adequate faculty, and performing assessment. **Methods:** At West Virginia University (WVU), we began a longitudinal US curriculum in 2012 with incorporation of didactic and practical sessions into gross anatomy, our systems-based 2nd year curriculum, physical diagnosis course, and clinical rotations. We included both written and practical assessment from the onset. After the initial four years, the first graduates were surveyed on their perceptions of the curriculum. Responses were correlated with specialty choice and clinical campus site. **Results:** Based on our survey (90% response rate), students felt US was useful for anatomical understanding and patient care. Overall, 93% of our respondents reviewed the curriculum favorably. Qualitative feedback was very positive with students desiring more ultrasound education and more required components, specifically in clinical rotations. **Conclusions:** Based on these results, some changes have already been implemented including decreased student to instructor ratios, more open scan time, and more required components. The breadth of formal assessment has increased. Multiple pilot programs for clinical rotations are being developed. There is an ongoing need for faculty development and continued assessment of US competency.

RUNNING HEAD: Longitudinal Ultrasound Curriculum at WVU SOM

INTRODUCTION

Over the past few decades, the usage of point of care ultrasound (POCUS) has greatly expanded. Where it was once primarily used in Cardiology and Obstetrics, it is now used diagnostically for a multitude of medical problems from appendicitis to occult hip fractures to retinal detachments. The portability and low cost of ultrasound gives patients and providers wider access to more advanced diagnostics and care, including traditionally specialized procedures once reserved for high level referral centers. This access extends from any hospital or clinic bedside to even very remote resource limited settings, such as rural Appalachia and Sub-Saharan Africa. Ultrasound is an efficient, cost effective tool which improves diagnostic accuracy and safety, reduces radiation exposure to patients, and increases patient satisfaction.¹ Due to these qualities, POCUS is a valuable tool for almost every medical specialty, such that basic ultrasound competence from every physician is a reasonable expectation, and should be a core competency for all graduating medical students.^{2,3}

Ultrasound training has become more common in residency and fellowship training nationwide, where its benefit has been demonstrated.⁴ It is possible that POCUS training would already be a basic component of undergraduate medical education, if not for the considerable challenges associated with implementing new practical skills-based training. Some challenges that have been previously described include lack of space in an already crowded curriculum, lack of facilities and equipment, lack of adequately trained faculty, performing adequate meaningful assessment, and a lack of hands-on opportunities for students.^{2,5} Despite these difficulties, a few pioneering medical schools have recognized the wide applicability and utility of POCUS, and have begun to institute ultrasound training into the undergraduate curriculum. At these institutions, ultrasound has been incorporated into clinical skills and anatomy courses with

RUNNING HEAD: Longitudinal Ultrasound Curriculum at WVU SOM

positive student feedback.⁶ The University of South Carolina School of Medicine provided a detailed description of their longitudinal curriculum in 2006, as well as a nine-year follow-up study outlining their successes, challenges, and evolution.^{2,7} Other schools have also instituted US curricula with reported success including Wayne State, University of California, Irvine, Ohio State, and the Icahn School of Medicine.^{3,6,8,9} These curricula vary from required components through all four years with US demonstrations in larger groups to honors curricula for select students, experiential learning modules, and/or small group sessions with variable reporting of competency assessment.

It is clear that medical schools are increasingly interested in implementing US into their curricula; however there is currently wide variability with methods of curricular implementation.⁶ Until recently, only a few descriptions of comprehensive, longitudinal US curricula have been published.^{3,6-9} More examples of curricular incorporation, emphasizing the different aspects of success versus challenges overcome may be valuable to educators and school leadership early in the process of US curricular integration.

At West Virginia University (WVU), US training was incorporated not as a stand-alone curriculum, but as a curricular “thread,” with components in many courses throughout the four years of medical school. This “thread” model introduces unique advantages and challenges, specifically regarding its assessment and incorporation during clerkships. We hope that our present description, successes versus challenges, outcomes of implementation, and lessons learned will assist others who are beginning this process, specifically related to the concept of a curricular thread, performance of practical assessment, and incorporation into clinical rotations.

MATERIALS & METHODS

RUNNING HEAD: Longitudinal Ultrasound Curriculum at WVU SOM

Context

The West Virginia University (WVU) Doctor of Medicine (MD) curriculum admits approximately 115 students per class. The first two years are held on the Morgantown campus. The MS1 curriculum is largely a discipline-based curriculum (biochemistry, physiology, anatomy, histology, etc). The MS2 curriculum is a more system-based curriculum integrating microbiology, pathology, immunology, and pharmacology. The physical diagnosis and clinical integration (PDCI) course spans the first 2 years of the curriculum. For the clinical years (MS3, MS4), students are assigned to one of three campuses, Morgantown, Charleston, or Eastern with approximately 65, 35, and 15 students assigned to each campus, respectively. WVU is fortunate to be home to state of the art simulation facilities, including available ultrasound equipment at all three campuses.

Impetus

The Department of Emergency Medicine at WVU had recently commenced a fellowship in Clinical Ultrasound in July 2011. During the preceding graduate medical education approval process, school leadership was introduced to the utility of US as a general tool for physicians, causing interest in this field to grow. The medical school then sought more information, and requested a subsequent proposal be developed for a longitudinal US curricular thread at WVU.

After initially gaining approval for a 4th year clinical ultrasound elective from the school's curriculum committee, a subcommittee was formed to develop a longitudinal curricular thread for clinical ultrasound. This subcommittee was composed of faculty from all aspects of the undergraduate medical education program, including basic sciences, clinical skills and simulation, and multiple specialists from clinical rotations. The subcommittee was tasked with

RUNNING HEAD: Longitudinal Ultrasound Curriculum at WVU SOM

assessing the general and specific needs of our students, developing the goals, objectives, educational strategies, and overall implementation plan, as well as competency assessment for this curricular thread. Specific discussions included who would lead the thread, what would be taught, by whom, where in the different parts of the curriculum, how to include meaningful and effective practical skills, how it would be assessed, and how to create synergy with the larger curriculum. The proposal was presented to the curriculum committee and after several revisions, was eventually accepted for implementation for the class matriculating in fall 2012. A Thread Director was named to oversee and guide the implementation.

Description of Ultrasound Curriculum*Building the Foundation*

In January 2013, the comprehensive US curricular thread was implemented, beginning with the incoming MS1 students. Each additional year of the thread was added sequentially over the next four years. The general philosophy of the curriculum was to teach high-yield US content with broad relevance across most medical specialties. A clinical ultrasound framework was integrated within and superimposed onto the existing curriculum as follows: 1) Indications, 2) Image acquisition, 3) Image interpretation, 4) Clinical integration.

To address issues of curricular space, course directors were involved from the early design period in order to identify optimal areas to include US content and practical sessions that most seamlessly flowed with the larger curriculum. To address facilities and equipment, we were able to identify existing, appropriate physical space, and worked with leaders from other schools to coordinate scheduling, allowing for effective sharing of the space between schools. We also received financial support from the Dean's office to purchase equipment. We sought the best

RUNNING HEAD: Longitudinal Ultrasound Curriculum at WVU SOM

pricing from several vendors, and obtained refurbished equipment that met our needs. We were initially able to obtain 20 cart-based US systems, with at least 10 of each major transducer type: phased array, curvilinear, and linear, and a variety of other more specialized transducers. We also purchased 20 single probe GE V-scans, which were distributed to each campus based on class size: 14 to the Morgantown campus (to be used during both the pre-clinical and clinical years), 4 units to the Charleston campus, and 2 units to the Eastern campus for use during the clinical rotations. All handheld units were initially housed at each site's simulation center, where they could be signed out by students and/or faculty. A cart was housed with three transducers at the Eastern campus; the Charleston campus was fortunate to have one or two previously acquired US carts.

From a faculty perspective, we have relied heavily on expert faculty from within the Department of Emergency Medicine, including residents and US fellows. However, we have been fortunate to recruit expert educators from other departments to participate in hands-on US teaching for our students, including sonographers and physicians from Radiology, Family Medicine, Surgery, Obstetrics/Gynecology, Cardiology, and Intensive Care. Some important strategies in recruiting faculty have included:

1. **Give faculty tools for success.** We provided detailed expectations and step-by-step instructions for each practical session, as well as offered brief faculty review sessions prior to labs.
2. **Respect and appreciate faculty time.** We often asked for volunteers to teach in only one or two lab sessions. If many faculty can give a small time commitment, the work is less burdensome. We also attempted to show gratitude both in-person and with public letters of thanks.

RUNNING HEAD: Longitudinal Ultrasound Curriculum at WVU SOM

3. **Seek faculty feedback.** We continually sought feedback from faculty in order to improve the logistics and materials for lab sessions.

To provide meaningful assessment, we worked with course directors to devise optimal strategies for timing and performance of assessment that was most synergistic within the previously existing curriculum. Lastly, to assure students had adequate hands-on opportunities beyond structured labs, we incorporated open lab sessions; we made cart-based equipment available to students during off-hours, and allowed sign-out of handheld units for self-guided practice.

MSI Year

The most logical and least intrusive way to incorporate US into the first year was during the gross anatomy portions of the Human Structure course. Six lectures were developed that introduced the use of clinical ultrasound, and correlated appropriately with the anatomy content. Each lecture was accompanied by a two-hour workshop. Approximately one-third of the class was assigned to the workshop at a time; students were assigned to attend the workshops during a portion of their gross anatomy lab dissection time. Great care was taken to assign students in a fashion that allowed each group, at any given dissection table, to continue their gross dissections, while 1-2 students were away attending US lab. A large simulation/skills classroom containing multiple patient beds that was typically used in the School of Nursing was identified and a shared schedule was coordinated. For most labs, 10 beds, each with an ultrasound machine and a standardized patient was arranged. Four students were assigned to each bed. Generally, one faculty was assigned to two adjacent beds. Step-by-step laboratory guides were developed, and made available to the students. The guides provided detailed instruction on which transducers, machine settings, patient positioning, initial transducer placement and strategies to identify given

RUNNING HEAD: Longitudinal Ultrasound Curriculum at WVU SOM

anatomical structures. Images and diagrams of sonographic anatomy were included. The sequential lectures and labs consisted of:

1. Introduction to Ultrasound and the Ultrasound of the Upper Extremity
2. Ultrasound of the Lower Extremity
3. Ultrasound of the Heart and Thorax
4. Ultrasound of the Abdomen
5. Ultrasound of the Retroperitoneum and Pelvis
6. Ultrasound Anatomy for Medical Procedures

The students were assessed in a multimodal fashion via written and practical exams. Written US material was assessed by three separate US-specific multiple choice quizzes administered approximately every 3-4 weeks. These quizzes focused on proper technique and recognition of structures. Additionally, US content consisting of clinical vignette multiple choice questions was included on larger Human Structure course exams, occurring approximately every 5 weeks. Lastly, an end of semester practical assessment was administered. The practical consisted of six stations, where students were required to obtain a satisfactory image of a given anatomical structure within five minutes at each station. Structures were randomly assigned from a list of previously reviewed structures from the course corresponding to each body area.

MS2 Year

As these initial students progressed to second year, US content was incorporated with their lectures in coordination with basic science faculty. For example, during the lectures on endocarditis, echocardiographic images reviewing the pathologic findings were included.

RUNNING HEAD: Longitudinal Ultrasound Curriculum at WVU SOM

Additionally, for the physical examination clinical encounters, students were provided instructions and clinical context with expectations to acquire US images of select structures that corresponded to the component of the physical examination for that module. For example, students were expected to acquire images of the carotid artery, internal jugular vein, and thyroid gland during the module on the head and neck examination. Select practical sessions were held that corresponded to the organ systems being covered in the course. Prior to practical sessions, students were expected to review brief online videos reviewing key sonographic pathology. For example, during the cardiac module, a brief online video reviewing key echocardiographic pathologic findings was administered, and students practiced their technique in guided laboratory sessions that were structured similarly to sessions during their first year. Initially, sessions on lower extremity deep venous thrombosis, cardiac, and female pelvis ultrasound were included. Although students were required to attend all sessions, formal assessment was not performed for the initial class.

MS3 Year

As students enter the 3rd year, they are assigned to different campus sites for clinical rotations. Each site has its own faculty, clinical schedule and spaces, educational facilities, and information systems. These barriers present a challenge in offering a standardized curricular thread. During the third year, students were provided with and encouraged to review brief case-based videos on select high-yield, clinically focused US topics. These videos were developed by Emergency Medicine US faculty, ranging from 5-15 minutes long, and were available on YouTube. Videos were supplemented with written quizzes that were also encouraged, but not initially required. These optional quizzes were the only form of assessment in the initial class. Students had access to handheld equipment (GE single probe V-scans) for use in the clinical

RUNNING HEAD: Longitudinal Ultrasound Curriculum at WVU SOM

environment, and were instructed on proper utilization. Instructions for utilizing US during their clinical rotations included:

1. Students should discuss with faculty if performing the US was appropriate.
2. Students should obtain verbal patient consent, explaining their role and the educational nature of the US.
3. Students should only scan patients with a previously established means to diagnosis: oversight from a faculty with adequate US experience, appropriate recent or planned imaging, or other diagnostic procedure (i.e. aspiration of ascites).
4. Students should compare their findings to that available to them listed in #3, and reflect on areas for improvement, as well as the role of US in the clinical context.

The Obstetrics & Gynecology rotation had already been teaching US, and added it as a required procedure for their rotation. Additionally, during the Surgical clerkship, students were required to attend a practical session on US-guided central venous catheter placement, as well as a simulated patient scenario involving post-operative intra-abdominal bleeding, where US is used to confirm the diagnosis.

MS4 Year

In fourth year, the curriculum was more varied due to electives. Students still had access to equipment and multiple scanning opportunities, but with less structure. Electives in Radiology and Emergency & Clinical US were available to fourth year students. US is used and taught in other fourth year rotations, including Anesthesia and Critical Care, although in a less standardized fashion.

RUNNING HEAD: Longitudinal Ultrasound Curriculum at WVU SOM

Measurement & Analyses

In 2016, a survey of the graduating medical students who had completed the full US curriculum was conducted. The survey consisted of the following: 12 Likert Scale questions regarding opinions and perceptions on the utility of the US content; demographic-based questions, including intended specialty and campus attended during clerkship years; and open-ended questions on the successes and areas of potential improvement for the curriculum. For example, *Ultrasound will help me make more accurate diagnoses* was scored using the Likert scale options of *Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree, and I prefer not to answer*. We hypothesized that students entering specialties with more or less anticipated US emphasis or usage would perceive the curriculum differently. The full version of the survey administered to these students can be seen in the Supplementary Material.

Descriptive statistics were calculated for all variables, with comparisons made between the three campuses. We devised a scoring system for the Likert Scale questions, with the maximum possible score was 62, if all areas of the curriculum were rated as strongly favorable. Scores >42 were regarded as favorable, and scores were compared across anticipated specialties and campuses. Responses to open-ended questions were analyzed using conventional content analysis, wherein text responses were coded and then grouped into categories and eventually into emergent themes for each question.

Dissemination

The survey was distributed in February 2016 via Research Electronic Data Capture (REDCap) to a listserv of students anticipating matriculation in May 2016. REDCap is a secure, web-based application designed to support data capture for research studies.¹⁰ The survey was

RUNNING HEAD: Longitudinal Ultrasound Curriculum at WVU SOM

optional, and results were anonymous. A \$10 Starbucks gift card was offered as an incentive to anyone who completed the survey. This study was approved by the West Virginia University Institutional Review Board.

RESULTS

Student Performance

For this initial class, the primary required assessments took place during the first year of the curricular thread. All students passed all ultrasound components with an average score of 89% on graded US materials including US specific quizzes, the practical examination, and the US specific questions on Human Structure examinations.

Survey Outcomes

We received responses from 82 out of 91 graduating medical students (90% response rate) who had participated in the full curriculum. Most students (62%) completed their rotations at the Morgantown campus. The most popular reported specialty choices were Internal Medicine (10) and Pediatrics (10). Our three campuses had the following positive survey rates: Morgantown – 92.2% (47/51), Charleston – 100% (20/20), and Eastern 81.8% (9/11). The overall positive survey response rate was 93%, with the Charleston campus rating the curriculum most favorably at 100% (Figure 1). The US curriculum received the highest average score from students pursuing Ophthalmology (55.67/62) and the lowest average score from students pursuing Otolaryngology (42/62), as seen in Figure 2.

<Insert Figure 1>.

<Insert Figure 2>

Across all three campuses, the majority of students felt that the curriculum will aid them in developing more accurate diagnoses and allow them to perform procedures in a safer manner

RUNNING HEAD: Longitudinal Ultrasound Curriculum at WVU SOM

(Table 1). Out of 82 responses, we received 6 negative surveys (7%). Among the 16 student-preferred specialty choices, those that scored poorly included Emergency Medicine (1), Family Medicine (2), Internal Medicine (1), Pediatrics (1), and Psychiatry (1). Of those students enrolled at the Morgantown campus, 69% believed that US was inadequately incorporated into their clinical rotations.

<Insert Table 1>.

Written comments were provided by 67/82 (82%) of students. Upon conducting content analyses, two overwhelming themes emerged from the data: increase US usage and integration during third and fourth year rotations, and increase faculty US usage and integration. Students were adamant about wanting more US integration into clerkships. Students also desired more simulation labs, workshops, and refresher courses, allowing for more educational opportunities, since continuing education and usage drop off after second year. Comments were frequently specific to clerkship site. For example, Charleston campus students noted a lack of portable units and an inability to access them. Eastern campus students requested to work with a sonographer on all shifts. Morgantown campus students desired more US education than the 4th year elective.

DISCUSSION

Based on the results of our survey, the goals of introducing a clinically relevant, hands-on, active learning curriculum for POCUS that was perceived as valuable by students was achieved. Open-ended responses were overwhelmingly positive, with many students suggesting that more mandatory US components be included during the clinical years of their training. Students consistently proposed ways to incorporate US into the curriculum, with the common theme that they simply wanted to learn more US during their education. More simulation labs, workshops, and refresher courses were common recommendations. Another recurrent suggestion

RUNNING HEAD: Longitudinal Ultrasound Curriculum at WVU SOM

for improvement to the curriculum was to increase faculty US usage and integration across multiple specialties. Students are aware that certain specialties may use US more than others, but state that they frequently faced resistance and skepticism from faculty. Unfortunately, students are concerned that this is causing a decrease in their US usage and educational opportunities.

The authors characterized anticipated specialties into heavy use of ultrasound and light use of ultrasound. This characterization was based solely on author opinion. We theorized that students anticipating practice in “ultrasound heavy” specialties would have more favorable perceptions of the curricular thread. Interestingly, some of the lowest survey scores were from students anticipating matching into “US heavy” specialties, but there was an overall trend towards higher survey scores from students pursuing “US heavy” rotations (see Figure 2). It may be that students pursuing “US heavy” specialties have more interest in US education, but some may also have higher expectations for their US education.

General Improvements to the Curricular Thread

Over the past few years, many updates and improvements have been made to our curricular thread. Some of these changes were planned from the onset and initially weren’t feasible in the early stages of implementation, due to the high demand for faculty time when starting a new large-scale initiative similar to this. Other improvements were incorporated in response to feedback from students on course surveys and from the faculty during course and clerkship director meetings. A summary of the curricular thread, its implementation, challenges, and ongoing development is presented in Table 2.

<Insert Table 2>.

RUNNING HEAD: Longitudinal Ultrasound Curriculum at WVU SOM

More handheld units have been acquired. We currently use the GE dual probe V-scans, which allows for highly portable access to a wide variety of US applications. We now have 100 of these units available, 48 of which are at the Morgantown campus' simulation center for general sign-out, while the others are assigned to specific clerkships at each campus. Since US is widely available in Obstetrics & Gynecology clinical spaces, no handhelds are assigned to that clerkship, and none are assigned to the Psychiatry clerkship. Distribution of the handheld units was based on relative numbers of students and clinical sites at each campus (Table 3).

<Insert Table 3>.

Open lab scanning time has increased. Students continue to have after-hours access to equipment where they may practice. This open lab time and after-hours access is available to all students, but primarily utilized by students in the pre-clinical years. There are periodic informal open lab times proctored by a single faculty. Additionally, the Ultrasound Interest Group was founded shortly after the initiation of our curricular thread, holding periodic practical reviews and lunchtime sessions approximately every six weeks to assist junior students with various US topics.

MSI Year

A lecture and demonstration on US use in the evaluation of cardiovascular physiology is now a part of the Human Function course. Cardiovascular and respiratory physiology laboratory sessions during Human Function now include US content. During practical sessions, we have instituted smaller student to workstation ratios; currently, most workshops stick to a 2:1 ratio. With the decreased ratio, workshops are more efficient, and no additional instruction time is

RUNNING HEAD: Longitudinal Ultrasound Curriculum at WVU SOM

required. An additional lecture and demonstration covering ocular and head and neck US has been incorporated.

MS2 Year

The embedded US content that is given by faculty has increased, as more faculty have become comfortable discussing this content. The students are now evaluated on US knowledge during the 2nd year with clinical vignette-style multiple choice questions focused on image interpretation, recognition of pathologic findings, and introductory clinical integration. These questions are now included on the general course examinations as well. Additionally, the required Observed Structured Clinical Examination (OSCE) contains a station that assesses practical US skills.

MS3 Year

The required US content in the clinical rotations has increased. The Obstetrics & Gynecology requirements are now more specific, and students are given more opportunities to perform fetal and endocavitary studies. The Surgery clerkship has added required US scans to the rotation. Additionally, the clerkships for Internal Medicine, Family Medicine, and Pediatrics at each campus have incorporated US experiences and content into their structure in different ways with multiple pilot programs ongoing. WVU students now must pass a clinical skills practical examination to be eligible for graduation. One or more stations assessing practical US skills, as well as clinical integration, has recently been incorporated as part of this examination.

MS4 Year

There are still many opportunities for students to scan and handheld equipment is widely available. Additional functionality now allows students to log their US studies in E-Value, our

RUNNING HEAD: Longitudinal Ultrasound Curriculum at WVU SOM

school's procedural and clinical tracking system. Enrollment in the elective for Emergency and Clinical Ultrasound continues to increase.

Areas of Continuing Development

Pre-Clinical

There are continued efforts to incorporate US content further into the physical diagnosis course. Students are currently given assignments to perform specific US scans during patient experiences; however, these images are not routinely captured, tracked, and no formal process for formative feedback exists. We hope to incorporate image archival and feedback processes for students in the near future. Optimal methods for practical assessment is another area of ongoing development.

Clinical

Similar to the pre-clinical years, students currently have no system to archive images and receive structured feedback. We hope to incorporate these capabilities in the near future. As noted above, practical assessment of US skill and clinical integration are being further developed. Faculty development is ongoing to assist faculty in not only incorporating US as part of their clerkships, but also as a patient care tool.

Limitations

Our study has several limitations. The most significant is that our survey reflects student perception. It does not objectively assess student competence in POCUS nor its impact on patient care or the larger health care system. Although, as mentioned above, students did perform well on objective POCUS assessment within the curriculum. While we believe that producing more physicians with skills in POCUS will ultimately improve patient care and health care costs and

RUNNING HEAD: Longitudinal Ultrasound Curriculum at WVU SOM

while there is evidence for the benefits of POCUS in these areas, our data does not directly address these issues.¹¹⁻¹⁴ Recall is another limitation. The nature of this survey that was administered at the end of medical school may lead to poor recollection of specific US components by students. Further work is needed to clarify the benefits of POCUS training to students as they move into graduate level training as well as the benefits to patients and health care delivery as a whole.

Conclusions

Thanks to the vision and support of the leadership at the WVU School of Medicine, as well as the collaborative multidisciplinary interest and support, we were able to develop and implement a successful curricular thread for POCUS that was well received by our first graduating class. We have been able to navigate the well-known challenges, while incorporating a meaningful and relevant hands-on, active learning experience. Some of the keys to our success have been support from leadership, sufficient planning that involved faculty from the impacted courses, and an emphasis on intense practical experience for students. As this curricular thread continues to evolve along with advances in US technology, we anticipate a greater role of US in not only physician education, but other health professions as well.^{15,16} We envision that with continued progress, US will be seen less as a separately identified skill set, and instead a routine component of bedside care for all physicians and health care providers.

REFERENCES

1. Howard ZD, Noble VE, Marill KA, Sajed D, Rodrigues M, Bertuzzi B, Liteplo AS. Bedside ultrasound maximizes patient satisfaction. J Emerg Med. 2014 Jan;46:46-53.

RUNNING HEAD: Longitudinal Ultrasound Curriculum at WVU SOM

2. Hoppmann RA, Rao VV, Poston MB, et al. The evolution of an integrated ultrasound curriculum (iUSC) for students: 9-year experience. *Crit Ultrasound J*. 2015 Dec;7(1):18.
3. Bahner DP, Goldman E, Way D, Royall NA, Liu YT. The state of ultrasound education in U.S. medical schools: Results of a national survey. *Acad Med*. 2014 Dec;89(12):1681-1686.
4. Kelm DJ, Ratelle JT, Azeem N, et al. Longitudinal ultrasound curriculum improves long-term retention among internal medicine residents. *J Grad Med Ed*. 2015 Sep;7(3):454-457.
5. Phelps A, Wan J, Straus C, Naeger DM, Webb EM. Incorporation of ultrasound education into medical school curricula: Survey of directors of medical student education in radiology. *Acad Radiol*. 2016 Jul;23(7): 830-835.
6. Nelson BP, Hojsak J, Del Rossi E, Karani R, Narula J. Seeing is believing: Evaluating a point-of-care ultrasound curriculum for 1st-year medical students. *Teach Learn Med*. 2017 Jan-Mar;(1):85-92.
7. Hoppmann RA, Rao VV, Poston MB, et al. An integrated ultrasound curriculum (iUSC) for medical students: 4-year experience. *Crit Ultrasound J*. 2011;3:1-12.
8. Rao S, van Holsbeeck L, Musial JL, Parker A, Bouffard JA, Bridge P, Jackson M, Dulchavsky SA. A pilot study of comprehensive ultrasound education at the Wayne State University School of Medicine: A pioneer year review. *J Ultrasound Med*. 2008 May;27(5):745-749.
9. Wilson SP, Mefford JM, Lahham S, Lotfipour S, Subeh M, Maldonado G, Spann S, Fox JC. Implementation of a 4-year point-of-care ultrasound curriculum in a liaison committee on

RUNNING HEAD: Longitudinal Ultrasound Curriculum at WVU SOM

- medical education-accredited US medical school. *J Ultrasound Med.* 2017 Feb;36(2):321-325.
0. Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N, Conde JG. Research electronic data capture (REDCap) – A metadata-driven methodology and workflow process for providing translational research informatics support. *J Biomed Inform.* 2009 Apr;42(2):377-81.
 1. Kanji HD, McCallum J, Sirounis D, MacRedmond R, Moss R, Boyd JH. Limited echocardiography-guided therapy in subacute shock is associated with change in management and improved outcomes. *J Crit Care.* 2014 Oct;29(5):700-705.
 2. Hall MK, Taylor RA, Luty S, Allen IE, Moore CL. Impact of point-of-care ultrasonography on ED time to disposition for patients with nontraumatic shock. *Am J Emerg Med.* 2016 Jun;34(6):1022-1030.
 3. Kameda T & Taniguchi N. Overview of point-of-care abdominal ultrasound in emergency and critical care. *J Intensive Care.* 2016 Aug 15;4:53.
 4. Bhagra A, Tierney DM, Sekiguchi H, Soni NJ. Point-of-care ultrasonography for primary care physicians and general internists. *Mayo Clin Proc.* 2016 Dec;91(12):1811-1827.
 5. Steinwandel U, Gibson NP, Rippey JC, Towell A, Rosman J. Use of ultrasound by registered nurses – A systematic literature review. *J Ren Care.* 2017 Jan;1-11.
 6. Whittaker JL & Stokes M. Ultrasound imaging and muscle functions. *J Orthop Sports Phys Ther.* 2011 Aug;41(8):572-580.

RUNNING HEAD: Longitudinal Ultrasound Curriculum at WVU SOM

Table 1. Likert-style questions regarding opinions and perceptions on ultrasound utility with their associated percentage agree or strongly agree response rate.

Likert-style Question	Percentage (%) Response Agree or Strongly Agree
<i>The ultrasound curriculum was valuable to my medical education.</i>	92.59
<i>Ultrasound will help me improve my differential diagnoses.</i>	87.80
<i>Ultrasound will help me make more accurate diagnoses.</i>	91.46
<i>Ultrasound will help me perform safer procedures.</i>	98.78
<i>Learning ultrasound improved my understanding of anatomical structures and relationships</i>	87.80
<i>Learning ultrasound helped me better understand the physical examination.</i>	65.85
<i>I found the hands-on ultrasound labs with standardized patients helpful in learning ultrasound</i>	94.94
<i>I found the hands-on ultrasound labs with standardized patients helped me gain confidence in interacting with patients.</i>	84.81
<i>I found the hands-on ultrasound labs with standardized patients helpful in developing professionalism and communication skills.</i>	82.28
<i>I feel that the incorporation of ultrasound into the clerkships (3rd and 4th year) was adequate</i>	23.17
<i>I feel the ultrasound curriculum should continue.</i>	98.77
<i>I think every doctor should be taught to use ultrasound.</i>	93.83

RUNNING HEAD: Longitudinal Ultrasound Curriculum at WVU SOM

3

4 **Table 2.** Summary of the US Curricular Thread, including the implementation, challenges, and

5 ongoing development.

	MS1	MS2	MS3	MS4
Course(s)	Human Structure	Microbiology and Immunology Pathology Pharmacology Physical Diagnosis/Clinical Integration	Obstetrics/Gynecology Surgery Internal Medicine Family Medicine Pediatrics Psychiatry	Emergency and Clinical US Elective Radiology Elective Anesthesia Critical Care
Applications	Extremities, MSK, Vascular, Peripheral nerves Echocardiography Pulmonary Abdominal Retroperitoneal Male and Female Pelvis Procedural	Skin/Soft Tissue Pulmonary Echocardiography Lower Extremity DVT Female Pelvis (Endovaginal) Male Pelvis Abdominal, including Pediatric	Echocardiography Ascites/Paracentesis Renal Skin/Soft Tissue Gallbladder FAST Lower Ext. DVT AAA Fetal Female Pelvis	FAST RUSH Echocardiography Abdominal/Retroperitoneal Pulmonary Male and Female Pelvis Skin/Soft Tissue Ocular Extremities Procedures
Clinical Emphasis	Image Acquisition Image Interpretation	Image Interpretation Clinical Integration	Indications Clinical Integration	Indications Clinical Integration
Assessment (current)	MCQs on general exams, US specific quizzes, practical evaluation, formative feedback	Required Attendance, OSCE, MCQs on exams	Required Elements, Clinical skills exam	Elective, variable
Challenges	Space, time, faculty	Space, time, faculty, image archival and formative feedback	Faculty development, image archival, formative feedback	Faculty development, image archival, formative feedback
Ongoing Development	Investigating incorporation of	Investigating image archival	Faculty development, investigating multi-	Investigating image archival systems, working

RUNNING HEAD: Longitudinal Ultrasound Curriculum at WVU SOM

	US simulators, incorporation into problem-based learning curriculum	systems, systems to provide formative feedback, improvements to practical assessment, investigating US simulators	disciplinary case based learning activities, investigating image archival systems	to formalize US expectations
--	---	---	---	------------------------------

Table 3. Distribution of handheld US units by campus and clerkship.

		Campus		
		Morgantown	Charleston	Eastern
Specialty	Family Medicine	8	6	2
	Internal Medicine	6	4	2
	Pediatrics	6	4	2
	Surgery	6	4	2

FIGURE LEGENDS

Figure 1. Overall survey results differentiated by clinical campus site. Those surveys that scored greater than 42 out of 62 possible points on the cumulative Likert scale were considered favorable and are shaded dark.

Figure 2. Survey quality by level of utilization in specialty.

Figure 1. Overall survey results differentiated by clinical campus site. Those surveys that scored greater than 42 out of 62 possible points on the cumulative Likert scale were considered favorable and are shaded dark.

Figure 1. Overall survey results differentiated by clinical campus site. Those surveys that scored greater than 42 out of 62 possible points on the cumulative Likert scale were considered favorable and are shaded dark.

Author

Figure 2. Survey quality by level of utilization in specialty.

*Heavy US Use indicates specialties that the authors estimate may have higher rates of US utilization (including Emergency Medicine, Anesthesia, Family Medicine, General Surgery, Obstetrics & Gynecology, and Radiology).

**Low US Use indicates specialties that have estimated lower rates of US utilization (including Dermatology, Ophthalmology, Orthopedics, Internal Medicine, Neurology, and Otolaryngology).

Figure 2. Survey quality by level of utilization in specialty.

Author

Minerva Access is the Institutional Repository of The University of Melbourne

Author/s:

Minardi, J;Ressetar, H;Foreman, T;Craig, K;Sharon, M;Bassler, J;Davis, S;Machi, A;Cottrell, S;Denne, N;Ferrari, N;Landreth, K;Palmer, B;Schaefer, G;Tallaksen, R;Wilks, D;Williams, D

Title:

Longitudinal Ultrasound Curriculum Incorporation at West Virginia University School of Medicine: A Description and Graduating Students' Perceptions.

Date:

2019-01

Citation:

Minardi, J., Ressetar, H., Foreman, T., Craig, K., Sharon, M., Bassler, J., Davis, S., Machi, A., Cottrell, S., Denne, N., Ferrari, N., Landreth, K., Palmer, B., Schaefer, G., Tallaksen, R., Wilks, D. & Williams, D. (2019). Longitudinal Ultrasound Curriculum Incorporation at West Virginia University School of Medicine: A Description and Graduating Students' Perceptions.. J Ultrasound Med, 38 (1), pp.63-72. <https://doi.org/10.1002/jum.14662>.

Persistent Link:

<http://hdl.handle.net/11343/285142>