

MEDICAL EDUCATION/MEDICAL STUDENT

Musculoskeletal ultrasound in internal medicine residency – a feasibility study

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Introduction: Ultrasound has become indispensable in medicine for diagnosis and therapeutics. In Internal Medicine Residency Training Program (IMRTP), there is a deficiency of a structured, competency-based musculoskeletal ultrasound (MSKUS) training despite its growing popularity.

Methods: We conducted a feasibility study for incorporating MSKUS in IMRTP and competency assessment. We recruited internal medicine residents from all training levels. Rheumatology attending with expertise in MSKUS supervised curriculum-design and patient-based assessment. A structured curriculum was developed for knee MSKUS, including training material and a pre- and post-test. An Observed Structured Clinical Exam (OSCE) was used for competency assessment. Attending evaluations and participant feedbacks were collected.

Results: Fifteen residents participated and 12 completed the OSCE. The pre–post tests showed a statistically significant increase ($p < 0.001$) for all subcomponents (anatomy, pathology, and biophysics). The residents scored high on the OSCE [8.8 ± 1.1 (range 7–10)]. Attending evaluations for cognitive and technical skills were rated ‘Excellent’ (66%) and ‘Good’ (87%), respectively. The training program was perceived very valuable with regard to time and resources spent by residents and faculty, although some felt a need for more patient assessments.

Discussion: The competency assessed with our OSCE and highly positive feedback reflects this preliminary study’s importance and sets the platform for future studies of formal ultrasound training in internal medicine.

Keywords: *education; musculoskeletal ultrasound; medicine residency; rheumatology; curriculum development; feasibility study*

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Ultrasound is becoming an indispensable diagnostic resource in medicine. It can be universally applied without contraindications, offers real-time imaging with easy bedside access and can be applied for interventional procedures through direct visualization (1). It is already well established for diagnostic and therapeutic use in various specialties, including physical medicine and rehabilitation, obstetrics and gynecology, and emergency medicine (2). The internal medicine specialties, including cardiology, endocrinology, rheumatology, nephrology, and pulmonary critical care are now using ultrasound as an extension of the physical examination and for interventions. There have been numerous studies evaluating incorporation of ultrasound training into these training programs (3, 4). The use of ultrasound, primarily for diagnostic and therapeutic musculoskeletal problems, has seen a surge among providers and hospitals (5–7). Residents com-

monly use ultrasound limited to central line placement in the intensive care units and a few subspecialty areas based on interest. It is less common, however, for Internal Medicine Residency Training Program (IMRTP) to provide a formal training curriculum beyond these limited uses.

Musculoskeletal problems are one of the most common reasons for ambulatory care visits in the United States, accounting for 8.3% of the 1.2 billion visits per year (8). According to the Centers for Disease Control, musculoskeletal and connective tissue diseases are also one of the most frequent diagnoses for emergency department visits, estimated at 8,239,000 (SD 498,000) visits annually – about 6.3% (SD 0.2) of the total (9). These figures highlight the burden of musculoskeletal problems in both ambulatory and inpatient domains in the United States. Needless to say, ultrasound can be considered a vital tool in the

assessment and management of patients with musculoskeletal issues (1). Internal medicine trainees would therefore benefit greatly from its incorporation in their daily practice, being able to do bedside and clinic-based musculoskeletal ultrasound (MSKUS).

We wanted to conduct a study that would give qualitative and quantitative ideas about incorporating ultrasound in practice for the internist-in-training. The goal of our study was to assess both the feasibility of incorporating a basic MSKUS curriculum into an IMRTP and the development of competence of the trainees through this process, within limited time frames and resources. *Our hypotheses were that a structured curriculum in MSKUS in IMRTP will result in attainment of competence in basic ultrasound science, application of an appropriate technique, and collection and interpretation of images obtained; and that the residents and staff would view the curriculum as a valuable investment of time and resources.*

Methods

Study design

The study was performed at a university-affiliated community hospital over a 3-month period. For ease of assessment and predicted ease of learning curve, we selected the knee joint for complete assessment, and the presence of effusion as pathology of focus. The institutional review board (IRB) of the Reading Health System approved this study. Figure 1 outlines the sequence of events for the study.

Pre- and post-test

Volunteer internal medicine residents with no prior knowledge of MSKUS use were recruited and, after they agreed to participate, were provided with focused educational material on knee anatomy and physiology and ultrasound basics (www.essr.org/html/img/pool/knee.pdf) and two 1-h lecture sessions (10). Residents completed a 20-question pre- and post-test assessing knowledge of knee anatomy and physiology and biophysics of knee ultrasound. They were then given the opportunity to perform hands-on MSKUS of the knee first in pairs and then on a volunteer patient. The volunteer patients selected for the study were patients with and without knee effusion as finding on clinical exam, to facilitate comparison and learning. Rheumatology faculty provided direct observation and feedback at this step. They assessed participants in the hands-on session for overall competence, performing the procedure independently, and assessment of cognitive and technical skill using a 4-point Likert scale (Excellent, Good, Marginal, Poor).

Testing competence with an OSCE

The primary outcome measure was an Observed Structured Clinical Exam (OSCE) at the end of the 3-month

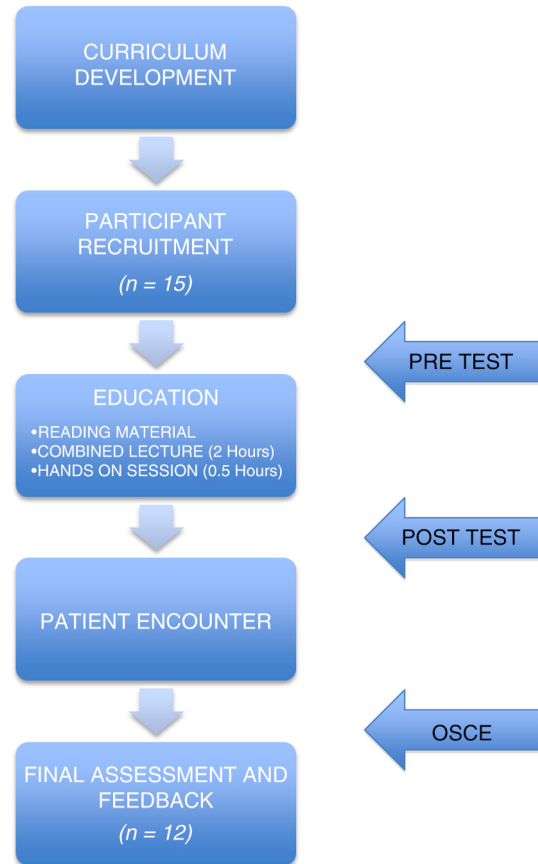


Fig. 1. Structure and approach to assessment in the study.

period, which contained still images for interpretation, and two patient-based scenarios designed to evaluate correct assessment and interpretation. Faculty evaluated the participants for convention use, identifying appropriate pathology and use of the ultrasound machine and its function. Standard convention from the reference text (10) was used for medial and proximal body parts to be placed on the upper left side of the image screen to take images. Similarly, the anatomic knowledge was based on the educational material provided and discussed aspects of the knee joint and spatial relationship of surrounding structures. Machine use included probe placement, use of knobs and buttons to obtain and modify images.

Post-study feedback

Feedback about the program was collected at the end from participants who completed the OSCE and from the supervising faculty. The faculty assessing skills and providing feedback did not participate in evaluation of the OSCE to avoid bias. The participants were de-identified in their forms and tests, by assigning them a serial number and the evaluator did not have access to participant information. All data were collected and password protected per IRB guidelines by the principal investigator.

Statistical analysis

The responses on the pre- and post-tests were collected and analyzed using a paired *t*-test. Competence assessment of participants and feedback from the participants and faculty were summarized using descriptive statistics. Data analysis was conducted using SPSS® v 22.0 (IBM, Cambridge, Massachusetts) and a *p*-value of <0.05 was considered to be statistically significant.

Results

Recruitment of residents and pre- and post-test

A total of 15 residents enrolled in the study. Of these, 12 completed the final OSCE, while the remaining three did not complete as they were unavailable at the time of the OSCE. All participants were able to go through the material and lectures, and spent half an hour on the paired hands-on session. The pre- and post-test scores showed statistically significant differences not only for the biophysics portion of the test but also for anatomy and pathology questions, as shown in Table 1. These results remained significant even when we excluded those who did not complete the final OSCE.

Patient encounters and hands-on training

Ten out of the 15 participants (66%) were rated 'Excellent' and the rest 'Good' in their cognitive skillset (able to identify, describe, and explain findings). For the technical skillset, 13 (87%) were considered 'Good' and two were rated 'Excellent' (ability to use the machine, probe positioning, and adjust controls). All 15 participants were thought to have competence to independently perform the ultrasound.

Development of competence assessment – The OSCE

The mean total score on the two-component OSCE \pm SD was 8.8 ± 1.1 (range 7–10) out of a maximum 10. Half of this score (5 points) was based on the written component to identify and mark an effusion, if any (4.1 ± 0.8). The rest of the points were based on direct observation of skills on the volunteer patient (3 points for convention use, anatomy and machine use, and 2 points for presence or absence of pathology, the knee effusion). All 12 participants in

the final OSCE were able to identify knee effusion, or the absence of, on the two exam patient knees. One of the participants did not use image convention appropriately in the patient encounter, and two could not successfully identify components in machine use.

Participant and attending post-study feedback

Feedback from the 12 participants completing the entire study was generated from a 4-point Likert scale as above and responses are summarized in Table 2. In addition to these questions, participants were asked if the two practice patient sessions prior to OSCE were enough; eight (67%) agreed, while the rest thought more sessions were needed with volunteer patients.

Attending perception was assessed for the two faculty members using a similar 4-point Likert scale. They thought the initial training was adequate, and so was the perceived competence (both rated at the highest level for each question). One of them thought the number of sessions with patients was enough while the other recommended at least five sessions in total. Both suggested that the ultrasound experience needed more practice for complete assessment, and that the residents and faculty should take it up at the rheumatology clinic for regular use.

Discussion

Our study demonstrates that MSKUS incorporation is a feasible option for an IMRTP and is viewed positively by both faculty and participants for the investment of time and resources. Residents were able to develop competence in limited assessment (the knee joint) and of a given pathology (knee effusion). Our study addresses the perceived barriers in incorporating MSKUS in the IMRTP (11) through feasibility assessment and feedback, and sets a background for further studies on MSKUS in the future.

There is a gap in the literature on MSKUS assessment at the IMRTP level; however, there have been some studies looking at ultrasound use at the medical school level (11, 12). Bahner et al. investigated ultrasound training offered at the 134 U.S. MD-granting medical schools (11). Of the representative 82 (61.2%) responders, only about 62% had integrated ultrasound training into the undergraduate curriculum. Although close to 80% agreed ultrasound should be a part of their curriculum, only less than 20% actually reported this as their institutional priority. Lack of space in the curriculum was cited as the most significant barrier (logit +0.49, SE 0.11) (11). In another study by Bahner et al., authors report success in incorporating ultrasound for fourth year medical students. However, the number of musculoskeletal scans performed was the lowest of all disease subgroups studied in their publication (12). Due to a deficiency of a structured MSKUS training program or internal medicine residents, and the importance of

Table 1. Pre- and post-test outcome analysis (*n* = 15)

| Variable (total questions) | Pre-test | | Post-test | | <i>p</i> -value |
|----------------------------|----------|------|-----------|------|-----------------|
| | Mean | SD | Mean | SD | |
| Biophysics (12) | 3.88 | 1.32 | 11.13 | 0.63 | <0.001 |
| Pathology (4) | 0.97 | 0.90 | 3.07 | 0.68 | <0.001 |
| Anatomy (4) | 1.60 | 0.92 | 3.28 | 0.50 | <0.001 |
| Total (20) | 6.45 | 1.62 | 17.48 | 1.13 | <0.001 |

Table 2. Summary of resident perception of the MSKUS training program ($n = 12$)

| Question | Great | Good | Fair/marginal |
|--|----------|--------|---------------|
| 1. Was reading material valuable in my mastery of core learning content? | 4 | 8 | 0 |
| 2. Was initial orientation to ultrasound and practice with peers valuable in gaining technical competence? | 10 | 2 | 0 |
| 3. Was performing ultrasound under supervision of a rheumatologist helpful in developing cognitive and technical competence? | 7 | 5 | 0 |
| 4. Was the time commitment for ultrasound training program worthwhile with regard to the knowledge and skills gained? | 5 | 7 | 0 |
| Question | Too much | Enough | Not enough |
| 5. Were the number of training procedures performed adequate? | 0 | 8 | 4 |

musculoskeletal diseases for the internist, our study is an attempt to fill the void in this training process. Since the study involved a preliminary approach to ultrasound in general with a selected focus area for evaluation, it sets the stage for further development of ultrasound curricula in musculoskeletal and other organ systems to improve patient care.

There are a few noteworthy limitations in this study. Since this was a preliminary feasibility study, the number of participants and area of focus for the study was limited. Nevertheless, the strong positive response and feedback highlights the need for further studies recruiting more residents, possibly expanding to other training programs and carried over longer periods of time. There is some variability expected due to the learning curve of each resident and year of training, and also individual interest in learning the course. Future studies should advisably consider both level of training and interest in the program.

In addition, our study is a preliminary study looking at the feasibility of incorporating MSKUS in the general IM educational framework. Therefore, future studies should incorporate detailed analysis of joints commonly associated with pathology, such as the shoulder for rotator cuff disease, wrist for carpal tunnel disease, and digits for early erosive disease evaluation.

Another issue to consider is our Likert scale use. Although we followed the same scale and design throughout the surveys for uniformity, and it was pilot tested before use in the study, there is an element of inherent arbitrariness in the scale itself. Using a 4-point scale increases the likelihood of selection of a positive or negative response; however, its use in small sample studies carries the risk of over-estimating a response, usually skewed more positive than negative. This is reflected in our study not reporting sufficient negatives, limiting our capacity for statistical analysis on this subset of data. It would have perhaps been better to use a 5-point or even a 10-point Likert scale for the study and this factor remains one of the drawbacks of our study. Nevertheless, our strong

positive responses and feedback prompts need for larger studies to study specific effects in feedback in greater detail, and perhaps using a broader Likert scale including a neutral response.

Conclusions

Despite a few limitations, our study highlights the importance of focused training methods for MSKUS to be incorporated into the IMRTP. The next conceivable step would be to expand on this feasibility study to a broader base, studying multiple areas of musculoskeletal interest. Furthermore, there is an increasing need for studies looking at inter-rater reliability and reproducibility of the ultrasound findings to address the limitations of this method. Ultrasound training is developing into a necessary skill set for the internist, and this study may provide a guide or structural framework for further assessment and interpretation of the incorporation of ultrasound in IMRTPs.

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Conflict of interest and funding

The authors have not received any funding or benefits from industry to conduct this study.

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