Teaching Bedside Sonography Using Peer Mentoring
A Prospective Randomized Trial

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Objectives—Bedside sonography is a growing field of medicine, but there is little evidence about how to teach it to medical students. A peer-mentoring system may help preclinical medical students learn bedside sonography.

Methods—In 2008 and 2009, participating first-year medical students completed an image recognition test at 0, 2, and 4 months and were randomized to an early or a late intervention group. In hands-on sessions, senior medical students taught the early intervention group how to perform a Trinity hypotensive ultrasound protocol between months 0 and 2 and then taught the late intervention group the Trinity protocol between months 2 and 4. Participants completed a practical examination at month 4. We measured the improvement in knowledge after the intervention and retention of knowledge and skills in the early intervention group at month 4. First-year medical students completed precourse and postcourse surveys about comfort and skills with sonography.

Results—Eighty-six first-year medical students enrolled; 79 completed the precourse survey; 54 completed all knowledge tests; 52 completed the practical examination; and 49 completed the postcourse survey. Of the 125 nonparticipants, 109 completed the precourse survey, and 25 completed the postcourse survey. Participants’ knowledge scores increased by 30% after the intervention. The early intervention group retained 92% of the knowledge gained. Thirty-six percent of participants were able to complete the Trinity protocol in 15 minutes during the practical examination, with no significant difference between the early and late intervention groups. Participants responded positively about the experience and indicated that hands-on sessions were helpful.

Conclusions—Peer mentoring is a useful method for teaching sonography to preclinical medical students.

Key Words—bedside sonography; educational methods; peer mentoring; randomized trials

Bedside sonography is increasing in importance as a diagnostic and therapy-assisting modality in many fields of medicine, particularly critical care.1–6 However, advances in sonography are beginning to outpace practicing physicians’ ability to learn necessary skills after residency. Therefore, the bulk of bedside sonography training is being moved earlier and earlier in medical curricula, sometimes beginning in the first year of medicine with anatomy.5,7,8 Research seems to indicate that medical students welcome this change, but then the issue becomes how to best teach sonography to medical students and residents, particularly with limited faculty available to teach this relatively new clinical skill.9,10
Researchers have recently begun looking into methods for teaching sonography to students and residents. There are several available models for teaching sonography, including human models, nonhuman models for procedures, phantoms, and multimedia simulators. Teaching methods have traditionally included didactics and clinical practice. Newer research indicates a potential role for peer mentors, although this method is new enough that it is still met with some prejudice by learners.

The purpose of this study was to further evaluate the role of peer mentoring in teaching bedside sonography to medical students. We wished to evaluate the effects of peer mentoring on image acquisition, interpretation, and retention of knowledge obtained. For this study, we selected the Trinity hypotensive ultrasound protocol as the bedside sonographic examination to be taught.

The Trinity Hypotensive Protocol was developed by one of the authors (D.P.B.) for use in evaluating patients with hypotension of unknown etiology. As a critical care diagnostic tool, it has wide application and is thus ideally suited as a learning goal for groups of students going into various specialties. It includes 8 views: cardiac parasternal long and short axes, subxiphoid/suprarenal aorta, superior mesenteric artery, aortic bifurcation, pouch of Douglas, right upper quadrant, and left upper quadrant.

Materials and Methods

Our research protocol was determined to be Institutional Review Board exempt by The Ohio State University Office of Responsible Research Practices.

Data Collection

In 2008, first-year medical students at The Ohio State University were administered a survey about their previous knowledge and experience in sonography. They then received basic training in sonography as part of their anatomy course, which was completed in early October 2008. We invited students to enroll in this study if they were interested in learning more about sonography. Students enrolled by completing an online recognition quiz of images obtained during a normal Trinity protocol and documenting their consent to participate (time point 1). The recognition quiz was developed at the school of medicine and contains 80 images and 40 extended multiple-choice questions asking participants to identify anatomic structures, such as would be identified during their didactic sessions (see online supplement Trinity Recognition Exam). Participants then attended a 1.5-hour didactic session about sonography and the Trinity protocol taught by a faculty member then were randomized to either an early or a late intervention group. The purpose of this temporal randomization was to allow for evaluation of knowledge retention.

The late intervention group continued their usual first-year medical student activities until a 2-month follow-up in early December. Meanwhile, the early intervention group was asked to attend 4 hands-on sonography sessions mentored by fourth-year medical students enrolled in The Ohio State University’s honors ultrasound elective. Participants were asked to learn one of the following at each session: (1) focused assessment with sonography for trauma scan views (Trinity protocol views 6–8 plus the subxiphoid view of the heart); (2) aortic views (Trinity protocol views 3–5), (3) cardiac views (Trinity protocol views 1 and 2); and (4) a review of all Trinity protocol views as well as individual practice time. The first-year medical student to mentor ratio was not to exceed 5:1 for these sessions. Attendance at the sessions was monitored although not accounted for in the analysis.

From late December to early January, participants once again took the online recognition quiz (time point 2). During February and March, the late intervention group underwent an educational intervention similar to what the early intervention group had received, while the early intervention group continued their usual first-year medical student activities. In late March, the online quiz was administered a third time (time point 3). This staggered intervention allowed for direct comparison of groups, education of all interested participants, and evaluation of retention in the early intervention group.

After time point 3, all participants were invited to attend a final 1.5-hour didactic session and to participate in a practical examination. During the practical examination, participants were asked to obtain, label, and save images from as many of the Trinity protocol views as they could in 15 minutes or less. An attending physician with extensive sonography experience and credentials as a registered diagnostic medical sonographer graded these images using the Brightness Mode Quality Ultrasound Imaging Examination Technique (B-QUIET) scoring system (see below for details). In May 2009, a follow-up survey was administered to all first-year medical students about their sonography knowledge and experience thus far.

Crossover from one group to another was allowed in a few circumstances, and participants were allowed to take part in various parts of the study regardless of whether they had completed all prior activities (ie, one could feasibly take the follow-up survey or practical examination without finishing the quizzes).
The B-QUIET Scoring System
The B-QUIET system is a 10-item scoring tool for ultrasound image quality. Ten aspects of an image are graded 1 to 4. Aspects include patient labeling, body markers, comments, application/focal zone, depth, gain, and quality of the image in each of 4 quadrants: near field, far field, leading edge, and receding edge. The total B-QUIET scores therefore range from 10 to 40, and experienced sonographers obtain B-QUIET scores of about 35 to 38.

Data Analysis
All statistical analyses were done using Stata SE version 9.2 software (StataCorp, College Station, TX). We considered statistical tests significant at \( \alpha = .05 \) unless otherwise specified. Given the distribution of the data, medians and their confidence intervals (CIs) are reported instead of means unless otherwise noted. Likewise, we used nonparametric statistical tests preferentially.

Data obtained from the baseline survey were used to detect whether participants were dissimilar from nonparticipants with respect to sex, age, projected career pathway, and prior sonography experience. The same tests were run with the study population to detect significant differences in group assignment after randomization. We used a binomial test for age and exact tests for other variables.

Two primary hypotheses were tested: (1) early intervention group quiz scores would improve more than late intervention group scores at time point 2, and (2) all participants would have a significant improvement in quiz scores after intervention. We tested the first hypothesis by building a CI for the difference in median improvement (time point 2 score – time point 1 score), comparing the late intervention group to the early intervention group. We tested the second hypothesis using a similar test for paired data, comparing scores immediately before a participant’s intervention and immediately after the intervention. Because there were two primary outcomes, \( \alpha = .025 \) was used instead of .05.

A secondary hypothesis was that the early intervention group would retain at least 80% of the points they had gained between time points 1 and 2 at the time point 3 follow-up. Therefore, retention would be adequate if its entire CI was greater than 80%. Using preliminary data and the number of participants enrolled, we estimated a statistical power of 0.9 at this 80% cutoff.

Other secondary outcomes were practical examination performance and survey results. We expected that practical examination performance would demonstrate adequate learning of sonographic skills necessary to perform a Trinity protocol, and the surveys would reveal a generally positive attitude about the teaching received and the role of sonography in medical education. There were no formal hypotheses or criteria for these outcomes, but summaries are reported. We ran all analyses on an intention-to-treat basis, ie, we did not account for attendance at hands-on sessions.

Results
A flow diagram of study participation is found in Figure 1. Eighty-six first-year medical students enrolled, and the study finished with 43 students in each randomization group.

One-hundred eighty-nine first-year medical students responded for the initial survey, including 79 who participated in the study. Data from this survey are summarized in Table 1. We found no significant differences between participants and nonparticipants or between the early and late intervention groups with respect to sex, age, projected career, or prior sonography experience.

Figure 2 summarizes the results of quiz scores for the 54 participants who took all 3 quizzes. Scores for the early intervention group improved from a median of 33% correct at baseline to 73% after intervention, whereas the late intervention group modestly improved from 25% to 45% during that time. From time point 1 to 2, larger increases in scores were observed in the early intervention group. The difference (between groups) in median score improvement was 25% (95% CI, 18%–33%; \( P < .001 \)). At time point 3, both groups scored a median of 70%. Averaging between both groups, participants achieved an absolute increase of 30% on quiz scores from preintervention to postintervention time points (95% CI, 24%–35%; \( P < .001 \)). At the time point 3 follow-up, the early intervention group retained a median 92% of knowledge gained during the intervention (95% CI, 84%–100%). Thus, both primary as well as the secondary end points proved significant.
Fifty-two participants took part in the practical examination. Two participants’ data were lost, presumably because they were saved onto a wrong disk. Of the 50 remaining participants, 18 (36%) were able to complete the Trinity protocol in 15 minutes. Those who did not finish were able to obtain a median of 6 images (interquartile range, 4–7). From the images that were obtained, participants achieved a mean score of 3.3 (of 4) on labeling, 3.2 on focus, depth, and gain, and 3.0 on visualization of pertinent anatomy. Individuals’ average total B-QUIET scores ranged from 15 to 38 (of 40), with a mean of 31.5 (95% CI, 30.1–32.9). By intervention group, the medians (and interquartile ranges) of B-QUIET scores were 31 (26–35.8) for the early intervention group and 33.4 (31–35.3) for the late intervention group. There seemed to be a trend toward better performance by the late intervention group than the early intervention group on all practical examination measures, but none was statistically significant ($P > .05$ for all comparisons).

Seventy-four students completed the final survey, 49 of whom had participated in the study. Survey details are available in online supplemental Tables 2 and 3. Participants were significantly more comfortable than nonparticipants with basic sonographic techniques, theory, and obtaining Trinity protocol views. This difference was most pronounced in knobology and obtaining Trinity protocol views: areas emphasized during small-group sessions. Feedback from participants regarding the teaching methods was generally quite positive, with the possible exception that the amount learned from the mentors seemed to vary by who was mentoring a session. Also, first-year medical students were still hesitant to perform a Trinity protocol in the hospital setting even after the intervention. Finally, it is noteworthy that a paired signed rank test revealed that first-year medical students found hands-on sessions more useful than faculty lectures ($P = .0002$).

### Table 1. Baseline Characteristics of Participating and Nonparticipating First-Year Medical Students Matriculating in Fall 2008

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Early Intervention Group (N = 36), n (%)</th>
<th>Late Intervention Group (N = 43), n (%)</th>
<th>P</th>
<th>Nonparticipants (N = 109), n (%)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>25 (69)</td>
<td>25 (58)</td>
<td>.35</td>
<td>55 (50)</td>
<td>.10</td>
</tr>
<tr>
<td>Age, y</td>
<td>Median, 23</td>
<td>Median, 22</td>
<td>.07</td>
<td>Median, 22</td>
<td>.61</td>
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<tr>
<td>Projected career path</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Radiology</td>
<td>3 (8)</td>
<td>6 (14)</td>
<td>.21</td>
<td>7 (6)</td>
<td>.45</td>
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<tr>
<td>Emergency or critical care</td>
<td>8 (22)</td>
<td>2 (5)</td>
<td>10 (9)</td>
<td></td>
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<tr>
<td>Surgical</td>
<td>13 (36)</td>
<td>17 (40)</td>
<td>39 (36)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medical</td>
<td>11 (30)</td>
<td>16 (38)</td>
<td>44 (40)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other/Unknown</td>
<td>1 (3)</td>
<td>2 (5)</td>
<td>9 (8)</td>
<td>&gt;.99</td>
<td></td>
</tr>
<tr>
<td>Prior sonography experience &gt;2 h</td>
<td>0 (0)</td>
<td>2 (5)</td>
<td>3 (3)</td>
<td>&gt;.99</td>
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<tr>
<td>Baseline quiz score (% answers correct)</td>
<td>Median, 28</td>
<td>Median, 25</td>
<td>.34</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>IQR, 8–43</td>
<td>IQR, 11–51</td>
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<td></td>
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</tr>
</tbody>
</table>

IQR indicates interquartile range.

*These data were only available for 79 of the 86 participants.

Comparison of intervention groups to one another.

Participants versus nonparticipants.

*These scores include participants who were eventually lost to follow-up, so they differ from those reported in “Results” and Figure 2.

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Figure 2. Quiz scores at baseline, after early intervention group (A) intervention, and after late intervention group (B) intervention. Early intervention group mentoring took place between baseline and 2 months. Late intervention group mentoring took place between 2 and 4 months.
Discussion

Our study shows that peer mentoring results in increased knowledge of sonography relative to didactics alone. It also results in reasonable practical skill among learners and provides a good retention rate of knowledge gained. Similar survey findings between participants and nonparticipating first-year medical students indicate that these data can be extrapolated to other medical students.

Although our study did not directly compare peer mentoring to faculty instruction, it adds to a growing body of evidence that medical students can learn bedside sonography and that peer mentoring is a valid, practical method for teaching bedside sonographic techniques to medical students. Knobe et al found that the mentors’ knowledge also improved with this teaching style, an effect that we observed anecdotally but did not measure in our study. Peer mentoring seems to benefit all parties involved. Finally, B-QUIET scores in this study reveal that our first-year medical student population did not attain the same degree of proficiency as experienced sonographers, but we do think that their scores reflect an excellent start in learning bedside sonography.

We did not account for attendance at hands-on sessions, so the full effects of teaching are not quantifiable. However, this decision was necessary for an intent-to-treat study, and results will therefore be more applicable to medical schools without required attendance. Loss to follow-up was also an issue, which we accounted for in part by only using data from participants who had finished all quizzes, but there may be yet nonmeasurable differences between those who completed follow-up and those who did not.

In conclusion, we think that bedside sonography is an important burgeoning field of clinical medicine that should and can be taught even during preclinical years of medical school, and it can be done well via peer mentoring. Early exposure of tomorrow’s physicians to bedside sonography will help them bring sonography to its best, most wide-spread clinical potential.

References

12. Dames, J, Jeanmonod D, Cadigan B. Comparison of a multimedia simulator to a human model for teaching FAST exam image interpretation and image acquisition. Acad Emerg Med 2011; 18:413–419.