

Impact of a Hands-on Pre-Clinical Neurosurgery Elective Course on Second-Year Medical Student Interest and Attitudes

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Alexandra A Sansosti^{1*}, Rachel C Jacobs^{1*}, Aleksandra Safonova¹, Ronak H Jani¹, Jack Schumann¹, Robert M Friedlander^{1,2}, L Dade Lunsford^{1,2}, Michael M McDowell² and Raymond F Sekula^{1,2}

¹University of Pittsburgh, Pittsburgh, PA, USA. ²Department of Neurological Surgery, University of Pittsburgh Medical Center, Pittsburgh, PA, USA.

ABSTRACT

INTRODUCTION: Medical student involvement opportunities and educational experiences with surgical residents during medical school have been shown to increase the chance of students deciding to specialize in surgical specialties. This study aims to determine the effect of a neurosurgery elective during the second preclinical year on student interest and opinion of neurosurgery.

METHODS: Thirty-nine students completed opinion-based surveys and factual knowledge quizzes during a neurosurgical elective course over 3 iterations, which included lecture and skills lab instruction. Pre- and post-course surveys used the Likert scale, with a score of 1 corresponding to the most negative opinion and a score of 10 corresponding to the most positive opinion, in order to measure various aspects including interest in neurological surgery, understanding of the field, and perception of female inclusion in the field. Weekly pre- and post-lecture quizzes assessed practical knowledge of neurosurgical topics.

RESULTS: A higher percentage of students rated neurosurgery highly as a career possibility ($\geq 8/10$ interest level) post-course (58.6%) compared to pre-course (45.7%). Post-course, students reported a significantly increased mean understanding of neurosurgery on the Likert scale compared to pre-course (6.1 ± 1.7 vs 4.4 ± 2.0 ; $P = .001$). Knowledge based-content assessment revealed a significant increase in overall correct answers after lectures ($\text{mean}_{\text{pre}} = 3.85$, $\text{mean}_{\text{post}} = 5.05$, $P = .001$). Inclusion of female instructors in the second and third iteration of the course resulted in a significant increase in students' perception of female inclusion in the field of neurosurgery (7.6 compared to 5.6, $P = .01$).

CONCLUSIONS: Early exposure to subspecialties may assist in making important career decisions. The implementation of this neurosurgical elective improved medical students' perception of the field and enhanced knowledge of the lectures and procedures. This study can be used as a framework for implementation of this curriculum at other institutions.

KEYWORDS: Neurosurgery, medical, student, education, course

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CORRESPONDING AUTHOR: Michael M McDowell, Department of Neurological Surgery, University of Pittsburgh Medical Center, 200 Lothrop Street B400, Pittsburgh, PA 15213-2582, USA. Email: mcdowellmm2@upmc.edu

Introduction

Of matriculating medical students who reported a primary interest in neurosurgery, a third (29.5%) began residency training in the field of neurological surgery following graduation from medical school. This translates to approximately 70% of medical students who ultimately applied into a field other than neurosurgery despite their primary interest. In comparison, other fields report follow-through rates approaching 50%, which demonstrates potential for improvement.^{1,2} In addition, 13% and 24% of male and female residents, respectively, who begin residency training in neurosurgery, will not graduate.³ Although the etiology is most likely a multi-factorial phenomenon, limited pre-clinical exposure to neurosurgery could be contributing to an unsatisfactory experience during residency.

*These two authors contributed equally to this manuscript.

Currently, exposure to neurosurgery is limited to the clinical years, which includes the third and fourth years of medical school. Limited opportunity exists during the pre-clinical years, and due to time constraints and patient safety concerns, teaching in the operating room during the third and fourth years may also be under-prioritized.⁴ Considering that the deadline for residency applications is early in the fourth year, this time frame allots medical students close to 1 year to become integrated into the field and eventually decide to apply. Therefore, opportunities to introduce students to the neurosurgical department, gain knowledge about what the field entails, and increase familiarity and proficiency with basic procedures may help guide students and should be offered during the pre-clinical years.⁵⁻¹¹

It has been shown that positive experiences with surgical residents increase chances of students deciding to specialize in



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surgical specialties.¹²⁻¹⁴ Additionally, exposure to neurosurgery-specific educational activities and formalized curricula fosters involvement, knowledge and interest among medical students.¹⁵⁻¹⁷ Moreover, preclinical surgical electives with hands-on procedural components can leave powerful, long-lasting positive impressions on students and their career choices, which extends beyond the scope of shadowing experiences.¹⁸ Overall, literature suggests that preclinical electives have a favorable effect on student interest, yet these electives remain under-utilized and understudied. We therefore developed a pre-clinical elective course with practical procedural components for medical students at our institution interested in neurological surgery.

Methods

During the spring term of 2017, the authors offered a five-week preclinical elective course for second-year medical students interested in learning more about neurosurgery at a tertiary care institution with a large neurosurgical department. The course was again offered in fall term of 2018 and 2019 and expanded to an 8-week course. The curriculum was developed by a neurosurgery resident, with overall supervision by a faculty neurosurgeon and professor of anatomy. Third-year medical students assisted with the organization of the course. Additional collaborators included faculty members and several residents. The decision to limit enrollment to second-year students was made to ensure adequate anatomy, neurology, and neuroscience background. The course was divided into two-hour weekly sessions held on Monday evenings to avoid conflict with required coursework. Data was collected during each course iteration. This study was reviewed and exempted under UPMC IRB Protocol PRO17110576.

Course objectives and completion requirements

The elective course sought to give enrolled students a broad introduction to the field of neurological surgery. Sessions were focused on selected neurosurgical subspecialty topics in both didactic and practical settings. Didactic sessions taught students about central disciplines of neurosurgery and illustrated multiple career pathways available within neurosurgery such as primarily clinical practices as well as basic science research heavy practices. Practical sessions gave students exposure to performing several practical procedures commonly used in neurosurgery. Additionally, students gained familiarity with the Department of Neurosurgery, and vice versa, as at least one faculty and multiple residents attended each session. In this way, students were able to explore what life is like as a resident or practicing neurosurgeon, learn about different styles of practice and areas of specialization, and have a recognizable contact within the department. Finally, students were encouraged to develop potential research ideas and pursue neurosurgery research, fostering interest in research and potentially increasing department productivity. Course completion requirements included attendance participation of 4 of 5 course sessions in

the first iteration and 7 of 8 course sessions during the second and third iterations. Students were evaluated on a pass/fail basis and granted a certificate of completion for a passing grade.

Course didactic content

Each class covered a different topic in neurosurgery. Lectures were given on diagnosis of and surgical approach to various common neurosurgical diagnoses and specialized discussion of cerebrovascular disease, central nervous system tumor pathologies, pediatric-specific diseases, neurotrauma, peripheral nerve disorders, gamma knife radiosurgery (GKRS), endoscopic endonasal skull base, epilepsy, and spinal pathologies. Additionally, prior to each practical session, a short lecture was given on the content of the procedure, surface anatomy, and indications to perform the given intervention. Longitudinal content throughout the course focused on developing student skills in diagnosis, oral presentations of imaging or cases, and disease management and treatment.

Course practical content

Practical sessions aimed to provide hands-on experience conducting procedures. These classes intended not to evaluate student mastery of techniques, but to introduce students to performing common procedures done by residents and practicing neurosurgeons in a low-risk environment as a learning-reinforcement tool and as a demonstration of the breadth of neurosurgical practice. One session involved a virtual procedure utilizing the GKRS planning simulation (Elekta AB, Stockholm, Sweden). All other practical sessions utilized procedure kits obtained from the Department of Neurosurgery. Sessions included lumbar punctures, endoport and endonasal procedure skills, external ventricular drain (EVD) placement, carotid exposures and endarterectomies, pedicle screw fixation, temporal lobectomies, practice performing Chiari decompressions with duraplasty, and peripheral nerve decompressions. All procedures were performed using cadavers dedicated for medical education. Permission for cadaver use was obtained via the School of Medicine Office for Oversight of Anatomic Specimens.

All sessions were divided evenly into two 1-hour segments: 1 hour for didactic lecture, and 1 hour for hands-on practice. The exception to this format was a 2-hour-long standalone class on EVDs. An optional presentation on balancing research with a clinical career, given by a faculty academic neurosurgeon, was offered the week after the course ended. The syllabus for this course including the course objectives for each session is provided in the Supplement (S1).

Surveys

Surveys were provided to students at the beginning and conclusion of the elective course for qualitative measurements of student perceptions of neurosurgery and personal abilities,

which was IRB exempt under quality improvement. All questions were opinion-based and answered using a Likert scale of 1-10, with a low score representing a low or negative opinion of the question and a high score representing a high or positive opinion of the question. Average change in Likert score pre- and post-course was calculated for each question. Students were also solicited for thoughts and opinions on the course via an open-response question at the end of the post-course survey. All surveys were filled out anonymously. The survey is provided in the Supplement (S2).

Content quizzes

Content quizzes aimed to quantify factual neurosurgical knowledge that the students possessed prior to the course compared to knowledge gained throughout the course. Two quizzes (version A and version B), composed of 10 questions each, were written for each session. Five of these questions were based on the material presented during the particular session (*relevant*), and the other 5 tested general neurosurgical knowledge of comparable level in topics not covered in any session (*irrelevant*). Prior to each class, half of the students (group A) were given quiz version A to complete, and the other half (group B) completed quiz B. At the end of the session, group A completed quiz B, and group B completed quiz A. All quizzes were filled out anonymously. This process was repeated for each of the 5 sessions with a total of 20 distinct multiple-choice questions for each session: 10 relevant to the session topic, and 10 pertaining to other disciplines of neurosurgery not discussed during the course as a whole. We calculated the student pretest and posttest score differences for the *relevant* and *irrelevant* material separately to assess the overall change in factual knowledge on the topic of focus for each session.

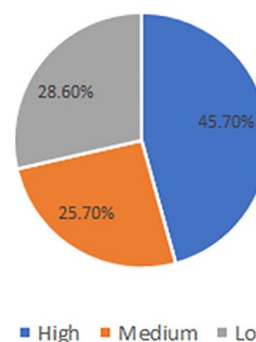
Results

During the first iteration, 14 students were enrolled in the elective course, of which 4 (29%) were female and 10 (71%) were male. During the second iteration, 9 students were enrolled, of which 5 (56%) were female and 4 (44%) were male. During the third iteration, 16 students were enrolled in the elective course, of which 9 (56%) were female and 7 (44%) were male. In total over the course of 3 years, 39 students were enrolled, 19 (48%) of which were female. Of note, the 4 students involved in organizing the course over the 3 iterations were not included in the enrollment count and included 3 females and 1 male. In addition, 2 of the 4 student course assistants are currently neurosurgery residents and 1 student is a general surgery resident.

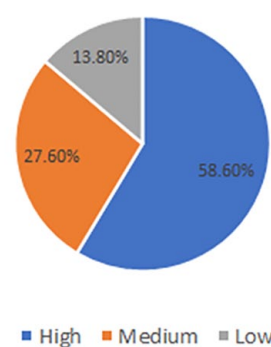
Likert survey

Overall there were 39 students (100%) that completed the pre-course survey and 29 students (74%) that completed the post-course survey for the combined cohorts, with 10 students lost to follow-up. When questioned about their opinion of the field

Pre-course Interest in Neurosurgery



Post-course Interest in Neurosurgery



p = 0.07

Figure 1. Pie chart showing the results of the pre- and post-course survey question asking students about their interest in pursuing neurological surgery as a career.

of neurosurgery, students interviewed maintained a mean high opinion of the field both before and after the course (7.6 ± 1.7 vs 7.3 ± 1.8 ; $P = .47$). When questioned about their level of knowledge about the field of neurosurgery, students initially reported a mean moderate level of understanding (4.4 ± 2.0). After the course students reported a mean level of understanding that was significantly higher and more uniform (6.1 ± 1.7 ; $P < .001$). Regarding the level of understanding of the details involved in working as a neurosurgical resident, students reported a moderate level of understanding before and after the course (5.2 ± 1.9 vs 7.4 ± 1.8 ; $P < .001$). Regarding the potential for applying for a neurosurgical residency position, students rated their likelihood of applying similarly pre and post-course (6.4 ± 2.7 vs 7.6 ± 2.2 ; $P = .07$). When examining the distribution of scores related to applying for a neurosurgical residency position, 45.7% of students submitted a score of 8-10, 25.7% submitted a score of 5-7, and 28.6% of students reported a score of 0-4 prior to the course. After the course, 58.6% of students reported a score of 8-10, 27.6% of students reported a score of 5-7, and 13.8% of students reported a score of 0-4 (Figure 1). Of students rating neurosurgery 8-10, the mean was 8.9 prior to the course and 9.1 after the course.

Students reported a higher confidence level in learning procedures before and after this course (6.4 ± 1.6 vs 7.5 ± 1.5 ;

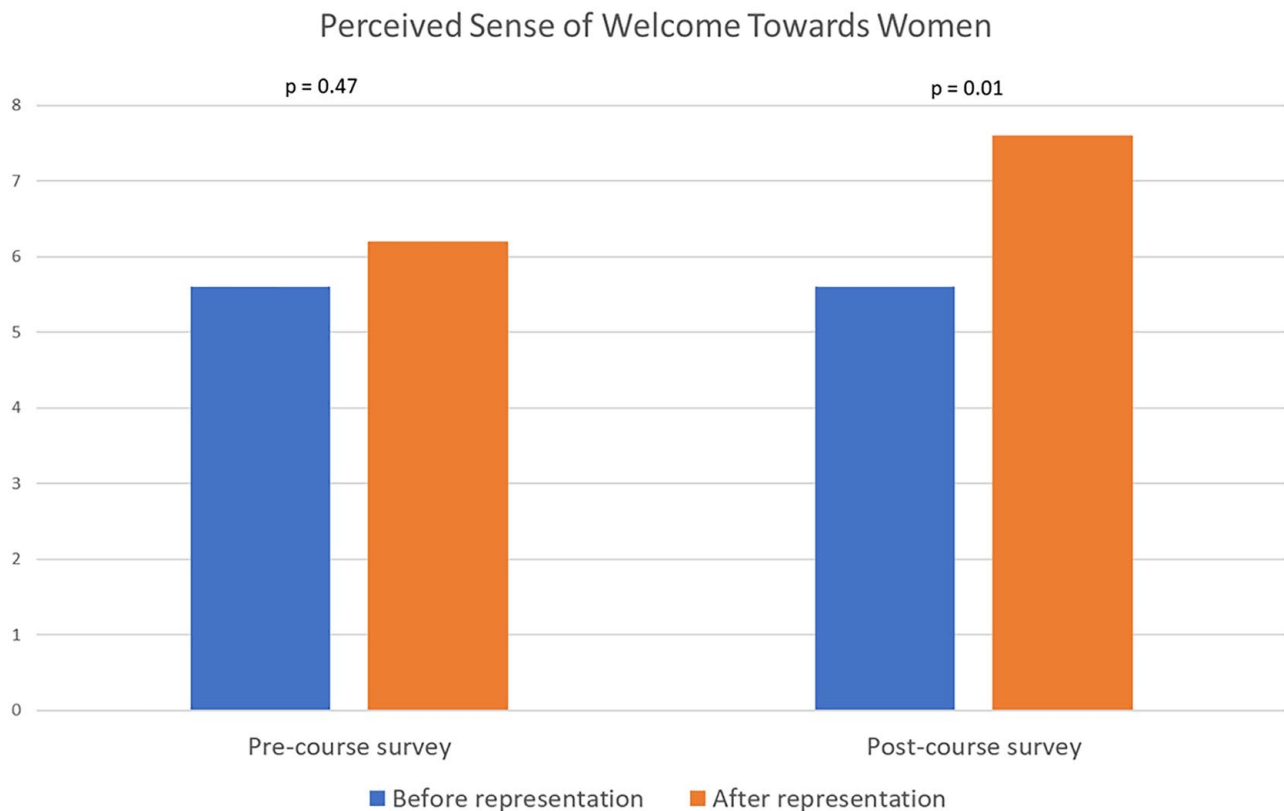


Figure 2. Results of the survey response for the perceived welcome of women in the field of neurological surgery. There was an increase in the level of perceived acceptance of women in the field from the first to the third year of the course which coincided with the involvement of more women in teaching the course sessions.

$P = .01$). Students reported an increased quality of exposure to neurosurgery compared to other schools before and after the course (5.8 ± 2.5 vs 8.8 ± 1.3 ; $P < .001$). Students reported a similar level of confidence with engaging with neurosurgical faculty and residents after the course (7.0 ± 1.8 vs 7.6 ± 2.2 ; $P = .22$). When questioned about diversity in neurosurgery, students maintained moderately high agreement that neurosurgery was open to diverse groups (7.3 ± 2.0 vs 7.3 ± 1.9 ; $P = .99$).

Prior to adding female faculty as instructors for the course, there was no significant difference between the pre- and post-course perception of female acceptance in neurological surgery ($\text{mean}_{\text{pre}} = 5.6 \pm 1.4$ vs $\text{mean}_{\text{post}} = 5.6 \pm 1.7$; $P = .84$). However, in the second and third years in which female instructors were represented in the course (1 attending, 2 residents), there was a significant increase in the perception of acceptance of female physicians in the field ($\text{mean}_{\text{pre}} = 6.2 \pm 2.4$, $\text{mean}_{\text{post}} = 7.6 \pm 1.7$; $P = .03$) (Figure 2).

Open-response survey

Nine students (50%) responded to the open-response question on the post-course survey. Six responses expressed enthusiasm for the practical sessions of the course. Four responses provided constructive criticism of course logistics and execution. Three responses suggested other desirable topics to cover in future iterations of the course: functional neurosurgery, increased

emphasis and practice interpreting imaging, and an overview of neurosurgery fellowships/sub-specialties. One response stated that all interactions with course faculty and residents were positive, but the respondent from the first year of the course remained unconvinced the neurosurgery program is welcoming or supportive of women.

Knowledge-based content quizzes

Prior to instruction, the mean correct number of answers was 3.9, compared to a mean of 5.1 post-instruction ($P < .001$). The mean number of relevant questions correct prior to testing was 2.0 versus 1.8 for irrelevant questions. The mean number of relevant questions correct after testing was 3.0 (48% relative improvement; $P < .001$) versus 2.07 (13% relative improvement) for irrelevant questions ($P = .07$).

Discussion

In this study, a mixed didactic and practical neurosurgery elective was designed and offered for second-year U.S. medical students. A similar course offered to preclinical students at Vanderbilt University School of Medicine focused on didactic lectures and discussions on neurosurgical topics. The course demonstrated that structured interaction with attending neurosurgeons as part of a pre-clinical elective course improves medical student perceptions of the field of neurosurgery.¹⁹

Additional pre-clinical, surgical courses have been studied at Cornell University and Columbia University College of Physicians & Surgeons.^{20,21}

In our course, students demonstrated overall improvement in knowledge-based quiz scores, reflecting that the sessions were informative and supplementary to the traditional medical school education. Further, our results indicate that our combined method of teaching was effective, perhaps providing a compounded effect of both lecture-based passive learning and active learning through hands-on activities. The results of our qualitative surveys indicate that students hold positive opinions about neurosurgery. Regarding acceptance toward traditionally under-represented groups in neurosurgery, students reported general agreement that diverse groups of people are welcome in the field. While medical student exposure to neurosurgery in the preclinical years is limited, the exposure of medical students to female neurosurgeons is even less frequent.²² Interestingly, there was a significant increase in the post-course perception of accepting women in neurosurgery after incorporating female instructors in years 2 and 3 as compared to the first year. Prior to female resident and faculty involvement, students reported ambivalence about women being accepted members of the neurosurgical community, and there was no change from pre-course to post-course perception. This change in perception by students of welcoming of women in neurosurgery with the inclusion of a female course instructor substantiates the ample evidence that female mentors and role models play a critical role in the training and recruitment of women in neurosurgery. In fact, studies demonstrate that the presence of role models and mentoring are the most influential factors, rather than the often assumed “lifestyle” issues, as the driving forces behind career selection.²²⁻²⁵ Our findings demonstrate that exposure of medical students in preclinical years to female neurosurgeons may increase outreach and influence career selection decisions made by women.

Overall, this study indicates that increased exposure to neurosurgical faculty, residents, lectures, and procedures increased interest in pursuing neurological surgery as a field. This is consistent with existing literature on the effect of preclinical experiences on interest in a surgical field. For example, at Columbia University College of Physicians & Surgeons, the addition of a general surgery interest group focused on engagement of pre-clinical students coincided with tripling applications into general surgery, with nearly 12% of the class applying into the specialty.²¹ Although it was stated earlier that 2 students who took part in this course are currently neurosurgical residents, the full effect of this course remains to be seen. Follow-up surveys of all prior attendees in addition to implementation of future iterations of this course will need to be performed to determine the rate of application to and successful entry into neurosurgical residencies. One limitation to this study is the absence of a control group, which in this case would be defined as students who did not participate in this course. It is vital to

analyze both the rate of application among students who took this elective and compare this to students who did not take this elective to understand the effect.

Other limitations to this study include the need for a more in-depth analysis of attending/resident teaching and subsequent impact in order to create a standardized curriculum that is able to be implemented among other institutions. In addition, further exploration into student motives for choosing careers in neurological surgery may help medical schools to better cater to student interests and provide opportunities to explore less visible specialties. While one of the ultimate goals of this course was to introduce students to faculty in order to become involved in research projects, this was not formally analyzed. It would be interesting to investigate the effect of the course on involvement in research leading to subsequent presentations and publications. Lastly, while this study showed that the inclusion of females had a positive effect on students' perception of female inclusion in the field, this was not specifically analyzed for other under-represented groups. The analysis into the ratio of male to female medical students with each iteration could be extended to analyze the distribution of additional minority groups. However, all 3 iterations of the course had consistent under-represented minority representation for the faculty. As a result, no change in perception of minority inclusion was noted.

Conclusion

With the current medical student curriculum, clinical exposure to neurosurgery may not occur until the third or fourth year of medical school. This requires students to independently seek out exposure. However, early preclinical exposure to the neurosurgical field is vital for medical students to gain a more comprehensive understanding of the field including clinical knowledge and procedures as well as interact with the neurosurgical faculty in order to appropriately determine their interest and prepare for applying to residency. The implementation of this eight-week pre-clinical neurosurgical elective improved medical student's perception of the field and enhanced knowledge of the lectures and procedures. Further studies are necessary to evaluate the rate of application and entry into neurosurgical fields as a result of this course and to develop a standardized, accessible curriculum for implementation at additional medical schools.

Supplemental material

Supplemental material for this article is available online.

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