Improving Neurosurgery Resident Microdissection Through Placental Simulation

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Prior work has shown that the human placenta is an available and realistic model for microdissection simulation. We sought to find a measurable improvement in the technical skills of neurosurgical residents with deliberate practice of microdissection tasks using a placental model. Postgraduate year (PGY) 1 to 3 neurosurgery residents were consented. A 1-min video of each participant’s baseline skills skeletonizing placental vessels was recorded. Participants underwent 10 practice sessions with intermittent informal feedback for 30-60 min over 18 mo. Another 1-min video was recorded following the 10th dissection. The videos were blinded and assessed by 3 board eligible or certified microsurgical neurosurgeons using a modified Objective Structured Assessment of Aneurysm Clipping Skills. Performance was compared via t-testing among four domains: instrument handling, time flow and forward planning, quality of dissection, and respect for tissue. Microdissection, instrument handling, and quality of dissection were significantly improved after deliberate practice with the placental simulator (P < .05). Improvement was seen in time flow and forward planning and respect for tissue; however, this failed to be significant. Subjectively, residents expressed enjoyment performing the exercise. They also expressed a desire for demonstrations or videos to watch before practice sessions. The placental simulation model provides microsurgical skill development with minimal deliberate practice sessions. Practice exercises are favorably regarded and interest in continuing them is strong by residents. Residents expressed a desire to make the dissection more deliberate with demonstration, breakdown of steps, and mimicry, which could improve the effectiveness and enjoyment of the skills session.

KEY WORDS: simulation task training, medical education, neurosurgery, placenta

A strong association has been found between positive patient outcomes after surgery and objective measurements of technical skill. This finding suggests that mastery of technical skills is of utmost importance in surgical education as it directly relates to better patient outcomes. Surgical simulation has been shown to directly improve technical skills in a hands-on, extra-operative environment. Additionally, with the creation of skill measurements like the Objective Structured Assessment of Technical Skills (OSATS), there are concrete methods to track skill improvement and by extension predict surgical readiness. These findings have driven multiple surgical specialties, specifically neurosurgery, to adopt simulation enhanced curriculums.

Various models of neurosurgical simulation have been explored, including the use of cadavers, synthetic models, and virtual reality. These models have shown benefits, such as shortening the learning curve of operating, and downsides, namely the inability to accurately simulate the complex anatomy of the central nervous system. To overcome these barriers, human placenta are beginning to be used to simulate brain vasculature. In 2014, Magaldi was the first to use this model in vascular neurosurgery training—specifically in the training of cerebral aneurysm clipping. He has described the method of preparation, types of exercises possible, the high face, construct, content, and predictive validity of placenta models. As viable placenta are available at every hospital, this model of neurosurgical simulation is highly appealing.

The placenta model was used in skills lab sessions for aneurysm clipping, and we hypothesized that the preparation of the vessels and dissection was an effective simulator for splitting the fissure
and microdissection. We sought to utilize the placental model to improve junior neurosurgery resident performance in microdissection through the implementation of 10-sessions of dedicated microsurgery practice.

METHODS

Institutional Review Board (IRB) approval was obtained and postgraduate year (PGY) 1 to 3 residents were given the opportunity to participate. This training level was selected as they were unlikely to have significant microscopic practice outside of the skills lab. Residents that chose to voluntarily participate were consented.

Placentas were collected from postpartum patients who had been screened for standard infectious diseases and would have been destined for biologic waste disposal. To shorten the time needed to prepare the placenta samples, a modified version of Magaldi's original protocol was utilized. Normal water was used to rinse clot and blood from the outside of each placenta with a 6F urinary catheter and the allantoic membrane was removed to better visualize the vessels. The umbilical cord was cut such that 10 cm was left attached to the placenta. The 6F catheter was inserted into each umbilical vessel one at a time, and water was pushed through the vasculature utilizing a 20 mL syringe. The vessels were massaged as the water was pushed to coax out the blood and any clot stuck within the vessels. Once the vessels were clear, the placentas were placed in refrigeration. Placentas were kept for repeated use for 1 to 4 wk and disposed of afterward.

Over 18 mo, each resident participated in 10 separate practice sessions following their baseline recording session. The residents worked with the placental models for 30 min to 1 h. During these sessions, residents skeletonized placental vessels with standard neuro microsurgical instruments and an operative microscope. Arteries with fewer branches were utilized as they were more suitable for dissection. Residents were encouraged to work with suction in their left hand to simulate the instruments most commonly used in fissure dissection. Informal feedback was given at each dissection session by an attending neurosurgeon and occasionally a chief resident during at least one point in each session.

Baseline video recordings were made of each resident at the start of the study. Recordings were collected through the built-in microscope camera, with care taken to exclude identifiable information (faces, voices, clothing, etc.) Following the completion of 10 practice sessions, the residents were recorded while skeletonizing a placental vessel.

Technical Rating of Surgical Skill and Analysis

Scoring of the videos by 3 board eligible or certified microsurgical neurosurgeons was performed in a completely random and blinded fashion. The pre- and postdissection were not presented in order. The scoring was calculated using a modified version of the Objective Structured Assessment of Aneurysm Clipping Skills (OSAACS) form (Figure 1). The OSAACS is an adaptation of the OSATS that is thought of as the gold standard of objective surgical technique scoring. The OSAACS score chart originally includes 9 dimensions that relate to specific aspects of surgical performance within microsurgery. Each dimension is scored on a scale of 1 to 5 (lowest to highest value), with a total possible score of 45 points. Our modified version only assessed instrument handling, time flow and forward planning, quality of dissection, and respect for tissue as these were thought to be the most important concerning microdissection.

The pre- and postpractice OSAACS scores were compared via t-testing. PGY level is not reported due to the small study sample allowing for the identification of participants.

RESULTS

Six junior neurosurgical residents volunteered to participate in the study. Four residents completed all 10 practice sessions and recorded their final dissection. Two residents were unable to complete their practice sessions due to the COVID-19 pandemic and skills lab closure. Photos and videos of placental dissection are included in Figure 2, Video 1, and Video 2. Video 1 is the prepractice control dissection for Participant A. Video 2 is the postpractice final dissection for Participant A.

The pre- and postpractice OSAACS scores of the participants are displayed in Table. A statistically significant improvement is seen in the domains of instrument handling ($P = .009$) and quality of dissection ($P = .039$). Time flow and forward planning ($P = .06$) and respect for tissue ($P = .084$) were not statistically significant. The greatest improvement was seen in instrument handling, with an increase in the OSAACS score of 1.50.

The participants reported subjective enjoyment of the exercise as well as a desire to continue working past the allotted time. Frequent requests for demonstration or videos prior to the dissection were made by the residents. While feedback and coaching were provided, demonstration or videos were not, as it was not included in the study design.

DISCUSSION

This study demonstrates that with 10 sessions of deliberate practice on a placental model, overall junior neurosurgery resident performance in microsurgical dissection is improved. Specifically, improvements are seen in instrument handling and quality of dissection. These findings suggest that supplementing traditional neurological training curricula with placental simulation may be beneficial to neurosurgery residents in their junior years (PGY 1-3) of training.

Currently, widespread adoption of simulation-based education in neurosurgery has been slow despite evidence showing a shortening the learning curve of technical skills and a reduction in morbidity from resident errors. Zevin et al8 offer several possible explanations as to why, including a lack of comprehensive simulation-enhanced curricula, a lack of manpower and staffing, and the prohibitive cost associated with surgical simulation. Several programs across the United States have published reports of their simulation-based curricula, offering insight into how they have managed to incorporate these sessions into their training education. These reports help address the first two barriers Zevin et al8 noted; however, cost continues to be a significant barrier as virtual reality systems start at $600 and cadaveric models continue to be expensive as well as in short supply. Luckily, the placental model has emerged as a valuable tool in neurosurgical education.
**FIGURE 1.** Modified OSAACS scoring rubric used to assess resident microdissection.

| Participant | Instrument handling | Time flow and forward planning | Quality of dissection | Respect for tissue |
|-------------|---------------------|--------------------------------|----------------------|-------------------|
|             | Pre     | Post | Pre     | Post | Pre | Post | Pre     | Post |
| 1           | 2.67    | 4    | 1.67    | 3.33 | 3   | 4    | 2       | 4    |
| 2           | 1.67    | 3.33 | 1.67    | 2.33 | 2.67| 3.67 | 2.33    | 2.33 |
| 3           | 3       | 4    | 1.33    | 1.67 | 2.33| 3    | 2       | 1.33 |
| 4           | 2       | 3.33 | 1.67    | 2.33 | 1.67| 3    | 2       | 1.33 |
| Total       | 9.34    | 14.66| 6.34    | 9.66 | 9.67| 13.67| 8.33    | 8.99 |
| Mean        | 2.335   | 3.665| 1.585   | 2.415| 2.4175 | 3.4175| 2.0825  | 2.2475|
| P-value     | .014    | .091 | .039    | .811 |      |      |         |      |

**TABLE.** Modified OSAACS Scoring Pre- and Postplacental Simulation.
Human placentas have been used in microsurgery training since 1979; however, they have recently reemerged as a tool in neurosurgical training.6,7 Recent studies have shown that placental models are useful in vascular neurosurgical education as they approximate the M2-M4 cerebral and superficial temporal arteries and have strong face, content, and construct validity regarding aneurysm clipping.7 Although these studies suggest the placental model is useful in aneurysm-related instruction, there...
is a scarcity of research looking at alternative utilizations of this model. It remains unclear how to best implement these models into a neurosurgical education curriculum on a larger scale.

This study shows objective improvement in junior neurosurgical resident microsurgical performance across a wide domain of microsurgical skills, suggesting this model has alternative uses outside of aneurysm clipping. Although improvement was found in instrument handling and quality of dissection, time flow and forward planning and respect for tissue were not statistically significant. We suspect that either the time was not sufficient for improvement in these domains or that more focused instruction is needed to see significant improvement. Despite the findings from these subdomains, we feel this pilot study supports the use of simulation in junior resident education and provides a framework that other programs can utilize to incorporate simulation-based curricula into resident education.

At our institution, a weekly resident surgical skills lab was developed to expand the focus of neurosurgical training from simple surgical skill rehearsal to neurosurgical knowledge acquisition with an emphasis on anatomy, surgical and clinical decision-making, and surgical skill development. This placental exercise provided junior residents with regular attending instruction and exposure to surgical microscopes, microsurgical instruments, and life-like vasculature with a clear goal: skeletonizing vessels. The results of this study show a clear technical benefit was gained from these sessions. This exercise provided an interactive, safe, and fun educational experience that was well regarded by the residents. These subjective findings are interesting as the residents continually pushed for more time with the placental simulator, working to improve their microsurgical technique with deliberate practice. Instilling this pursuit of surgical expertise in the early years of training is essential for neurosurgical curricula into resident education.

This comprehensive educational experience comes with challenges. Without genuine passion from faculty for this education platform, the program would not be successful as simulator development and adaptation into weekly sessions requires a large time commitment. The time commitment for residents can also be a challenge with their clinical and research responsibilities. Despite these challenges, each resident gained extensive 1-on-1 faculty mentorship and didactic engagement, providing an extremely valuable time for residents to further both clinical and technical skills.

**Limitations**

This study was limited by a small sample size, as is expected drawing from a single institution resident cohort. One confounder in our study results may be the long length of time the study was conducted, and the clinical exposure the residents may gain outside of the lab. Concentrating sessions in a shorter period may help isolate study affect more directly; however, this is difficult to do with neurosurgical resident schedule demands. Other limitations could include using an nonrepresentative video recording, external factors impacting dissection (fatigue, comfort), and observation bias as the residents knew they would be evaluated. Despite these limitations, the overall improvement seen in this pilot cohort, along with prior studies supporting the use of this model in vascular training, suggests a clear benefit of the placental model. Further studies will continue to adapt the placental model to novel exercises and track resident performance through deliberate practice.

**CONCLUSION**

Deliberate practice of neurosurgical microdissection utilizing a placental model provided an enjoyable training experience for junior neurosurgery residents with technical improvements seen in instrument handling, time flow and forward planning, quality of dissection, and respect for tissue. These findings suggest that supplementing traditional neurosurgical training curricula with placental simulation may be beneficial to neurosurgery residents in their junior years (PGY 1-3) of training.

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**REFERENCES**

1. Birkmeyer JD, Fink JF, O’Reilly A, et al. Surgical skill and complication rates after bariatric surgery. *N Engl J Med*. 2013;369(15):1434-1442.
2. Peters JH, Fried GM, Swanson LL, et al. Development and validation of a comprehensive program of education and assessment of the basic fundamentals of laparoscopic surgery. *Surgery*. 2004;135(1):21-27.
3. Martin JA, Regehr G, Reznick R, et al. Objective structured assessment of technical skill (OSATS) for surgical residents. *Br J Surg*. 1997;84(2):273-278.
4. Bernardo A. Virtual reality and simulation in neurosurgical training. *World Neurosurg.* 2017;106:1015-1029.
5. Jabbour N, Snyderman CH. The economics of surgical simulation. *Otolaryngol Clin North Am.* 2017;50(5):1029-1036.
6. Oliveira Magaldi M, Nicolato A, Godinho JV, et al. Human placenta aneurysm model for training neurosurgeons in vascular microsurgery. *Neurosurgery*. 2014;10(Suppl 4):592-600; discussion 600-601.
7. Belykh E, Miller EJ, Lei T, et al. Face, content, and construct validity of an aneurysm clipping model using human placenta. *World Neurosurg.* 2017;105:952-960.
8. Zevin B, Aggarwal R, Grantcharov TP. Surgical simulation in 2013: why is it still not the standard in surgical training? *J Am Coll Surg.* 2014;218(2):294-301.
9. Sachdeva AK. Acquiring and maintaining lifelong expertise in surgery. *Surgery*. 2020;167(5):787-792.