

ORIGINAL RESEARCH

PEER REVIEWED

The Impact of Early Vascular Simulation Training in Medical School Education

[Sara Soliman, BS](#)[Samrat Gollapudi, BS](#)[Stuti Jha, PhD](#)[Brandon J. Goodwin, DO, BS](#)[Dylan Trawinski, BS](#)[Alissa Brotman O'Neill, DO, FACOS](#)Keywords [Simulation Training](#)

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Abstract

Purpose: This study evaluates the efficacy of vascular surgery simulation training in learning surgical skills, improving readiness for clinical rotations or fourth-year sub-internships, and capturing early interest in surgical specialties. **Methods:** Thirty-four medical students participated in 2 days of vascular surgery simulation training on open and endovascular abdominal aortic aneurysm (AAA) repair, carotid endarterectomy, femoral bypass, vascular anastomosis, and venous access. Pre- and post-surveys used a 5-point Likert scale to assess changes in confidence, knowledge of vascular procedures, and attitudes toward implementing similar simulations into the curriculum. **Results:** Initially, 88.9% and 87.5% of students in Groups 1 and 2, respectively, rated their confidence level in performing vascular surgery as a 1 or 2. Post-simulation, these numbers decreased to 14% and 23%. Before the simulation, 100% rated their knowledge level as a 1 or 2 for open femoral bypass, while 80.25%, 87.5%, and 87.5% did so for carotid endarterectomies, AAA repair, and vascular anastomosis, respectively. These percentages decreased to 38.46%, 46.16%, 41.67%, and 46.35% post training, and 72.3% and 81.2% of participants felt their curriculum needed improvement for surgical residency preparation. Additionally, 88.89% and 92.86% in Groups 1 and 2, respectively, believed similar simulation training would enhance their skills and readiness for surgical clerkships and residencies. **Conclusion:** Early vascular surgery simulation increased students' interest, improved their confidence and knowledge in performing vascular surgery, and enhanced their readiness for surgical clerkships and residencies. Implementing simulation into the preclinical curriculum is recommended to improve surgical training outcomes.

Introduction

After medical school, becoming a board-certified vascular surgeon consists of completing a 5-year general surgery residency with a 2-year vascular surgery fellowship or a 5-year integrated vascular surgery residency.¹ Both pathways are highly competitive, although the latter is more selective. In 2024, there were only 100 available spots for the integrative pathway and 131 available vascular fellowship spots for the indirect path.^{2,3} Unsurprisingly, the average candidate who matches either path is decorated with numerous research and volunteer experiences and exceptional board examination scores across all levels. In fact, for general surgery in 2022, the average applicant had United States Medical Licensing Examination (USMLE) Step 1 and 2 scores of 237 and 250, respectively, with 8.6 abstracts, presentations, and publications, and 8.9 volunteer experiences. That same year, the average applicant for the integrated vascular surgery pathway had USMLE Step 1 and 2 scores of 241 and 250, respectively, with 12.4 abstracts, presentations, and publications, and 7.1 volunteer experiences.⁴ This demonstrates that medical students must show an early interest in general and vascular surgery to gain relevant experiences in research and extracurricular activities that will enhance their likelihood of matching.

Increasing students' preclinical exposure to various specialties is crucial, especially for those interested in highly competitive surgical specialties. Early exposure is paramount, as it gives students more time to obtain relevant scholarly activities and volunteer opportunities. Unfortunately, a widespread lack of preclinical exposure to surgery and other competitive specialties makes students rely on their third-year clinical rotations to discover their interests. A study conducted by Karthik et al found that 60% of medical students chose their specialty during their third year and were more likely to choose a specialty that appeared earlier in their clerkship order.⁵ Interestingly, 5 students in the same study decided not to consider pursuing some specialties due to late exposure

in their clinical rotations.⁵ This makes matching into competitive specialties, such as general surgery and the integrated vascular surgery residency, challenging. Rachoin et al explained that students who decide late to pursue competitive specialties might not have the time and resources to conduct enough scholarly activity to be considered competitive.⁶ This is detrimental, as students cannot truly explore potential interests and are limited to the boundaries set by their medical school education curriculum. Some studies have found that this can be mitigated by implementing more preclinical shadowing experiences, mentorship opportunities, and surgical electives, as these are the most influential factors that impact students' specialty choices.^{5,7-9} One study by Drolet et al implemented a preclinical surgical elective consisting of lectures, operating-room shadowing, rounding with the surgical team, and an oral presentation, among other assignments. After the elective, there was an increased interest in pursuing a career in surgery and confidence in surgical skills.⁹ Undoubtedly, this early exposure allowed students to understand their surgical career goals, if any, and start making themselves competitive early on.

An additional way to increase early interest in competitive surgical specialties is through early preclinical exposure to surgery via simulation. Whether the simulation is through virtual reality or physical trainers, students can learn about different surgical specialties, understand the scope of practice, learn surgical skills and procedures, and, most importantly, feel confident upon entering their surgical clerkship. One study among medical students in the United Kingdom found that interest in orthopedics and surgery increased after using a hip-arthroscopic virtual reality simulator. Specifically, the average interest in orthopedics increased from 5.3/10 to 8.4/10 on the Likert scale.¹⁰ Results from another simulation study for cardiothoracic surgery showed that, after simulation, 39% of the students who participated decided to select a thoracic surgery subspecialty elective during their third year.¹¹ Collectively, these studies show that surgical simulation is a fantastic way to expose students to surgical subspecialties within preclinical medication education and can profoundly impact specialty choices. Therefore, this study aims to elucidate the effectiveness of vascular surgery simulation training, hoping to increase early interest in surgery and improve student readiness for surgical rotations.

Methods

Study Overview

This cross-sectional study evaluates the efficacy of vascular surgery simulation training in learning surgical skills, enhancing readiness for third-year surgical rotations and/or fourth-year sub-internships, and capturing early interest in surgical specialties. Medical students were invited to participate in either one or both days of our 2-day focus group, pending availability. Each day was structured with morning education on vascular diseases and surgery, and afternoon vascular simulation training. A pre- and post-survey was administered to students on both days before the start of educational training and after the completion of simulation training. Before starting, Institutional Review Board (IRB) approval was obtained from the Rowan-Virtua School of Osteopathic Medicine (Study ID: PRO-2023-331).

Participants

Participants in the focus groups were recruited 1 month before each focus group date. Only third- and fourth-year medical students were eligible to participate. Completing the third-year core surgery rotation and participating in both focus group dates were optional.

Focus Group Education and Training

Focus Group 1

Focus Group 1 took place in October 2023, and the goals were to educate students on topics such as peripheral vascular disease and management, abdominal aortic aneurysm (AAA) repair, and vascular anatomy of the abdomen and lower extremities. Upon completing the required pre-survey, students were given the following lectures: Venous Disease, Aortic Aneurysm, and Peripheral Arterial Disease. Following the lectures, the following vascular simulators were brought in by Medtronic and Gore: endovascular aortic and thoracic aneurysm and peripheral arterial simulators, as well as ultrasound and venous access simulators. Students were randomly separated into 3 groups and were assigned to visit as many simulators as possible. Surgeons from the Rowan-Virtua School of Osteopathic Medicine and Virtua Health and medical representatives from Medtronic taught and guided students at each simulator. Upon completion, students were administered the post-survey.

Focus Group 2

Focus Group 2 took place in January 2024, and the goals were to educate students on topics such as neck, abdominal, and lower limb vascular anatomy; carotid endarterectomies; open AAA repairs; and femoral bypasses. Upon completing the required pre-survey, students were given lectures on AAAs, carotid artery disease, and peripheral arterial disease. Following the lectures, Gore brought in vascular simulators for the following operations: open AAA repair, carotid endarterectomy, and open femoral bypass. Students were randomly separated into 3 groups and were assigned to visit as many simulators as possible. Surgeons from the Rowan-Virtua School of Osteopathic Medicine and Virtua Health and medical representatives from Gore taught and guided students at each simulator. Upon completion, students were administered the post-survey.

Data Collection

Before the education and simulation training sessions started, a pre-survey was distributed to all students on the morning of each focus group. This survey assessed their familiarity with the vascular surgery topics to be covered that day and their prior surgical experience. Upon completion of the lectures and simulation training, a post-survey was distributed to students to complete before

leaving, which aimed to evaluate their knowledge of the vascular surgery topics covered, their overall confidence in completing the vascular surgeries that the surgeons and medical representatives taught, and whether similar education should be implemented into the medical education curriculum. The surveys consisted of open-ended and multiple-choice questions using the 5-point Likert scale. The scale of responses using the Likert scale ranged between “1- not confident or knowledgeable” and “5 - very confident and knowledgeable”. Surveys were created through Qualtrics and administered to the participants. No personal information or identifiers were collected, and each survey response remained anonymous.

Results

Participant Information

Thirty-four medical students were enrolled over the 2-day study period. Of the 34, 88.4% of the participants were in their third year of medical school, and 61.1% of the participants in Focus Group 1 had completed their surgery clerkship, with 18% having completed their clerkship specifically on a vascular surgery service. Only 1 student reported having any experience with vascular surgery simulation. In Focus Group 2, 93.7% of the participants had completed their surgery clerkship, with 26.67% having completed their clerkship on a vascular surgery service. Due to the overlap of students in both focus groups, 7 participants reported having some experience with vascular surgery simulation. Across both focus groups, most participants were interested in specializing in general surgery (**Figure 1**).

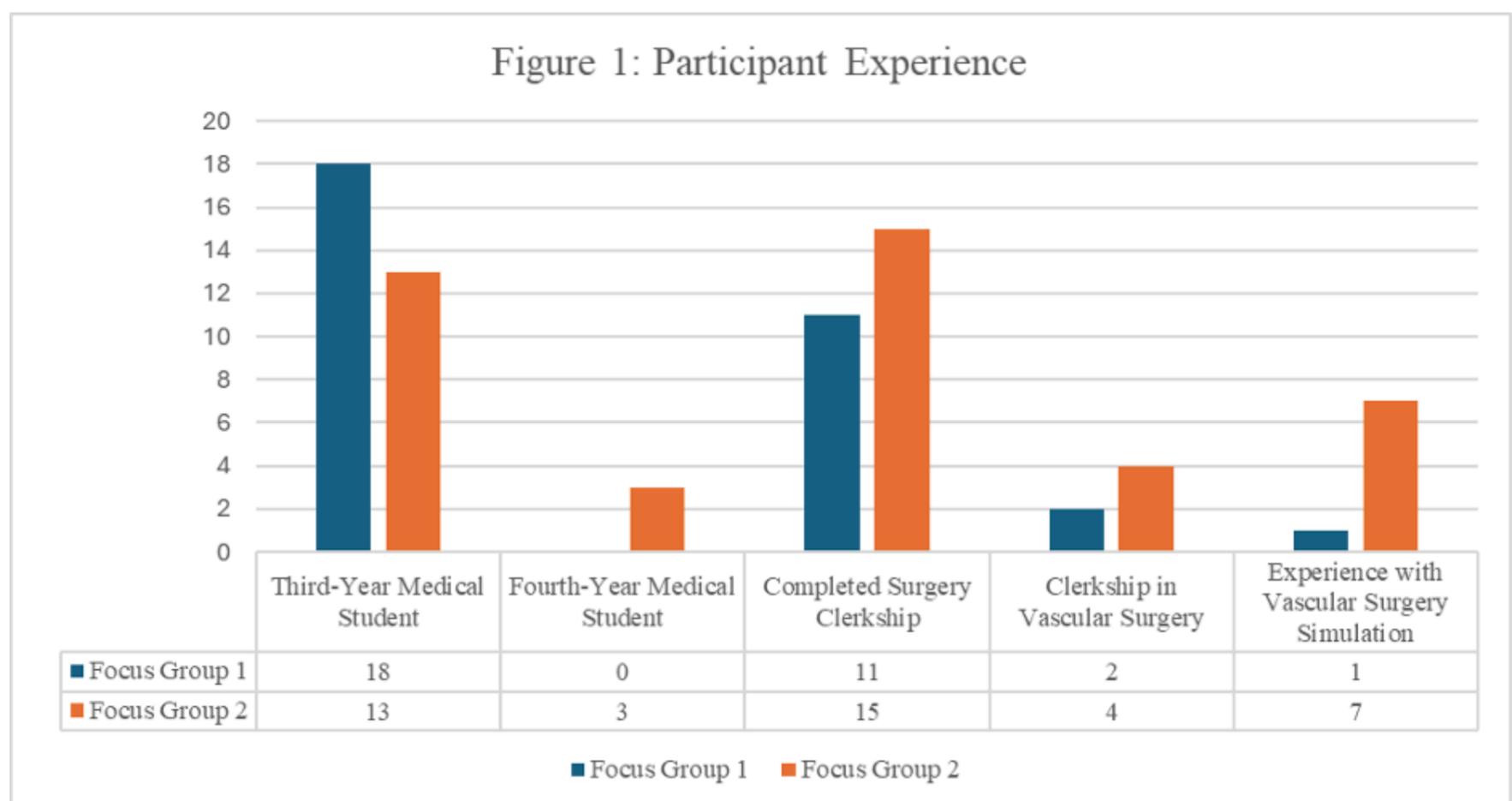


Figure 1. Participants’ responses from Focus Group 1 and Focus Group 2 regarding surgical experience.

Pre-Simulation Assessment

Participants were asked about their knowledge and confidence in performing vascular surgery without simulation training. Nearly 90% of the participants in each focus group rated their confidence level as a 1 or 2 in their ability to perform or assist in vascular surgery without prior simulation training. Participants were then asked to describe the most challenging and intimidating aspects of vascular surgery. In Focus Group 1, participants mentioned guidewire skills and blood vessel anatomy as their main challenges. In Focus Group 2, many participants mentioned damaging the blood vessels as their biggest fear in vascular surgery. To alleviate these concerns, participants hoped to get more hands-on training through the simulation exercise by learning about surgical procedures and becoming more familiar with them. When asked about familiarity with various surgical procedures such as thoracic aneurysms, aortic aneurysms, AAA repair, and vascular anastomosis, most participants said they had little to no experience in these procedures (**Figures 2 and 3**).

Figure 2: Knowledge in Vascular Topics and Surgeries

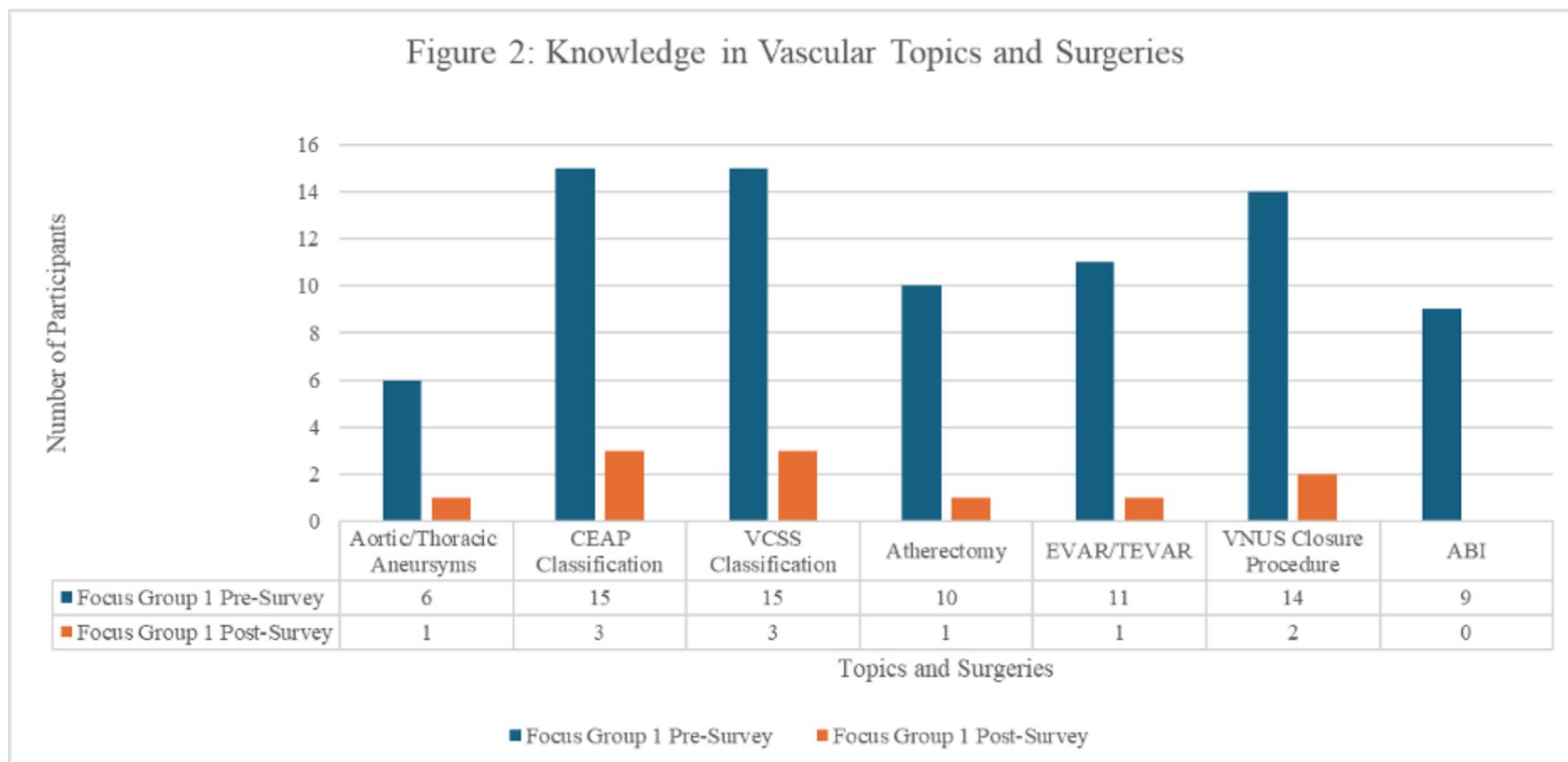


Figure 2. Focus Group 1's Pre- and Post-Experience Knowledge. Number of students who rated their knowledge as a 1 or 2 using the Likert scale in vascular topics and surgeries before and after the simulation. Abbreviations: CEAP, Clinical Etiological Anatomical and Pathophysiological; VCSS, Venous Clinical Severity Score; EVAR/TEVAR, endovascular aneurysm repair/thoracic endovascular aortic repair; ABI, ankle-brachial index.

Figure 3: Knowledge in Vascular Topics and Surgeries

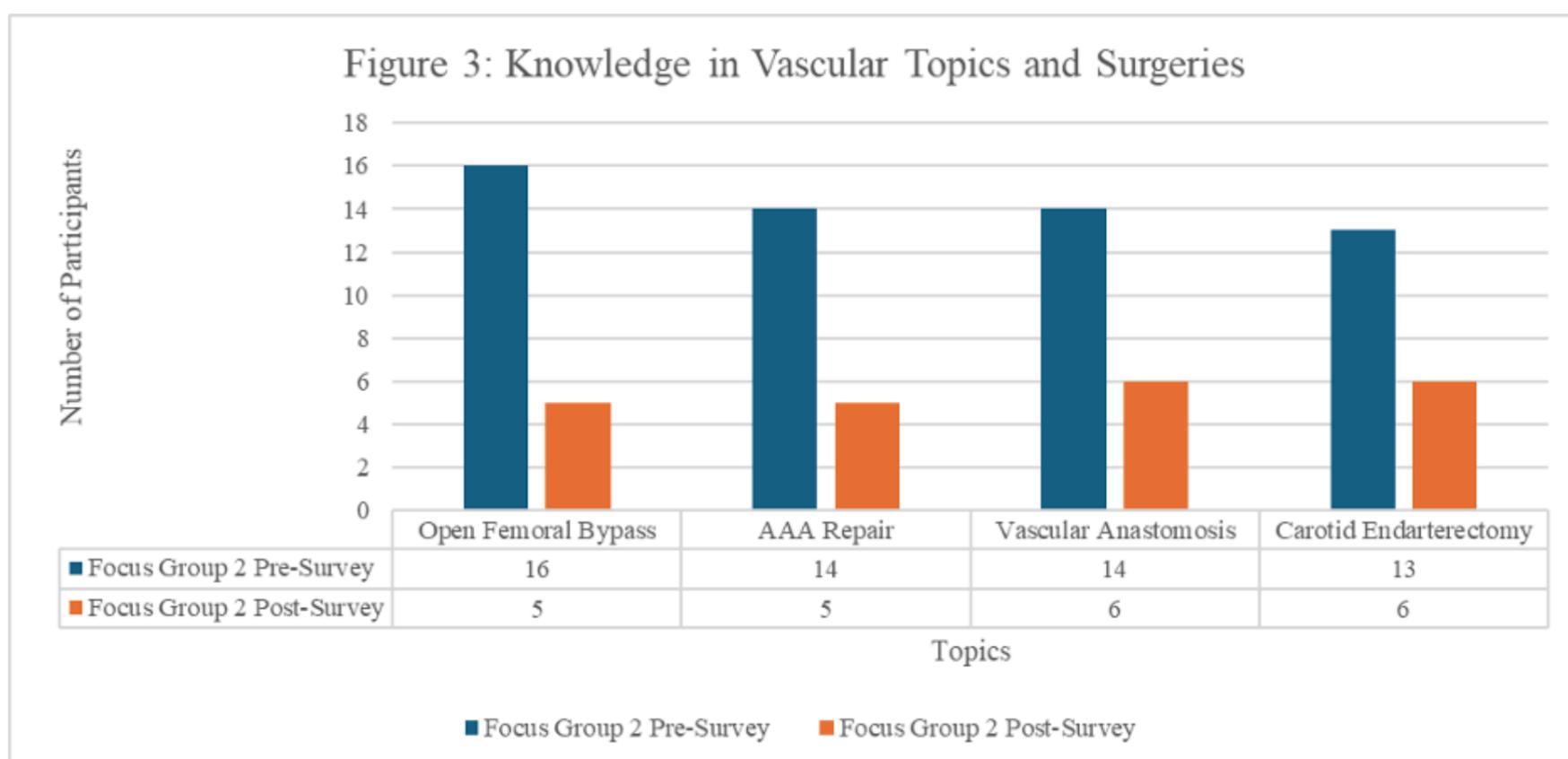


Figure 3. Focus Group 2's Pre- and Post-Experience Knowledge. Number of students who rated their knowledge as a 1 or 2 using the Likert scale in vascular topics and surgeries before and after the simulation. Abbreviation: AAA, abdominal aortic aneurysm.

In Focus Groups 1 and 2, 72.3% and 81.2% of the participants, respectively believed their current medical school curriculum and education must prepare them better to apply for surgical residency; 88.89% and 92.86% of the participants believed that implementing similar surgical education in their school's simulation lab would enhance their skills and readiness for surgical residency. In both groups, 100% of the participants said they would recommend the simulation training to other medical students. However, there was no consensus on the best time to introduce the training. A majority selected options "before 3rd-year clerkship" or "before 4th-year sub-internship".

Discussion

This study provides insightful data on the impact of simulation training on improving student readiness and interest in surgical subspecialties. Data from the pre-simulation assessments revealed a significant lack of confidence and knowledge among the students regarding vascular surgery procedures. Notably, most students across both focus groups expressed low confidence in performing or assisting in vascular surgeries without prior simulation training. Limited familiarity with surgical procedures such as thoracic and aortic aneurysms, AAA repair, and vascular anastomosis may have compounded this lack of confidence. Interestingly, post-training assessments showed a marked improvement in both confidence and knowledge. The hands-on experience provided by the simulation significantly enhanced the students' comfort with surgical tools and procedures. Additionally, there was a notable decrease in the number of students reporting a very low to low degree of confidence in their ability to perform vascular surgery procedures after the simulation training.

These results underscore the importance of integrating simulation-based training into the medical school curriculum. Close to 90% of participants believed that implementing this training would enhance overall readiness for surgical residency. We believe this can also benefit students who are entering their third-year surgical clerkships. This simulation training will improve technical skills, procedural knowledge, and student confidence, which are critical for effective learning and performance. It would be beneficial for medical schools to consider a week-long preclinical “boot camp” to familiarize students with relevant skills for clinical rotations, including a day for surgical simulation.

This project also demonstrates that with increased exposure to surgery, students’ attitudes toward surgery improve with a lasting effect, which is well documented to increase surgical match rates.¹²⁻¹⁴ One cohort study at Stanford tracked students’ interest in vascular surgery as they implemented a new vascular surgery elective, including didactics and simulators.¹⁵ Before the course began, only 8.5% of these preclinical students were seriously interested in vascular surgery as a career option. However, when students’ attitudes were surveyed again 1 year after the elective, 70% of participants considered it as a career.¹⁵ Allowing students to experience surgical simulators has often been associated with increased interest in surgery among the student body.¹⁵⁻²¹ One randomized control trial not only documented simulators to increase student interest in endovascular surgeries but discovered an important temporal connection.¹⁷ There was an inversely proportional relationship between student interest in surgery and time since simulation exposure, further suggesting the significance of an elective or course with repeated simulation engagement to improve student retention in the field.¹⁷

Early and repeated intervention with surgical simulators is crucial to producing more surgeons and combating the growing provider burden. While there is no consensus regarding into which year during medical education the use of simulators or surgical orientation should be incorporated, the noted temporal connection between student interest and surgical exposure suggests that earlier would be better.¹⁷ Introducing surgical education as early as the first year, and certainly before clinical rotations, may help standardize the understanding of the surgical subspecialties among a class. This may be particularly useful if students lack equal exposure opportunities before medical school.

Early exposure to training also correlates with increased surgical skills. The University of Tokyo explored this idea further through a simulation study in 2022.²² The authors investigated the effectiveness of a graft anastomosis simulation program for medical students with no prior surgical experience. Notably, the students were found to have significant improvement in suturing skills following the simulation training system. After 10 hours of training, students’ performance metrics were comparable to those of experienced vascular surgeons. Specific metrics, such as bite, pitch, skewness, and procedural time, were used to evaluate the students’ technique and skill. This rapid improvement emphasizes the potential of targeted simulation training to accelerate surgical skill acquisition.²² Similar findings were also seen in a simulation study in Rwanda.²³ A comprehensive surgical curriculum was developed, emphasizing surgery’s basic yet critical components to be taught to medical students. The survey evaluation from the breast biopsy module showed significant improvements in students’ self-reported competence and positive perceptions. Before the training, 79% of the students did not know the indications for the biopsy, 75% could not recall the procedure steps, and 95% failed to understand the contraindications. Post-training shows only 32% of the students could not recall the steps for the breast biopsy, and only 29% of the students did not know the indications and contraindications. Preliminary data from the breast biopsy module and the overall study may suggest the curriculum is helping improve students’ surgical skills and competence.²³

Future directions for this study include a comprehensive long-term survey to evaluate the effects of simulation training on surgical proficiency and increasing match rates in students. This survey should track medical students who have undergone simulation-based surgical training, assessing their performance/confidence levels over an extended period. Additionally, it should examine the impact of such training on their success rates in matching surgical residency programs. By focusing on these long-term outcomes, the study can provide valuable insights into the sustained benefits of simulation training, thereby informing curriculum development and enhancing the overall quality of surgical simulation education. This approach will help determine whether the initial advantages observed in simulation training translate into lasting improvements in surgical practice and career progression.

Study Limitations

The limitations of this study should be discussed. First, due to time constraints, not every participant could participate in each simulation. However, students had experience with at least 1 simulation station on each study day. Second, there was some overlap of students between the first and second groups, which contributed to the higher number of experienced participants who had used simulators in the past. Future studies addressing these limitations and studying the effect of these simulations on match rates can be a future direction for research.

Conclusion

Our study demonstrated that early vascular surgery simulation increased students’ interest, improved their confidence and knowledge in performing vascular surgery, and enhanced their readiness for surgical clerkships and residencies. Implementing simulation into the preclinical curriculum is recommended to improve surgical training outcomes, increase early interest in surgery, and allow students to start scholarly activity and gain relevant experiences tailored to matching vascular and/or general surgery. ■

Affiliations and Disclosures

Sara Soliman, BS, Samrat Gollapudi, BS, Dylan Trawinski, BS, and Alissa Brotman O’Neill, DO, FACOS, are from the Department of Surgery, Rowan University School of Osteopathic Medicine, Stratford, New Jersey.

Stuti Jha, PhD, is from the Department of Economics, Rowan University, Glassboro, New Jersey.

Brandon Goodwin, DO, is from the Department of Surgery, Rowan University School of Osteopathic Medicine, Stratford, New Jersey; Futures Forward Research Institute, Toms River, New Jersey; and Ocean Medical Center, Brick Township, New Jersey.

Corresponding Author: Alissa Brotman O'Neill, DO, FACOS, Department of Surgery, Rowan University School of Osteopathic Medicine, 113 Laurel Rd., Stratford, NJ 08084. Email: brotmaal@rowan.edu

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REFERENCES

1. Treffalls JA, Treffalls RN, Yan Q, Davies MG. How competitive are integrated vascular surgery residency programs? A ten-year comparison using a normalized competitive index. *Ann Vasc Surg.* 2022;87:263-269. doi:10.1016/j.avsg.2022.03.009
2. Results and Data: Specialties Matching Service. National Resident Matching Program. February 13, 2024. <https://www.nrmp.org/match-data/2024/02/results-and-data-specialties-matching-service-2024-appointment-year/>
3. Advance Data Tables 2024 Main Residency Match. National Resident Matching Program. 2024. <https://www.nrmp.org/wp-content/uploads/2024/03/Advance-Data-Tables-2024.pdf>
4. Charting Outcomes in the Match: Senior Students of U.S. DO Medical Schools. National Resident Matching Program. July 2022. https://www.nrmp.org/wp-content/uploads/2022/07/Charting-Outcomes-DO-Seniors-2022_Final.pdf
5. Karthik N, Greenfield M, Otteson T. The perceived impact of curricular and non-curricular factors on specialty interests and choice during medical school at a single center in the United States. *BMC Med Educ.* 2023;23(1):730. doi:10.1186/s12909-023-04731-1
6. Rachoin J-S, Vilceanu MO, Franzblau N, Gordon S, Cerceo E. How often do medical students change career preferences over the course of medical school? *BMC Med Educ.* 2023;23(1):596. doi:10.1186/s12909-023-04598-2
7. Kaminski A, Falls G, Parikh PP. Clerkship experiences during medical school: influence on specialty decision. *Med Sci Educ.* 2021;31(3):1109-1114. doi:10.1007/s40670-021-01281-3
8. Hernandez J, Al-Saadi S, Boyle R, et al. Surgeons can favorably influence career choices and goals for students interested in careers in *medicine*. *J Am Coll Surg.* 2009;209(1):62-67. doi:10.1016/j.jamcollsurg.2009.02.065
9. Drolet BC, Sangisetty S, Mulvaney PM, Ryder BA, Cioffi WG. A mentorship-based preclinical elective increases exposure, confidence, and interest in surgery. *Am J Surg.* 2014;207(2):179-186. doi:10.1016/j.amjsurg.2013.07.031
10. Bartlett J, Kazzazi F, To K, Lawrence J, Khanduja V. Virtual reality simulator use stimulates medical students' interest in orthopaedic surgery. *Arthrosc Sports Med Rehabil.* 2021;3(5):e1343-e1348. doi:10.1016/j.asmr.2021.05.014
11. Tesche LJ, Feins RH, Dedmon MM, et al. Simulation experience enhances medical students' interest in cardiothoracic surgery. *Ann Thorac Surg.* 2010;90(6):1967-1973; discussion 1973-1974. doi:10.1016/j.athoracsur.2010.06.117
12. Hill EJR, Bowman KA, Stalmeijer RE, Solomon Y, Dornan T. Can I cut it? Medical students' perceptions of surgeons and surgical careers. *Am J Surg.* 2014;208(5):860-867. doi:10.1016/j.amjsurg.2014.04.016
13. Kirkham JC, Widmann WD, Leddy D, et al. Medical student entry into general surgery increases with early exposure to surgery and to surgeons. *Curr Surg.* 2006;63(6):397-400. doi:10.1016/j.cursur.2006.05.005
14. Reed CE, Vaporciyan AA, Erikson C, et al. Factors dominating choice of surgical specialty. *J Am Coll Surg.* 2010;210(3):319-324. doi:10.1016/j.jamcollsurg.2009.11.016
15. Lee JT, Qiu M, Teshome M, Raghavan SS, Tedesco MM, Dalman RL. The utility of endovascular simulation to improve technical performance and stimulate continued interest of preclinical medical students in vascular surgery. *J Surg Educ.* 2009;66(6):367-373. doi:10.1016/j.jsurg.2009.06.002
16. Lee JT, Son JH, Chandra V, Lilo E, Dalman RL. Long-term impact of a preclinical endovascular skills course on medical student career choices. *J Vasc Surg.* 2011;54(4):1193-1200. doi:10.1016/j.jvs.2011.04.052
17. Markovic J, Peyser C, Cavoorea T, Fletcher E, Peterson D, Shortell C. Impact of endovascular simulator training on vascular surgery as a career choice in medical students. *J Vasc Surg.* 2012;55(5):1515-1521. doi:10.1016/j.jvs.2011.11.060
18. Aparajita R, Zayed MA, Casey K, Dayal R, Lee JT. Development and implementation of an introductory endovascular training course for medical students. *Ann Vasc Surg.* 2011;25(8):1104-1112. doi:10.1016/j.avsg.2011.07.002
19. Raheel A, Dalla S, Birney J, et al. Interactive multidisciplinary pilot workshop to improve medical student perception of and interest in breast surgical oncology. *Breast.* 2024;74:103690. doi:10.1016/j.breast.2024.103690

20. Yang A, Fernando S, Tighe J, O-Halloran M, Morphet J, Kumar A. Impact of an interprofessional surgical skills workshop on undergraduate medical and nursing student interest in a career in surgery: a thematic analysis. *J Surg Educ.* 2021;78(3):905-913. doi:10.1016/j.jsurg.2020.09.014

21. Campwala I, Aranda-Michel E, Watson GA, et al. Impact of a surgical subspecialty roundtable on career perception for preclerkship medical students. *J Surg Res.* 2021;259:493-499. doi:10.1016/j.jss.2020.09.015

22. Hanada K, Hoshina K, Tsuyuki S, et al. Ten-hour simulation training improved the suturing performance of medical students. *Ann Vasc Surg.* 2022;84:163-168. doi:10.1016/j.avsg.2021.12.076

23. Hey MT, Alayande BT, Masimbi O, et al. Developing a surgical simulation curriculum for the Rwandan context. *J Surg Educ.* 2023;80(9):1268-1276. doi:10.1016/j.jsurg.2023.06.007