Balamane S, Wiseman V, Brown P, Zelt D, Yacob M. A Review of Abdominal Aortic Aneurysm training in the Modern Era. *Intl J Surgical Education (IJSED)*. Published online May 29, 2024. doi:10.5281/zenodo.14838252

Review articles

A Review of Abdominal Aortic Aneurysm training in the Modern Era

Saad Balamane, MD Candidate[1,2], Vanessa Wiseman, MD[3], Peter Brown, MD, FRCSC[4], David Zelt, MSc, MD, FRCSC[4], Michael Yacob, MD, MEd, RPVI, FRCS[4][a]

[1] Medicine, Avalon University School of Medicine, [2] Faculty of Health Sciences, Queen's University, [3] Division of General Surgery, Queen's University, [4] Division of Cardiovascular Surgery, Queen's University

Keywords: Vascular surgery training, Surgeon volume, Endovascular procedures, Vascular surgical trainees, Abdominal aortic aneurysm

https://doi.org/10.5281/zenodo.14838252

International Journal of Surgical Education

This review summarizes the current landscape of vascular surgery training, highlighting the nuanced relationship between surgeon volume, the impact of vascular surgical trainees (VSTs), and the evolving milieu of endovascular procedures. Within this comprehensive analysis, a discernible trend surfaces, suggesting a correlation between surgeon volume and in-hospital mortality in open elective abdominal aortic aneurysm (AAA) repairs. The involvement of VSTs increases case complexity without compromise to peri-operative outcomes. As the surgical paradigm evolves, there has been a transition from open AAA repairs to endovascular aneurysm repair (EVAR), influenced by the expanding domain of endovascular techniques and technologies. This review further advocates for adaptable training methodologies, underscoring the role of simulation-based approaches in sustaining proficiency amidst the evolving surgical education paradigm.

INTRODUCTION

Vascular surgery has undergone substantial transformations in recent years, marked by advancements in endovascular techniques that have reshaped procedural approaches.[1-5] This comprehensive review expands into the evolving landscape of vascular surgery training. Our synthesis draws from an analysis of studies and publicly available data, notably the Accreditation Council of Graduate Medical Education (ACGME), to scrutinize the training paradigms of vascular surgery resident physicians. Emphasis is placed on discerning the impact of surgeon volume on outcomes, the role of vascular surgical trainees (VSTs), and the influence of advanced endovascular procedures on traditional open surgeries.

Surgeon Volume and Outcomes: Several studies have explored the relationship between surgeon volume and outcomes in open elective abdominal aortic aneurysm (AAA) repairs.[6-10] McPhee et al.[7] conducted a retrospective study revealing an independent and inversely correlated relationship between surgeon volume and in-hospital mortality for open elective AAA repairs. Specifically, a transition from low to high surgeon volume was associated with a notable reduction in mortality rates, with a statistically significant decrease from 8.7% to 6.2%. Modrall et al.[10] supported this, indicating that increased composite surgeon volume correlated with a statistically significant decrease for in-hospital mortality risk after open AAA repairs. The transition from low to high composite surgeon volume was associated with a substantial decrease in mortality rates from 8.9% to 6.5%.

Notably, the volume of open AAA repairs was no longer a predictor of in-hospital deaths after accounting for patient and hospital characteristics. This nuanced perspective, as highlighted by Modrall et al.,[10] suggests that a broader skill set, acquired through diverse vascular surgeries, may contribute to improved outcomes in open AAA repairs.

Impact of Vascular Surgical Trainees (VSTs): DiDato et al.[11] examined the influence of VSTs on perioperative outcomes in AAA repair cases. The presence of trainees correlated with statistically significant increases in bleeding, extended operation times, and postoperative length of stay. Specifically, bleeding complications increased from 5.3% to 7.8%, operation times extended from 180 minutes to 240 minutes, and postoperative length of stay increased from 5 days to 7 days. However, potentially fatal perioperative complications, such as mortality and major complications, did not exhibit a statistically significant rise.

Dynamics of Open AAA Repairs: Dua et al.[12] presented a predictive model highlighting a decline in open AAA repairs, attributed to the rising utilization of fenestrated EVAR (FEVAR) and branched EVAR (BrEVAR). The study emphasized the challenges this poses for vascular trainees,

a **Corresponding Author:** Dr. Michael Yacob, Vascular Surgeon and Assistant Professor Victory 3, 76 Stuart St, Kingston, ON, K7L 0A5 michaelyacob@gmail.com

potentially limiting their exposure to open AAA repairs. The decline in open AAA repairs was statistically significant, showing a decrease from 16.2 ± 8 in 2008 to 9 ± 6 in 2020.[13] Additionally, the increased adoption of simulation-based training in teaching institutions reflected a response to the evolving procedural landscape.[14]

SIMULATION FOR OPEN AAA REPAIRS

Integration of Artificial Intelligence (AI): Raffort et al.'s exploration into AI integration emphasizes its potential in revolutionizing preoperative planning.[15] AI's role in predicting AAA evolution and assessing postoperative outcomes stands out, providing VSTs with a sophisticated decision-making tool for personalized therapeutic approaches. The study highlights applications such as improving image segmentation, quantitative analysis, and characterization of AAA morphology using AI.

Intraoperative Decision-Making Simulation: Jogerst et al.'s innovative virtual simulation focused on intraoperative decision-making becomes pivotal. By replicating real-time scenarios, VSTs not only gain technical proficiency but also develop the ability to make informed decisions.[16] The study showcases the effectiveness of a low-fidelity, scalable, virtual platform in delivering knowledge and facilitating decision-making practice in a remote learning environment.

Validation and Effectiveness of Simulation: Maguire et al.'s systematic review provides a robust foundation for simulation-based training.[17] The review explores diverse simulator designs, including synthetic and cadaveric simulators, and underlines the importance of validated assessment metrics such as Objective Structured Assessment of Technical Skills (OSATS). It demonstrates the overall effectiveness of simulation in improving technical skills for open AAA repair.

Learning Curves and Competency Gains: Lawaetz et al.'s prospective study delves into learning curves within a simulation-based environment, offering specific insights into competency gains.[18] Structured feedback plays a crucial role in guiding VSTs through the learning process, facilitating a more rapid and efficient development of skills. The study notes a significant increase in mean scores, a decrease in supervisor interference, and improved procedure times over the course of the study.

Trainee Perspectives and Challenges: Pantoja et al.'s survey study addresses trainee experiences, revealing challenges faced during simulation-based education of open vascular surgery.[19] By acknowledging and addressing trainees' concerns, the study emphasizes the importance of refining simulation programs. It highlights the incorporation of simulation into basic technique training and open surgical training, providing tailored support for VSTs and recognizing the delicate balance between increased challenges and patient safety.

Framework for Trainee Preparedness: Smith et al.'s qualitative study identifies interconnected domains influencing trainee preparedness.[20] Beyond technical skills, the framework recognizes the role of faculty-trainee relationships, organizational features, and individual factors in shaping preparedness for independent practice. It provides a comprehensive guide for VSTs, navigating the complexities of surgical training.

Assessment Tool Development: Nayahangan et al.'s study on the development of the OPERATE tool becomes a crucial contribution.[21] With high reliability and discriminative ability, the tool offers a structured approach to competency assessment. It ensures targeted support for VSTs in their journey toward proficiency, highlighting the importance of validated assessment tools for formative and summative assessments.

Future Directions and Optimization: Falconer et al.'s narrative review critically appraises open technical skill acquisition in open vascular surgery.[22] It stresses ongoing research to define the optimum schedule for simulation, the style and content of simulation for specific learner groups, and the most effective ways to integrate simulation into vascular surgery training programs. This comprehensive overview provides a roadmap for future optimization of simulation-based training, ensuring a robust and adaptive framework for VSTs in the evolving landscape of vascular surgery training.

DISCUSSION

The amalgamation of data from various studies between 2008 and 2020 reveals the dynamic landscape of vascular surgery training. These findings underscore the pivotal role of surgeon volume in determining outcomes of open abdominal aortic aneurysm (AAA) repairs. McPhee et al.[7] and Modrall et al.[9] independently highlight the inverse correlation between surgeon volume and in-hospital mortality for open AAA repairs. The transition from low to high surgeon volume is associated with a significant reduction in mortality rates, emphasizing the importance of consistent exposure to these procedures. This suggests that maintaining a high composite surgeon volume, involving various vascular surgeries, may contribute to improved outcomes in open AAA repairs, moving away from the traditional focus solely on open AAA procedures.

Interestingly, while the volume of open AAA repairs was traditionally considered a predictor of in-hospital deaths, Modrall et al.[9] highlight that this association diminishes when accounting for patient and hospital characteristics. Instead, the focus shifts to the composite surgeon volume, encompassing various vascular surgeries. This nuanced perspective implies that a broader skill set, acquired through diverse vascular surgeries, may contribute to improved outcomes in open AAA repairs. This further emphasizes that a vascular surgery training program should be able to provide high volume exposure to open AAA repairs, so that trainees can be afforded the opportunity to build the foundational skills for transition to practice.

The influence of VSTs on perioperative outcomes adds another layer to the discussion. DiDato et al.[11] reveal that the presence of VSTs correlates with increased bleeding complications, extended operation times, and postoperative length of stay. However, it is noteworthy that potentially fatal perioperative complications, such as mortality

and major complications, do not exhibit a statistically significant rise, suggesting that the involvement of trainees may introduce challenges but does not compromise patient safety, since there is often a trainee immediately available to manage the complex post-operative care that is required. This emphasizes the need for a delicate balance between increased challenges and ensuring patient safety in the training of vascular surgical residents.

The narrative identified a key review with Dua et al.'s[12] predictive model, foreseeing a decline in open AAA repairs. This decline is attributed to the increased utilization of FEVAR and BrEVAR. The evolving landscape, marked by a surge in endovascular techniques, raises concerns about the potential impact on the exposure of vascular trainees to open AAA repairs.

In response to these challenges, Haiser and colleagues[14] illuminate the increasing prominence of simulation-based training in teaching institutions. This adaptive approach signifies a recognition of the evolving procedural landscape and the imperative to provide trainees with alternative avenues to maintain competency in open AAA repairs.

Simulation-based training has evolved into a cornerstone in addressing the dynamic demands of vascular surgery education.[15,16] This dynamic educational strategy plays a pivotal role in bridging the gap between traditional open procedures and emerging endovascular techniques. By exposing trainees to a diverse range of simulated scenarios, this approach not only fosters adaptability but also ensures proficiency across various facets of vascular surgery.

The immersive nature of simulation-based training allows Vascular Surgery Trainees (VSTs) to refine their technical skills in a risk-free environment. This hands-on experience extends beyond mere technical proficiency, encompassing decision-making, critical thinking, and effective communication – skills crucial for success in the complex and fast-paced environment of the operating room.

Moreover, simulation-based training directly addresses concerns raised by predictive models foreseeing a decline in open AAA repairs.[12] As the field embraces FEVAR and BrEVAR, simulation becomes an indispensable tool for ensuring that VSTs maintain competence in open AAA repairs. This forward-thinking educational strategy positions trainees to navigate the intricacies of both traditional and advanced techniques, promoting a well-rounded and adaptable skill set.

The integration of simulation-based education not only meets the challenges outlined by Haiser and colleagues[14] but also enriches the overall quality of vascular surgery training. It offers trainees the opportunity to encounter and manage a wide array of clinical scenarios, enhancing their ability to make informed decisions and execute procedures effectively.

In conclusion, the synthesis of findings accentuates the multifaceted nature of vascular surgery training. Surgeon volume emerges as a critical factor, but the dynamics of the association are evolving. The role of VSTs introduces complexities, necessitating a delicate balance between increased challenges and patient safety. The predictive model emphasizing the decline in open AAA repairs underscores the need for adaptive strategies in training paradigms.

Furthermore, the increasing prominence of simulation-based training in teaching institutions reveals a proactive response to the evolving procedural landscape. This adaptive approach signifies a recognition of the imperative to provide trainees with alternative avenues to maintain competency in open AAA repairs. Simulation-based training has evolved into a cornerstone, offering a dynamic bridge between traditional open procedures and emerging endovascular techniques. By exposing trainees to a diverse range of simulated scenarios, this approach not only fosters adaptability but also ensures proficiency across various facets of vascular surgery.

This comprehensive training approach, integrating both traditional and advanced techniques, aims to prepare the next generation of vascular surgeons for the evolving challenges and advancements in the field. As technology continues to advance, and educational methodologies evolve, the integration of simulation-based training remains crucial in providing VSTs with the comprehensive skills necessary for success in their future careers.

Submitted: May 25, 2024 EST. Accepted: May 25, 2024 EST.
Published: May 29, 2024 EST.

REFERENCES

1. Elsayed N, Zarrintan S, Khan MA, Naazie I, DeMartino R, Malas MB. The impact of endovascular repair of abdominal aortic aneurysms on vascular surgery training in Open aneurysm repair. *Ann Vasc Surg*. 2023;92:1-8. doi:10.1016/j.avsg.2023.01.017

2. Balamane S, Brown P, Zelt D, Yacob M. Endovascular aneurysm repair has changed the training paradigm of vascular residents. *Can J Surg*. 2021;64(6):72. https://link.gale.com/apps/doc/A689284437/AONE?u=anon~b9aa2d0a&sid=googleScholar&xid=9c17b2e3

3. Smith ME, Andraska EA, Sutzko DC, Boniakowski AM, Coleman DM, Osborne NH. The decline of open abdominal aortic aneurysm surgery among individual training programs and vascular surgery trainees. *J Vasc Surg*. 2020;71(4):1371-1377. doi:10.1016/j.jvs.2019.06.204

4. Swerdlow NJ, Wu WW, Schermerhorn ML. Open and endovascular management of aortic aneurysms. *Circ Res*. 2019;124(4):647-661. doi:10.1161/CIRCRESAHA.118.313186

5. Prinssen M, Verhoeven ELG, Buth J, Cuypers PWM, van Sambeek MRHM, Balm R, et al. A randomized trial comparing conventional and endovascular repair of abdominal aortic aneurysms. *N Engl J Med*. 2004;351(16):1607-1618. doi:10.1056/NEJMoa042002

6. Salata K, Hussain MA, de Mestral C, Greco E, Mamdani M, Forbes TL, et al. Prevalence of elective and ruptured abdominal aortic aneurysm repairs by age and sex from 2003 to 2016 in Ontario, Canada. *JAMA Netw Open*. 2018;1(7). doi:10.1001/jamanetworkopen.2018.5418

7. McPhee JT, Robinson WP, Eslami MH, Arous EJ, Messina LM, Schanzer A. Surgeon case volume, not institution case volume, is the primary determinant of in-hospital mortality after elective open abdominal AORTIC ANEURYSM REPAIR. *J Vasc Surg*. 2011;53(3). doi:10.1016/j.jvs.2010.09.063

8. El-Arousy H, Lim S, Batagini NC, Azim AA, Bena J, Clair DG, et al. Open aortic surgery volume experience at a regionalized referral center and impact on Accreditation Council for Graduate Medical Education Trainees. *J Vasc Surg*. 2019;70(3):921-926. doi:10.1016/j.jvs.2019.02.045

9. Schanzer A, Steppacher R, Eslami M, Arous E, Messina L, Belkin M. Vascular surgery training trends from 2001-2007: A substantial increase in total procedure volume is driven by escalating endovascular procedure volume and Stable open procedure volume. *J Vasc Surg*. 2009;49(5):1339-1344. doi:10.1016/j.jvs.2008.12.019

10. Modrall JG, Rosero EB, Chung J, Arko FR, Valentine RJ, Clagett GP, et al. Defining the type of surgeon volume that influences the outcomes for open abdominal aortic aneurysm repair. *J Vasc Surg*. 2011;54(6):1599-1604. doi:10.1016/j.jvs.2011.05.103

11. DiDato S, Farber A, Rybin D, Kalish JA, Eslami MH, Moreira CC, et al. The effect of trainee involvement on perioperative outcomes of Abdominal Aortic Aneurysm Repair. *J Vasc Surg*. 2016;63(1):16-22. doi:10.1016/j.jvs.2015.07.071

12. Dua A, Koprowski S, Upchurch G, Lee CJ, Desai SS. Progressive shortfall in open aneurysm experience for vascular surgery trainees with the impact of fenestrated and branched endovascular technology. *J Vasc Surg*. 2017;65(1):257-261. doi:10.1016/j.jvs.2016.08.075

13. ACGME. Accreditation Council for Graduate Medical Education. *Annual Data and Databook.*; 2008–2020. Accessed August 10, 2021. https://apps.acgme.org/ads/Public/Reports/Report/25

14. Haiser A, Aydin A, Kunduzi B, Ahmed K, Dasgupta P. A systematic review of simulation-based training in Vascular surgery. *J Surg Res*. 2022;279:409-419. doi:10.1016/j.jss.2022.05.009

15. Raffort J, Adam C, Carrier M, Lareyre F. Fundamentals in artificial intelligence for vascular surgeons. *Annals of Vascular Surgery*. 2020;65:254-260. doi:10.1016/j.avsg.2019.11.037

16. Jogerst K, Chou E, Tanious A, et al. Virtual simulation of intra-operative decision-making for open abdominal aortic aneurysm repair: A mixed methods analysis. *Journal of Surgical Education*. 2022;79(4):1043-1054. doi:10.1016/j.jsurg.2022.03.004

17. Maguire SC, O'Callaghan AP, Traynor O, Strawbridge JD, Kavanagh DO. A National Needs Assessment in Simulation Based Training in Vascular Surgery. *J Surg Educ*. 2023;80(7):1039-1045. doi:10.1016/j.jsurg.2023.05.005

18. Lawaetz J, Nayahangan LJ, Strøm M, et al. Learning Curves and Competences of Vascular Trainees Performing Open Aortic Repair in a Simulation-Based Environment. *Ann Vasc Surg*. 2021;72:430-439. doi:10.1016/j.avsg.2020.09.009

19. Pantoja JL, Archie MM, Baril DT, Moore WS, Lawrence PF. Trainee experience in simulation-based education of Open vascular surgery. *Annals of Vascular Surgery*. 2021;73:147-154. doi:10.1016/j.avsg.2020.11.026

20. Smith BK, Rectenwald J, Yudkowsky R, Hirshfield LE. A Framework for Understanding the Association Between Training Paradigm and Trainee Preparedness for Independent Surgical Practice. *JAMA Surg*. 2021;156(6):535-540. doi:10.1001/jamasurg.2021.0031

21. Nayahangan LJ, Lawaetz J, Strøm M, et al. Ensuring Competency in Open Aortic Aneurysm Repair - Development and Validation of a New Assessment Tool. *Eur J Vasc Endovasc Surg*. 2020;59(5):767-774. doi:10.1016/j.ejvs.2020.01.021

22. Falconer R, Semple CM, Walker KG, Cleland J, Watson AJM. Simulation for technical skill acquisition in open vascular surgery. *J Vasc Surg*. 2021;73(5):1821-1827.e2. doi:10.1016/j.jvs.2020.09.042