REVIEW ARTICLE

# VASCULAR SURGERY PROCEDURES PERFORMED BY RESIDENTS. A NARRATIVE REVIEW ON THE IMPACT IN 30-DAY OUTCOMES

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## Abstract

***Introduction:*** *Worldwide, there is an increase in scrutiny after surgical treatment of a vast array of pathologies. Doing so, a large body of evidence clearly supports centralisation, such as teaching hospitals, where a larger caseload enables optimal outcomes. These institutions have a strong presence of surgical residents seeking training in both technical and non-technical skills. Inevitably, as part of training, they will be involved in the surgical treatment of those patients, even as the primary operator. We sought to investigate the impact of trainee performed procedures in outcomes of common vascular procedures of different technical complexity.*

***Methods:*** *A non-systematic MEDLINE and Scopus databases review on the outcomes of resident performed common vascular procedures was performed.*

***Results:*** *Specific evidence in many procedures (venous disease, aortic aneurysms, peripheral artery disease) is lacking. After carotid endarterectomy (CEA), resident performed procedures seem to have similar cranial nerve palsy and stroke when compared to expert surgeons. Generally, resident-performed primary radiocephalic and elbow arteriovenous fistula (AVF) presents similar primary and secondary patency. As with CEA, AVF procedures performed by residents took longer. On aortic aneurysms, although no specific comparison has been performed, resident involvement (irrespective of surgeon or assistant) in these procedures does not seem associated with increased adverse events.*

***Conclusion:*** *In most vascular surgery procedures, little is known about resident performance and their impact on outcomes. Notwithstanding, resident-performed CEA and primary AVF seem free of major compromise to patients. Further research is warranted to clarify this topic.*

***Keywords:*** *Vascular Surgery (MeSH), Training Programs (MeSH), Survival Analysis (MeSH), Complications (MeSH)*

## INTRODUCTION

Worldwide, there is an increase in scrutiny after surgical treatment of a vast array of pathologies. This is the result of higher demands in patient safety and outcomes. Doing so, a large body of evidence clearly supports centralisation, particularly in high-risk and infrequent pathologies, where a larger caseload and infrastructure enables optimal outcomes. This is also the case in vascular surgery, where tertiary care university hospitals outperform smaller structures in certain pathologies.[1-5]

These institutions have a strong presence of surgical residents seeking training in both technical and non-technical skills. Inevitably, as part of training, they will be involved in the surgical treatment of those patients, even as the primary operator. We sought to investigate the impact of trainee performed procedures in outcomes of common vascular procedures of different technical complexity.

## METHODS

A MEDLINE and Scopus search using a combination of the terms "vascular procedures", "resident", "resident training", "amputation", "carotid endarterectomy", "varicose veins", "endovascular procedures", "hemodialysis access", "aortic aneurysm" and "outcomes" was performed. No language limitations were imposed. Manuscripts were considered irrespective of study design (retrospective, prospective, randomized clinical trials). Papers on common vascular procedures (varicose vein surgery, lower limb amputation, haemodialysis vascular access, peripheral artery disease, aortic aneurysms), published after the year 2000, were sought. Additional articles of scientific interest for the purpose of this non-systematic review were included by cross-referencing. Last search was run on March 1st 2024.

Original articles were eligible for inclusion if they described stratified (consultant vs supervised resident) outcomes of patients who underwent surgery for any of the above-mentioned conditions. Case reports were excluded. Case series of 10 or more participants were eligible. Papers studying non-vascular conditions were not included, as well as published abstracts and conference proceedings.

## RESULTS/DISCUSSION

### Aortic Aneurysms

Little is known on the impact of resident performed open or endovascular repair of aortic aneurysms, irrespective of location. On this topic, the authors found one single-center retrospective observational study (Table 1). Ribeiro et al, after propensity score matching 90 pairs of ruptured abdominal aortic aneurysms found no significant differences in 30-day mortality (27% supervised trainee [ST] vs. 29% consultant [C]; p=.74; OR 1.05, 95% CI 0.5-2.21) nor in 30-day major adverse events 54% ST vs. 52% C, p=.76, OR 1.31, 95% CI 0.66–2.65). OSR performed by ST was associated with a small but significant increase in operative time (200 ± 79 min ST vs. 168 ± 70 min C; p=.029). The authors recognize that in this adverse scenario, although the resident may have technically performed the surgery, overall leadership during these highly stressful situations is always carried by the consultant surgeon.[6] Conversely, data on elective abdominal aortic aneurysms repair was not found. In 2016, DiDato et al analyzed the American College of Surgeons National Quality Improvement Program (NSQIP) database from 2005 up to 2012. They identified 16.977 aortic aneurysm procedures (12.000 EVAR; 3655 infrarenal open aortic repair [OIAR] and 1319 juxtarenal open aortic repair [OJAR]).[7] Trainees were involved 6427 of 12,003 (54%) EVARs, 2281 of 3655 (62%) OIARs, and 984 of 1319 (75%) OJARs. After propensity score matching patients, no significant difference in mortality rates, cardiac, renal, respiratory, pulmonary, venous thromboembolism, wound complications or secondary interventions were noted between groups. However, trainee involvement in abdominal aortic aneurysms (AAA) repair led to a significant increase in operative time for EVAR (163 ± 77 vs 140 ± 67 minutes; P < .001), OIAR (217 ± 91 vs 185 ± 76 minutes; P < .001), and OJAR (267 ± 115 vs 214 ± 106 minutes; P < .001) and an extended length of stay for EVAR (3.1 ± 5.3 vs 2.8 ± 4.5 days; P < .001) and OIAR (10.6 ± 11.8 vs 9.1 ± 8.9 days; P < .001).[7] Resident involvement was ill characterized, and the reader is not able to analyze the specific role of the resident (primary operator, assistant) during the surgical procedure.

Meguid et al analysed the American National Inpatient Sample Dataset from 1998-2004 for the outcomes of ruptured AAA according to the hospital teaching status. Mortality was significantly lower at teaching hospitals than non-teaching hospitals (39.3% vs 44.5%; P < .05). After adjustment for operative volume, patient demographics, and comorbidities, a 25% decrease in likelihood of in-hospital death was found (OR 0.75; 95% CI 0.60-0.94; P < .05) in teaching hospitals.[8] Similar findings, with up to 50% reduction in perioperative death in those treated in teaching hospitals was found by Meuli et al in a recent Swiss nationwide analysis of ruptured AAA. [1]

Also, the presence of a vascular trainee has been associated with improved 30-day survival after ruptured AAA repair (OR 0.3, 95% CI 0.2-0.6) and this was thought to be a surrogate of institutional status.[9]

A review of 676 TEVAR procedures included in the American College of Surgeons NSQIP found no significant association between resident involvement (76.5% of procedures) and significant major adverse outcomes (death, respiratory, cardiac, acute renal failure). Again, the specific resident involvement was not characterized.[10]

Centralization of aortic aneurysm repair is increasingly advocated. It has the benefit of a larger, more robust infrastructure capable of answer to the increased demand throughout all stages of care. However, these structures have a significant number of residents seeking education, and these will take an active part in the treatment process. Ultimately, they can be the primary operator in a significant number of these procedures. For the time being, resident involvement on the treatment process seems relatively harmless. Further studies are needed to establish their impact on the outcomes, in particular those where they participate as the primary operator.

### Haemodialysis Vascular Access

Lazarides et al performed a survey to study "experts" opinion in vascular access for hemodialysis training using a closed questionnaire. The majority of "experts" consented that there is a lack of appropriate training in access creation and maintenance in a great extent, although they located the main deficit regarding access training in the preoperative planning and decision making.[11]

Therefore, there is debate about the influence of surgeon experience on the outcomes after arteriovenous fistula (AVF) creation. About this topic, the authors found 4 studies (3 retrospective, 1 prospective), comprising 665 patients. Regus and coworkers analysed the outcomes after forearm and or upper arm AVF depending on the surgeon experience. One hundred and fifty-nine patients were included

**Table 1** **Summary of the included studies**

| Author | Location | Study Period | Design | Number Patients | Procedure |
|---|---|---|---|---|---|
| Ribeiro et al | Portugal | 2011-2023 | Single-center retrospective | 180 | EVAR and OAR |
| Regus et al | Germany | 2012-2016 | Single-center retrospective | 159 | AVF |
| McGrogan et al | United Kingdom | 2009 | Prospective | 143 | AVF |
| Gundevia et al | United Kingdom | 2001-2004 | Single-center retrospective | 168 | AVF |
| Fassiadis et al | United Kingdom | 2002-2005 | Single-center retrospective | 195 | AVF |
| Cacciopa et al | Italy | 2005-2015 | Single-center retrospective | 1379 | CEA |
| Lutz et al | Germany | 1995-2004 | Multicenter Retrospective | 1379 | CEA |
| Metzger et al | Austria | 2002-2011 | Prospective | 816 | CEA |
| Ricco et al | France | 1995-2009 | Prospective | 1179 | CEA |
| Rijbroek et al | Holland | 1995-2000 | Single-center retrospective | 200 | CEA |

AVF: arteriovenous fistula; CEA: carotid endarterectomy; EVAR: Endovascular aneurysm repair; OAR: open aortic repair;

(90 radiocephalic AVF and 69 brachiocephalic AVF). Residents (from one to four years of experience) performed 85 procedures, while the remaining were performed by trained surgeons. As expected, forearm vessels were of reduced diameter compared to upper arm vessels, but no significant differences between groups in both demographic as well as in anatomic criteria were noted. Resident-performed radiocephalic AVF presented higher rates of immediate failure (P=.003), as well as reduced cumulative primary patency (P<.001). Regarding brachiocephalic fistulas, no significant differences were noted (P=.89).[12] On the contrary, Manohar and colleagues found no significant differences is the rates of clinical maturation following primary AVF (83.4% resident vs 90.1% expert, p=.113) in a cohort of 238 patients (154 radiocephalic and 84 upper arm AVF). Notwithstanding, mean operative time was significantly longer for residents (99.8 ± 18.2 min resident vs 56.2 ± 10.4 min Expert; p < .0001).[13]

In the same fashion, McGrogan et al, in a prospective registry of 162 patients, found no significant differences in post-operative access usage rate and patency, when depicting by surgeon experience.[14]

In a cohort of 168 patients (32% operated by a consultant, 29% by a supervised trainee, 30% performed independently by a trainee and 9% where the grade of the operating surgeon could not be established) both primary, primary assisted patency and overall fistula survival rates by operating surgeon status did not differ significantly (P=0.25; P=0.16 and P=.52, respectively).[15]

At last, in a cohort of radiocephalic fistulas, similar primary success rates were found (94.2% expert vs 81% resident, P < .01). Primary and secondary patency rates at 22 months were similar (P=0.025).[16]

Much of this data was included in a meta-analysis performed by Bath et al.[16] No significant differences in AVF primary nor secondary patency were noted (OR 0.84, 95% CI 0.43-1.66 and OR 0.97, 95% CI 0.60-1.57, respectively). Although no significant differences in patency were noted, an increase in surgical time is yet poorly defined, as was found by Manohar et al. In this particular surgical technique, which is commonly performed under local anesthesia in an outpatient setting, an increase in operative time may relate to significant discomfort in a group of frail and ill patients.[17]

### Major Amputation

Data regarding major amputation is scarce and conflicting, and the authors did not find any direct comparison between expert surgeon and resident in the literature. Iannuzzi and coworkers analyzed the American College of Surgeons National Quality Improvement Program (NSQIP) database from 2005 to 2010. A total of 11.038 major amputations (6302 above-knee amputations and 4736 below-knee amputation). Attendings were alone in 37.9% and residents were involved in the remaining 62.1% of cases. The primary operator was not specified. Crude mortality rates were lower if a resident was involved. Nevertheless, after correction for significant confounders, this association was lost (OR 0.92, 95% CI 0.80-1.07). Notably, if a resident was involved, there was an increased chance of the patient returning to the operating room (OR, 1.60; 95% CI, 1.38-1.84), and this was particularly relevant after below-knee amputation (OR, 1.73; 95% CI, 1.45-2.06). The sole presence of a resident in the operating room

does not depict his specific role on the team (primary operator, first assistant, second assistant, etc) and there are many other factors to be considered that may potentially impact outcomes (indication, urgency, weekend procedure, post-operative care, etc) that were not addressed in this analysis.[18]

Regarding the need for surgical revision, one study was identified that compared trainees and experts in terms of rates of amputation revision following initial amputation, reporting rates of 6.8% and 4.4%, respectively.[19]

Major amputations are commonly performed by both vascular and general surgeons, both nation and worldwide. Although a definitive and irreversible procedure, experience has led many expert vascular surgeons to let trainees perform these in a relatively early stage of their training. This is due to their technical simplicity compared to other vascular procedures. Notwithstanding, these procedures are associated with significant morbidity, mortality and need for surgical revision. Also, this group of patients demands an intense rehabilitation program, which needs a functional stump yet resistant to future trauma, therefore requiring a particularly experienced/knowledgeable surgeon. Further data is required regarding the outcomes of this surgery depending on expertise.

**Carotid Endarterectomy**

This is the procedure with the most available evidence on the topic of surgeon expertise and short-term outcomes. Recently, Bath et al eloquently performed a meta-analysis of this data. Nine studies (3 retrospective, 6 prospective) were included, totalling 5716 carotid endarterectomy patients.[20-28] They found no significant differences in 30-day procedural stroke (OR 0.89, 95% CI 0.59-1.32) or cranial nerve palsy (OR 0.90, 95% CI 0.49-1.66). Procedural stroke rates were in accordance with current guideline indications for carotid artery disease in most of the studies included.[29] Also cranial nerve palsy and post-operative death were in accordance with current literature. Overall, trainees took longer than the experts ($P < .001$). Lastly, mortality rates were similar (OR 0.73, 95% CI 0.29-1.81). This data suggests that training programs should acknowledge the presence of trainees early during residency in these procedures and that, at least in selected patients, the expert surgeon can safely allow the trainee to perform an increasing number of steps of the procedure. In a more advanced stage of training, the ability to let the resident lead (under supervision) the procedure is safe and would be a valuable training opportunity, in both technical and non-technical skills. At last, this can and should be openly addressed with patients.

Overall, data on the outcomes of many common vascular procedures depending on surgeon expertise are required. This will allow to improve surgical residency programs, as well to inform patients regarding safety concerns.

**Training Programs**

Worlwide, vascular surgery training programs are quite variable. In the USA, resident can choose an integrated residency program or follow a two-year program after completing a 5-year general surgery residency. Conversely, in Europe, many countries have an integrated program. Generally, it will last 5 to 6-years of dedicated vascular training following a 1 to 2-year general surgery rotation. In contrast, Ireland and the Netherlands have just 2-years of dedicated vascular training, The variation in training models, among other factors, can ultimately contribute to the scarce data on this topic.

**Limitations**

This study has limitations to be noted. First a non-systematic literature review was conducted, which presents inherent risk of bias. Second, most of the published literature published on this topic is single-center and retrospective in design. Also, most of these procedures have been performed in the early 2000s, and since then, many advances in surgical management, indications and perioperative care have been developed. The impact of resident training in urgent and endovascular procedures is almost absent. Ultimately, in some of the studies included, procedural steps performed by the resident when primary operator are not completely clear.[30]

## CONCLUSION

In most vascular surgery procedures, little is known about the resident performance and their impact on major outcomes, when compared to expert surgeons. However, resident-performed carotid endarterectomy and primary arteriovenous fistula seem safe and free of major compromise to patients. After major amputation, evidence is conflicting. The evidence on urgent and endovascular procedures is mostly unknown. Further research is warranted to clarify this topic.

## REFERENCES


1. Meuli L, Menges AL, Stoklasa K, Steigmiller K, Reutersberg B, Zimmermann A. Inter-Hospital Transfer of Patients With Ruptured Abdominal Aortic Aneurysms in Switzerland. Eur J Vasc Endovasc Surg 2023; 65: 484-492.
2. Partridge E, Brooks M, Curd C, Davis V, Oates C, Mc Geeney D. The effects of centralisation of vascular surgical services in the Bath, Bristol and Weston area on the carotid endarterectomy pathway. Ann R Coll Surg Engl. 2017; 99: 617-623.
3. Holt PJ, Karthikesalingam A, Hofman D, Poloniecki JD, Hinchliffe RJ, Loftus IM et al. Provider volume and long-term outcome after elective abdominal aortic aneurysm repair. Br J Surg 2012; 99: 666-672.
4. Budtz-Lilly J, Björck M, Venermo M, Debus S, Behrendt CA, Altreuther M et al. The impact of centralisation and endovascular aneurysm repair on treatment of ruptured abdominal aortic aneurysms based on international registries. Eur J Vasc Endovasc Surg 2018; 56: 181-188.
5. Trenner M, Kuehnl A, Salvermoser M, Reutersberg B, Geisbuesch S, Schmid V et al. Editor's Choice – High annual hospital volume is asso-

ciated with decreased in hospital mortality and complication rates following treatment of abdominal aortic aneurysms: secondary data analysis of the Nationwide German DRG Statistics from 2005 to 2013. Eur J Vasc Endovasc Surg. 2018; 55: 185-194
6. Ribeiro TF, Soares Ferreira R, Correia R, Bastos Gonçalves F, Amaral CO, Ferreira ME. Safety of Ruptured Abdominal Aortic Aneurysm Repair Performed by Supervised Trainees as Primary Operators: Analysis of a Contemporary Propensity Matched Cohort. Eur J Vasc Endovasc Surg. 2024. E-pub ahead of print.
7. 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: 16-22.
8. Meguid RA, Brooke BS, Perler BA, Freischlag JA. Impact of hospital teaching status on survival from ruptured abdominal aortic aneurysm repair. J Vasc Surg. 2009; 50: 243-250.
9. Brahmbhatt R, Gander J, Duwaryi Y, Ravi RR, Veeraswamy R, Salam A et al. Improved Trends in Patient Survival and Decreased Major Complications After Ruptured Abdominal Aortic Aneurysm Repair. J Vasc Surg 2016. 63: 39-47
10. Acheampong DO, Paul P, Guerrier S, Boateng P, Leitman IM. Effect of Resident Involvement on Morbidity and Mortality Following Thoracic Endovascular Aortic Repair. J Surg Educ. 2018; 75: 1575-1582.
11. Lazarides MK, Georgiadis GS, Georgakarakos EI. What is the best training for vascular access surgery? J Vasc Access. 2015; 16:S16-9.
12. Regus S, Almási-Sperling V, Rother U, Meyer A, Lang W. Surgeon experience affects outcome of forearm arteriovenous fistulae more than outcomes of upper-arm fistulae. J Vasc Access. 2017; 18:120-125.
13. Manohar M, Pol MM, Winston B, Chauhan A, Jarapala V, Sahir M. Effect of supervised surgical training provided to general surgery residents on clinical maturation of arteriovenous fistula surgery: A retrospective cohort study. Ann Med Surg (Lond). 2022; 82:104780.
14. McGrogan DG, Maxwell AP, Inston NG, Krishnan H, Field M. Preserving arteriovenous fistula outcomes during surgical training. J Vasc Access. 2014; 15: 474-80.
15. Gundevia Z, Whalley H, Ferring M, Claridge M, Smith S, Wilmink T. Effect of operating surgeon on outcome of arteriovenous fistula formation. Eur J Vasc Endovasc Surg. 2008; 35:614-618.
16. Fassiadis N, Morsy M, Siva M, Marsh JE, Makanjuola AD, Chemla ES. Does the surgeon's experience impact on radiocephalic fistula patency rates? Semin Dial 2007; 20: 455-457.
17. Bath MF, Awopetu AI, Stather PW, Sadat U, Varty K, Hayes PD. The impact of surgeon experience, Supervised Trainee vs Trained Surgeon, in Vascular Surgery Procedures: A systematic Review and Meta-Analysis. Eur J Vasc Endovasc Surg 2019. 58: 292-298
18. Iannuzzi JC, Chandra A, Rickles AS, Kumar NG, Kelly KN, Gillespie DL et al. Resident involvement is associated with worse outcomes after major lower extremity amputation. J Vasc Surg 2013; 58: 827-831
19. Cosgrove CM, Thornberry DJ, Wilkins DC, Ashley S. Surgical experience and supervision may influence the quality of lower limb amputation. Ann R Coll Surg Engl 2002; 84: 344-347
20. Bradbury A, Brittenden J, Murie J, Jenkins A, Ruckley C. Supervised training in carotid endarterectomy is safe. Br J Surg 1997; 84:1708-1710;
21. Cacioppa LM, Pini R, Longhi M, Vacirca A, Gallitto E, Faggioli G,et al. The value of carotid endarterectomy as a learning tool for trainees. Ann Vasc Surg 2018; 47:195-199.
22. Pai M, Handa A, Hands L, Collin J. Adequate vascular training; opportunities can be provided without compromising patient care. Eur J Vasc Endovasc Surg 2002; 23: 524-527.
23. Lutz HJ, Michael R, Gahl B, Savolainen H. Is carotid endarterectomy a trainee operation? World J Surg 2009; 33: 242-245.
24. Metzger P, Aspalter M, Guggenbichler S, Dabernig W, Linni K, Butturini E, et al. Case numbers in carotid surgery training can be accomplished and are not associated with an inferior outcome. Results of a university based tertiary care center study. Eur Surg 2014; 46: 239-243.
25. Naylor AR, Thompson MM, Varty K, Sayers RD, London NJM, Bell PRF. Provision of training in carotid surgery does not compromise patient safety. Br J Surg 1998; 85:939-942.
26. Ricco JB, Régnault De La Mothe G, Fujita S, Page O, Valagier A, Marchand C. Impact of routine completion angiography on the results of primary carotid endarterectomy: a prospective study in a teaching hospital. Eur J Vasc Endovasc Surg 2011; 41:579-588.
27. Rijbroek A, Wisselink W, Rauwerda JA. The impact of training in unselected patients on mortality and morbidity in carotid endarterectomy in a vascular training center and the recommendations of the European Board of Surgery Qualification in Vascular Surgery. Eur J Vasc Endovasc Surg 2003; 26: 256-261.
28. Krupski WC, Effeney DJ, Goldstone J, Deuel M, Webb RL, Etheredge SN et al. Carotid endarterectomy in a metropolitan community: comparison of results from three institutions. Surgery 1985; 98:492-499.
29. Naylor R, Rantner B, Ancetti S, de Borst GJ, De Carlo M, Halliday A et al. Editor's Choice - European Society for Vascular Surgery (ESVS) 2023 Clinical Practice Guidelines on the Management of Atherosclerotic Carotid and Vertebral Artery Disease. Eur J Vasc Endovasc Surg. 2023; 65 (1):7-111.
30. UEMS Training Requirements in Vascular Surgery https://www.uems.eu/__data/assets/pdf_file/0005/148406/UEMS-2021.19-European-Training-Requirements-in-Vascular-Surgery.pdf
Date accessed: 08/03/2024