



Cohort Study

Effect of supervised surgical training provided to general surgery residents on clinical maturation of arteriovenous fistula surgery: A retrospective cohort study

Manav Manohar^{*}, Manjunath Maruti Pol, Belmin Winston, Aakash Chauhan, Venu Jarapala, Mohammed Sahir

Department of Surgical Disciplines, CMET, Teaching Block, All India Institute of Medical Sciences, Ansari Nagar, New Delhi, 29, India



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ABSTRACT

Introduction: With the advent of endovascular technique and the emergence of vascular surgery as a separate branch distinct from general surgery, there is a decrease in exposure of open vascular technique to general surgery resident. Vascular access surgery is a vascular subspecialty area and not all residents get similar exposure during training, and this has implications if one becomes a vascular consultant in the future and have to undertake access surgery. There is no established protocol or duration, following which a surgical resident can be named as “trained” in vascular anastomosis. Our study tries to address the aforementioned problems; in particular the actual training that a general surgery resident needs in vascular access.

Objective: To study and compare the outcomes of AV Fistula surgeries, created by “trained” general surgical residents and consultant.

Method: A single-institution retrospective cohort study comparing two groups of cohorts: trained residents (group A) and consultant (group B). Study has been done in accordance with the standards of ICMJE and registered with the Clinical Trial Registry of India. (CTRI/2021/12/038581).

Result: Out of 238 patients recruited, 157 underwent surgery in group ‘A’ (the trained residents performing arteriovenous fistula surgery) and 81 underwent surgery in group ‘B’ (by consultant of general surgery). Clinical maturation noted after 8 weeks was 83.4% (131/157) in group A and 90.1% (73/81) in group ‘B’; ($p = 0.113$). The mean duration of surgery in group ‘A’ was 99.8 ± 18.2 min and group ‘B’ was 56.2 ± 10.4 min; (p value < 0.0001).

Conclusion: A structured training in vascular anastomosis provided to the newly recruited residents in general surgery for 6 months lead to outcomes that were comparable with the consultants.

1. Introduction

Over the past two decades, a few areas within general surgery have undergone dramatic evolution. One such example is vascular surgery. The complexity and diversity of vascular diseases, and development of endovascular techniques has resulted in the maturation of vascular surgery into a speciality distinct from general surgery. Unfortunately it has led to reduction in the number of open vascular surgical procedures (OVSP), and raised concern about the adequacy of vascular surgery training for general surgery residents (GSR’s) [1–3]. Additionally, there is a lack of structured training program for GSR’s, availability of a few

specialist vascular surgeons, and disproportionate increase in the number of post-graduate seats in medical colleges in India has resulted in dilution of surgical training and lack of development of vascular surgical skills among GSR’s [4,5]. Furthermore, residents even after three years of general surgical training have frequently expressed doubts about their readiness to practice vascular surgery on their own. Therefore, there is a need to evaluate the existing vascular and general surgery training program.

AVF creation is considered as a good training exercise for GSRs in vascular access as the technical complexity surrounding it is comparatively less, as in a femoral-popliteal bypass. The vessels involved are

^{*} Corresponding author. Department of Surgical Disciplines, CMET, teaching block, All India Institute of Medical Sciences, Ansari Nagar, New Delhi, 29, India.
 E-mail addresses: manav2958@gmail.com (M. Manohar), manjunath.pol123@gmail.com (M.M. Pol), belminwinston1097@gmail.com (B. Winston), aaakash.chauhan21@gmail.com (A. Chauhan), mahavv695@gmail.com (V. Jarapala), saheershaik786@gmail.com (M. Sahir).

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superficial and healthy, and dissection is relatively easy. The surgery is done under local anesthesia and anastomosis is easily reproducible. Moreover, the patency can be evaluated on table, post-surgery, by feeling for a palpable thrill [15].

Through this study we tried to evaluate the impact of structured six months of vascular training program provided to GSR's and compared the outcomes of AV Fistula surgeries created by trained GSR's to consultant.

2. Patients and methods

Design of the study: A single institution, retrospective analysis of prospectively maintained database, comparing the surgical skills between two groups: group 'A' [AVF surgery performed by trained residents] and group 'B' [arteriovenous fistula (AVF) surgery performed by attending surgeon of general surgery] between the year 2016–2018. Patency of the fistula was measured on table, by feeling for a palpable thrill. Functional patency was evaluated by adequate use of arteriovenous fistula for 3 repetitive hemodialysis, after 8 weeks following AVF surgery, and this was taken as the primary outcome of the study.

Objectives: to study and compare the outcomes of AV Fistula surgeries created by trained surgical residents to consultants.

Primary outcome of the study was the "functional patency" of the AVF which was adequate use of arteriovenous fistula for 3 repetitive hemodialysis, after 8 weeks following surgery

Inclusion criteria:

All the chronic renal failure patients who underwent AVF surgery.

- between 2016 and 2018, 18–65 years of age, both genders
- Patients willing for regular follow up
- Requiring a native AVF at wrist or cubital fossa as a first access

2.1. Exclusion criteria's

- History of surgery on vessels at or proximal to antecubital fossa
- Previous AVF, AV graft at or proximal to the antecubital fossa
- Central venous stenosis or occlusion of vein detected on DUS
- Deep vein thrombosis or arteriopathy
- Recent cannulation or multiple punctures of vein 2 weeks before creation of AVF
- Segmental or complete occlusion of vein detected on duplex ultrasonography (preoperative) or intra-operatively detected during patency test (inability to pass 2 mm vascular dilator into the vein and lack of backflow of blood).
- Peripheral arterial disease: vessels with extensive arterial disease (calcified or atherosclerosis of artery) detected on DUS prior to the surgery.
- Lower limb AVF
- Not willing for follow-up

Statistical analysis: The entire data was tabulated in MS-Excel 2016 data sheet. Continuous variables were expressed as the mean \pm standard deviation (SD) or median (Interquartile range [IQR]) as appropriate. Descriptive statistics and frequencies were obtained and comparisons were made using the SPSS version 25.0 statistical package (IBM statistic, New York, USA). Statistically significant differences between randomization groups (group A and group B) were assessed using the Pearson χ^2 test or the Fisher exact test for categorical variables. Student's t-test was used for analysis of continuous variables with parametric data and Mann Whitney test was used for analysis of non-parametric data. A value of $P < 0.05$ was considered to be statistically significant.

Methodology: Patients that underwent AVF surgery were segregated into two groups: group "A" and group "B". All parameters prior to the surgery, during operation and in follow-up period were extracted from hospital records. Preoperative parameters included age, gender,

presence of comorbidity (diabetes, hypertension, and peripheral vascular disease), duration of dialysis, patient education regarding AVF, history of cannulation in the past, preoperative examination findings like swelling in neck or chest, examination of artery and vein, and compliance with follow-up. Intra operative parameters included compressibility of vessel wall (hard segment of artery was considered as atherosclerotic and thickening of the vein was considered as thrombosed segment of veins) and site of the surgery performed. Postoperative complications included bleeding, thrombosis of anastomosed segment, oedema, infection, pseudo-aneurysm, and postoperative interventions. A DUS was not performed routinely (preoperatively or post operatively) in our center, due to huge volume load of CKD patients and the relatively long waiting list from radio diagnosis department. The functional patency of fistula evaluated by the successful use of AVF for 3 repetitive hemodialysis, 8 weeks following the surgery was considered as the primary outcome of the study.

The work has been reported in line with the STROCSS criteria:

Mathew G and Agha R, for the STROCSS Group. STROCSS 2021: Strengthening the Reporting of cohort, cross-sectional and case-control studies in Surgery. International Journal of Surgery 2021; 96:106165 [16].

3. Ethics and consent form

Ethical approvals of the study protocol were obtained from the relevant Ethics Committee (AIIMS) and informed consent was obtained from all subjects. Study has also been registered with the Clinical Trial Registry of India. (CTRI/2021/12/038581)

UIN: CTRI/2021/12/038581.

Hyperlink:

<http://ctri.nic.in/Clinicaltrials/showallp.php?mid1=63558&EnchId=&userName=CTRI/2021/12/038581>.

Training program: The training program begins as and when a resident joins the surgical residency. He or She is to assist in at least 20 cases with the attending vascular surgeon within a period of 2 months. Next step of training involves scrubbing with a senior resident or consultant, but the trainee would perform majority of the surgery including dissection, approximation of vessels, creation of arteriotomy, venotomy, posterior and anterior wall anastomosis. Separate grades would be awarded to the trainee in each of the mentioned aspects. Once a resident performed each of the individual steps satisfactorily in a minimum of 25 cases over a period of 6 months, he/she was declared as "trained" in AVF creation. Trained residents were then allowed to perform AVF surgery independently, without supervision. (However, the attending surgeon would remain on call within premises, but will not be present in the Operating room) 25 was chosen as an achievable number in 6 months, taking into aspect the availability of OT days and patient load, we had in our center.

Surgical technique: All AVF surgeries were performed under local anesthesia after obtaining a written and informed consent. In case of radio-cephalic AVF side to side anastomosis was performed, and in case of brachiocephalic or brachio basilic AVF either end to side or side to side (with ligation of distal end of the vein) anastomosis was done. Prolene 6-0 suture was used for anastomosis. Presence of palpable thrill immediately after completing the anastomosis was assessed. Vascular dilators were used whenever the thrill was absent or soft. Post-surgery patient was instructed to perform handgrip exercises. Follow up was performed on post-operative days 2, 14, and then on 8 weeks. Flow was assessed by palpation and auscultation and if in doubt a duplex ultrasonography (DUS) was performed. The functional patency of fistula evaluated by the successful use of AVF for 3 repetitive hemodialysis, 8 weeks following the surgery was considered as the primary outcome of the study.

4. Results

Out of 238 patients recruited, 157 underwent surgery in group A

(trained residents) and 81 underwent surgery in group B (consultants). There were five trained residents who performed surgeries. Mean age in group A was 42 ± 14 and in group B was 38 ± 13 years. Men were 167/238 (70.16%). About 50/238 (21%) were diabetic {33/157 (21%) in group A, and 17/81(20.9%) in group B; P = 0.995}. About 136/157 (86.6%) were hypertensive in group A, and 70/81 (86.4%) in group B; P = 0.965. About 23/238 (9.6%) had peripheral vascular disease {11/157 (7.01%) in group A and 6/81(7.40%) in group B; P = 0.53}. Notably, 195/238 (81.9%) were undergoing hemodialysis through a temporary catheter prior to creation of AVF. There was no significant difference between the preoperative variables between the two groups (Table 1). About 154/238 (64.7%) underwent radio cephalic arteriovenous fistula (RCAVF) and 84/238 (35.3%) underwent brachiocephalic AVF (BCAVF). Overall clinical maturation (CM) at 8 weeks was 204/238 (85.7%). **Success of surgery, as measured by the functional patency with two needles in AVF for 3 consecutive sessions, in group A when compared to group B was 131/157 (83.44%) versus 73/81 (90.12%) respectively, and p = 0.178, which showed no statistically significant difference.** (Table 2). Assisted maturation by radiological intervention was required in 2 cases in Group A and 2 cases in Group B. (p = 0.497). The duration of surgery in group A and group B was 99.8 ± 18.2 min and 56.2 ± 10.4 min respectively, and p value of <0.0001. Post-operative complications (post op failure, bleed, oedema, infection, and pseudo-aneurysm) did not show a significant difference in both the groups (Table 3).

5. Discussion

In our study, success rate in group A was statistically comparable to success rate in group B. This goes on to say that, with a proper structured curriculum of training in vascular access, trained residents were able to produce comparable outcomes as that of consultants. We also found that the incidence of post operative complications like postoperative bleed, pseudoaneurysm and infection were also comparable in the two groups, with no statistical difference.

There is more to surgical education and training than just operating. Initially the GSR's were allowed to spend time in the operating room observing and first assisting a senior surgeon performing a vascular surgical procedure. This allowed the resident to understand the flow of the operation, observe the operative techniques, and get a feel for how to do the procedure before actually allowed performing surgery [6]. The time surgical residents spend participating in procedures as a first assistant was valuable to their overall adaptation and skill learning.

A properly functioning vascular access is paramount for long term hemodialysis in patients with end stage renal disease. Many factors play a role in proper functioning and longevity of the vascular access, including the type of vascular access, surgical technique and management of complications. The native AVF is preferred over grafts for long-term hemodialysis vascular access. Outcomes of AVF surgery are dependent on preoperative evaluation, operative technique and follow up. The success rates of maturation of AVF, decided by the functional patency - range from 35% to 89% depending on the site of fistula. Voorzaat et al. [7], in a large cohort study among 1221 patients from

Table 1
Preoperative parameters.

Distribution of Preoperative parameters between the two Randomization Group			
Preoperative Parameter	Consultants(81)	Residents(157)	P Value
Age(Years,SD)	38,13.1	42,13.6	0.986
Gender(Males)	58	109	0.728
Gender(Female)	23	48	
Diabetes Mellitus	17	33	0.995
Hypertension	70	136	0.965
Peripheral Vascular Disease	12	11	0.053
Congestive cardiac Failure	0	4	0.147

Table 2
Intraoperative variables and outcome.

Intraoperative variables and Outcome			
Variables	Consultants(81)	Residents(157)	P Value
Distal AVF(RCAVF)	48	106	0.207
Proximal AVF(BC/BBAVF)	33	51	0.252
Post operative Bleeding Surgery	7	9	0.396
Intraoperative Atherosclerosis	3	10	0.391
Post operative Thrombosis	15	20	0.233
AVF Clinical Success	73	131	0.163
Maturation Failure	8	26	0.178

Table 3
Post-operative complications.

Post Operative Variables and Outcomes			
Parameters	Consultants(81)	Residents(157)	P Value
Post central line Dialysis	8*	35*	0.018*
Post AVF Failure	15	20	0.233
Angioplasty	2	2	0.497
Post operative Infections	9	10	0.201
Oedema	7	11	0.642
Collateral vein dilatation	2	3	0.776
pseudoaneurysm	2	7	0.446
Reinterventions	12	14	0.167

1997 to 2016, reported a maturation rate of 76% in forearm fistulas and 89% in upper arm fistulas. Dember et al. [8] Huijbrechts et al. [9] and Schinstock et al. [10] have reported success rates of 35% among 877 patients, 60% among 395 patients and 63% among 293 patients respectively. Studies have shown that surgical training is crucial to the success rate in AVF surgery and also those performing the surgery more often are shown to have more success rates [11,12].

Surgical technique and surgeon factor were associated with success rates (Fig. 1). In a matched case control study published by Farber et al., among 602 participants and 198 controls, a common correlate of diminished thrill, prognostic concern and surgeon frustration or longer surgical duration was associated with poor outcome [13]. In our study, we found that the success rate was higher in group A (83.4%) when compared to group B (90.1%), but it was not statistically significant (p = 0.178). The duration of surgery in group A and group B was 99.8 min and 56.2 min, p value of <0.0001, respectively.

It is also important to realize that vascular surgery training is definitely useful for the general surgeon. Open vascular surgical procedures often include techniques that are similar to other general surgical procedures. For example, the technique for creating a vascular anastomosis is similar to that for a biliary anastomosis. The vascular surgery experience would be helpful in any complex surgery, for example in the management of trauma patients. With time, vascular surgical operations are becoming increasingly difficult due to co-morbidities and atherosclerosis [14]. Therefore, GSR's must possess knowledge and professional competencies to cope with different circumstances. Development of skills and adaptation is possible with structured training.

Following are limitations of our study: This was a retrospective study with a short term (8 weeks) follow-up duration conducted at a single center. DUS was not performed routinely preoperatively or post operatively in all patients and therefore, we did not have a data on radiological maturation of AVF. Follow up was done by telephonic conversation and whatever patient said about his hemodialysis was considered true. Primary outcome of the study was subjective and not objective based on DUS findings. However, the functional patency of the fistula as decided by ability to use it for 3 consecutive hemodialysis would ultimately mean that the surgery was successful.

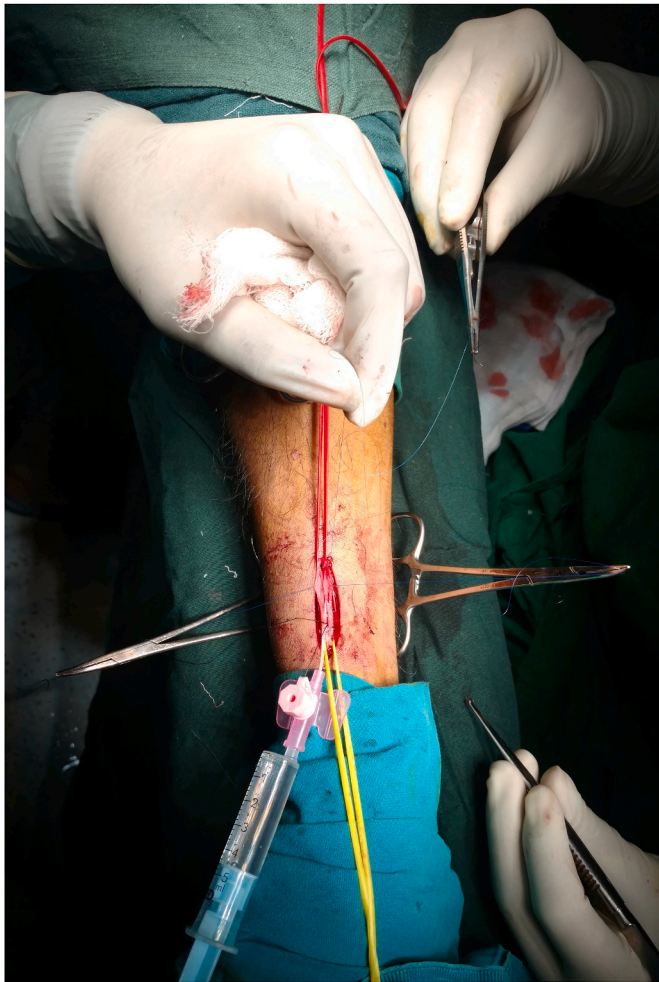


Fig. 1. The technique of placing traction on the anterior vessel wall and hydrostatic dilatation being performed to increase the luminal diameter of the draining vein.

6. Conclusion

A structured training in vascular anastomosis provided to the newly recruited residents in general surgery for 6 months lead to outcomes that were comparable to consultants. Further studies are required to ascertain the duration of training and number of surgeries required to be performed by GSR prior to their certification.

Ethical approval

Ethical approvals of the study protocol were obtained from the relevant Ethics Committee (AIIMS) and informed consent was obtained from all subjects. Study has also been registered with the Clinical Trial Registry of India. (CTRI/2021/12/038581)

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Author contribution

The study design was created by MM, MMP, and BW. MMP was the attending surgeon and oversaw all resident surgeries; MM, MMP, BW, AC, VJ, MS examined, worked up, and discussed the patient. MMP and qualified residents operated on the patients (MM, AC, BW, VJ, MS). MM, BW, AC, and VJ collected patient demographics, clinical details,

preoperative, intraoperative, and postoperative data, and generated an excel spreadsheet. MM and BW discussed the data with the statistician. MM and BW worked on the manuscript. MM, BW, and MMP edited and uploaded manuscript.

Consent

Written informed consent was obtained from the patient for publication of this case series and accompanying images. A copy of the written consent is available for review by the Editor-in Chief of this journal on request.

Registration of research studies

1. Name of the registry: CTRI, india
2. Unique Identifying number or registration ID: CTRI/2021/12/038581
3. Hyperlink to your specific registration (must be publicly accessible and will be checked): <http://ctri.nic.in/Clinicaltrials/showallp.php?mid1=63558&EncHid=&userName=CTRI/2021/12/038581>

Guarantor

Dr Manav Manohar, MS, AIIMS, New Delhi manav2958@gmail.com, 8447890647,9968859579 (+91).

Provenance and peer review

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.amsu.2022.104780>.

References

- [1] J.R. Potts 3rd, R.J. Valentine, Declining resident experience in open vascular operations threatens the status of vascular surgery as an essential content area of general surgery training, *Ann. Surg.* 268 (4) (2018) 665–673.
- [2] M.A. Malangoni, T.W. Biester, A.T. Jones, et al., Operative experience of surgery residents: trends and challenges, *J. Surg. Educ.* 70 (6) (2013) 783–788.
- [3] B.D. Suckow, P.P. Goodney, J.A. Columbo, et al., National trends in open surgical, endovascular, and branched-fenestrated endovascular aortic aneurysm repair in Medicare patients, *J. Vasc. Surg.* 67 (6) (2018 Jun) 1690–1697, e1.
- [4] J.B. Hanks, S.W. Ashley, D.M. Mahvi, et al., Feast or famine? The variable impact of coexisting fellowships on general surgery resident operative volumes, *Ann. Surg.* 254 (3) (2011 Sep) 476–483, discussion 483–5.
- [5] C.S. Joels, E.M. Langan 3rd, D.L. Cull, et al., Effects of increased vascular surgical specialization on general surgery trainees, practicing surgeons, and the provision of vascular surgical care, *J. Am. Coll. Surg.* 208 (5) (2009 May) 692–697.
- [6] A. Tanius, M. Wooster, A. Jung, et al., Open abdominal surgical training differences experienced by integrated vascular and general surgery residents, *J. Vasc. Surg.* 66 (4) (2017 Oct) 1280–1284.
- [7] B.M. Voorzaat, K.E.A. van der Bogt, C.J. Janmaat, et al., Dutch vascular access study group. Arteriovenous fistula maturation failure in a large cohort of hemodialysis patients in The Netherlands, *World J. Surg.* 42 (6) (2018 Jun) 1895–1903.
- [8] L.M. Dember, G.J. Beck, M. Allon, et al., Dialysis Access Consortium Study Group. Effect of clopidogrel on early failure of arteriovenous fistulas for hemodialysis: a randomized controlled trial, *JAMA* 299 (18) (2008 May 14) 2164–2171.

- [9] H.J.T. Huijbregts, M.L. Bots, C.H.A. Wittens, et al., CIMINO study group, Hemodialysis arteriovenous fistula patency revisited: results of a prospective, multicenter initiative, *Clin. J. Am. Soc. Nephrol.* 3 (3) (2008 May) 714–719.
- [10] C.A. Schinstock, R.C. Albright, A.W. Williams, et al., Outcomes of arteriovenous fistula creation after the fistula first initiative, *Clin. J. Am. Soc. Nephrol.* 6 (8) (2011 Aug) 1996–2002.
- [11] S.B. Palder, R.L. Kirkman, A.D. Whittemore, et al., Vascular access for hemodialysis. Patency rates and results of revision, *Ann. Surg.* 202 (2) (1985 Aug) 235–239.
- [12] O.E. Winsett, F.J. Wolma, Complications of vascular access for hemodialysis, *South. Med. J.* 78 (5) (1985 May) 513–517.
- [13] A. Farber, P.B. Imrey, T.S. Huber, et al., HFM Study Group, Multiple preoperative and intraoperative factors predict early fistula thrombosis in the Hemodialysis Fistula Maturation Study, *J. Vasc. Surg.* 63 (1) (2016 Jan) 163–170, e6.
- [14] W.J. McCarthy, Honor and responsibility, preparing the next generation, *J. Vasc. Surg.* 47 (3) (2008 Mar) 682–687.
- [15] A.K. Agarwal, N.J. Haddad, T.J. Vachharajani, A. Asif, Innovations in vascular access for hemodialysis, *Kidney Int.* 95 (5) (2019 May) 1053–1063, <https://doi.org/10.1016/j.kint.2018.11.046>. Epub 2019 Mar 4. PMID: 30922666.
- [16] G. Mathew, R. Agha, for the STROCSS Group, STROCSS 2021: Strengthening the Reporting of cohort, cross-sectional and case-control studies in Surgery, *Int. J. Surg.* 96 (2021), 106165.