# Functional Outcomes of Arteriovenous Fistulas Created by Nephrologist

Shrestha S,[1] Soni SS,[2] Vachharajani TJ[3]

[1]Department of Medicine

Nobel Medical College Teaching Hospital,

Biratnagar, Nepal.

[2]United Ciggma Hospital,

Aurangabad, India.

[3]Glickman and Kidney Institute,

Cleveland Clinic Lerner College of Medicine and Cleveland Clinic Foundation,

Cleveland, OH, USA.

**Corresponding Author**

Shailendra Shrestha

Department of Medicine

Nobel Medical College Teaching Hospital,

Biratnagar, Nepal.

E-mail: shailendranobel@gmail.com

**Citation**

Shrestha S, Soni SS, Vachharajani TJ. Functional Outcomes of Arteriovenous Fistulas Created by Nephrologist. *Kathmandu Univ Med J.* **Online First.**

## ABSTRACT

**Background**

Nephrologists worldwide, after undergoing surgical training, have reported creating arteriovenous fistulas (AVFs).

**Objective**

To demonstrate the functional outcome of arteriovenous fistulas created by a trained Nepalese nephrologist.

**Method**

This was a cross sectional study. A convenient sampling method was used and all consecutive AVFs created by a single nephrologist from January 2016 to December 2018 were included to assess their functional status within 3 months of creation. Patients with incomplete data and no follow up for up to 3 months post surgery were excluded.

**Result**

One hundred sixty six (166) arteriovenous fistulas were created during the study period; mean age of the patients was 52 ± 14 years, 121 (75%) male and 65 (39%) were diabetic.

The most common site of arteriovenous fistula creation was left radiocephalic (Lt RC) 69(41.5%), followed by left brachiocephalic (Lt BC) 66(39.7%). Other sites were left brachiobasilic (Lt BB) 10(6%), right brachiocephalic (Rt BC) 10(6%), right radiocephalic (Rt RC) 9(5.4%) and right brachiobasilic (Rt BB) 2(1.2%). 139 arteriovenous fistulas (83.7%) were functional within 3 months post creation. Functional outcomes of radiocephalic, brachiocephalic and brachiobasilic arteriovenous fistulas were 75.6%, 90.7% and 100% respectively at 3 months post creation.

Lymphoceles developed in three Lt BC arteriovenous fistulas, thrombosis in two Lt BC arteriovenous fistulas and infection in two Lt BC arteriovenous fistulas with pseudoaneurysm formation.

**Conclusion**

The functional outcome of arteriovenous fistulas created by a trained Nepalese nephrologist is similar to that reported in the literature.

## KEY WORDS

*Arteriovenous fistula, Interventional nephrology, Vascular access*

## INTRODUCTION

Arteriovenous fistulas (AVFs) are the lifeline to patients with end stage renal disease (ESRD) who are on hemodialysis; however, they are also the Achilles heel of a chronic hemodialysis program.[1] The first description of AVF was described in 1966 by a team of nephrologists and surgeons.[2] Over the years, some nephrologists from around the world, particularly from Europe (Italy and Germany), India and now United States, have started creating the AVF.[3-9] Reported outcomes of AVFs created by nephrologists are similar to that of the surgeons.[9]

A survey done in Italy showed that about 50% of nephrologists in the country perform AVF surgery.[10] A single centre study from Italy showed that 98% of vascular accesses were created by nephrologists out of which 90.8% were AVFs and remaining being cuffed central venous catheters and arteriovenous grafts.[11] It is estimated that about 20% of nephrologists in India and about 25% of nephrologists in China perform dialysis vascular access surgery.[9] Recently, nephrologists from the United States have shared the outcomes of AVFs created by them. They created AVFs in 105 patients over a 1 year period; 50% of the patients were diabetic. Twenty-one AVF were placed in the forearm (19.8%) with the remainder being placed in the upper arm vessels. Eighteen patients (18.56%) failed to mature at 6 weeks and eighty patients (84.21%) had a patent AVF at an average follow-up of 286.2 ± 98.14 days.[8]

Driven by an intense interest coupled with necessity, a nephrologist from Nepal learned the surgical skills of AVF creation from a nephrologist in India as a fellowship training supported by the Asian Pacific Society of Nephrology. In this manuscript, we describe the outcome of AFVs created by the Nepalese nephrologist upon return to his home country. We also discuss the hurdles faced by the nephrologists in acquiring the surgical skills and how best to overcome these hurdles.

## METHODS

The study was undertaken at Nobel Medical College and Teaching Hospital (NMCTH), Biratnagar, Nepal. This was a cross-sectional study. A convenient sampling method was used and all consecutive AVFs created by the single nephrologist (SS) from January 2016 to December 2018 were included to assess their functional status within three months. Patients with incomplete data and no follow up for up to 3 months post surgery were excluded. Ethical clearance was taken from Institutional review committee of NMCTH.

Suitability of the veins and arteries for the AVF creation was determined by the operating nephrologist by physical examination only. Physical examination included palpating the arterial pulse volume and arterial wall; veins were assessed by palpation with the aid of a tourniquet and by feeling the thrill on tapping the vein. Our first priority was to make distal AVF in non-dominant hand and we moved to proximal sites when the vessels at distal sites were not found suitable on clinical examination. The Allen test was checked before proceeding with distal AVFs. Preoperative Doppler ultrasonography (USG) mapping of the vessels was not performed to limit the financial burden. Baseline demographic characteristics were collected prospectively and digitally recorded. A written informed consent was taken from the patients prior to the procedure.

All procedures were performed under local anesthesia using injection xylocaine without adrenaline in a general surgery operating room. A pre-operative 1 gm cefazolin infusion was used as a prophylactic antibiotic. A longitudinal incision was preferred for the wrist AVFs and transverse incision for the proximal AVFs at the elbow. The target vein and artery were exposed using a combination of blunt and sharp dissection.

An end to side anastomosis (end of the vein anastomosed to the side of the artery) was the preferred technique. However, when the vein and the artery were in close proximity, side to side anastomosis (side of the vein anastomosed to the side of the artery) was utilized. The side to side anastomosis was then converted to a functional end to side anastomosis by ligating the vein distal to the anastomosis to prevent distal venous hypertension.

The vascular anastomosis was performed using a double needle prolene 6.0 suture and following the basic techniques of vascular suturing as described by Alexis Carrel (also known as the father of the vascular anastomosis).[12] The vessel walls were sewn from the middle of the arteriotomy and venotomy incision using continuous running sutures in both directions to make a final single knot on the anterior aspect of the anastomosis. Magnifying loupes were not used by the operating nephrologist.

All patients were followed up on 1st post-operative day and at 2 weeks and 3 months after the surgery to examine the wound, to assess the thrill and maturity of AVFs by physical examination. Ultrasound mapping of the AVFs were not done during the post-operative follow up. All AVFs that were used and supported blood flow of 300 ml/min during hemodialysis or found to be clinically mature on physical examination within 3 months of creation were classified as functional.

A retrospective analysis of the prospectively collected data was done to assess the demographics, the sites of AVFs, their functional status according to the site and complications encountered. All data were reported as mean ± standard deviation (SD) or number (N) and percentage (%). SPSS version 26 was used for statistical analysis.

## RESULTS

One hundred and sixty-six (166) AVFs were created during the study period in 152 patients; mean age of the patients was 52 ± 14 years, 121(73%) were male and 65(39%) diabetics. Only 25 patients (15%) were in the pre-dialysis state (Table1).

The two most common sites for AVFs were left radiocephalic (Lt RC) 69(41.5%), followed by left brachiocephalic (Lt BC) 66(39.7%) (Table1).

Other AVFs created were left brachiobasilic (Lt BB) 10(6%), right brachiocephalic (Rt BC) 10(6%), right radiocephalic (Rt RC) 9(5.4%) and right brachiobasilic (Rt BB) 2(1.2%) (Table1).

**Table 1. Baseline characteristics of the patients**

| Variables | Mean ± SD, N(%) |
|---|---|
| Age | 52 ± 14 years |
| Sex (M/F) | 121/45 (73/27) |
| **Causes of ESKD** | |
| CGN | 73 (44) |
| DM | 65 (39) |
| HTN | 20 (12) |
| Others | 8 (5) |
| Pre-dialysis patients | 25 (15) |
| **Sites of AVF** | |
| Lt RC | 69 (41.5) |
| Lt BC | 66 (39.7) |
| Lt BB | 10 (6) |
| Rt BC | 10 (6) |
| Rt RC | 9 (5.4) |
| Rt BB | 2 (1.2) |

SD, standard deviation; N, number; M, male; F, female; ESKD, end stage kidneydisease; CGN, chronic glomerulonephritis; DM, diabetes mellitus; HTN, hypertension, AVF, arteriovenous fistula; Lt RC, left radiocephalic; Lt BC; left brachiocephalic; Lt BB; left brachio-basilic; Rt BC, right brachiocephalic; Rt RC, right radiocephalic; Rt BB, right brachiobasilic.

End to side anastomosis was performed in 111(66.9%) cases (fig. 1) and side to side anastomosis with distal ligation of the vein in the remaining 55(33.1%) cases (fig. 2).

AVFs 139 (83.7%) were functional at 3-months post creation and were used for hemodialysis. Functional outcome of the AVFs according to the site of creation is shown in Table 2.

We encountered three cases of lymphoceles within 14 days post operatively, all in the Lt BC AVF (fig. 3). All three lymphoceles subsided with repeated needle aspiration and tight bandage application; however, two BC AVFs got thrombosed. Two Lt BC AVFs got infected about 2-weeks after surgery and developed a pseudoaneurysm requiring referral to a vascular surgeon.

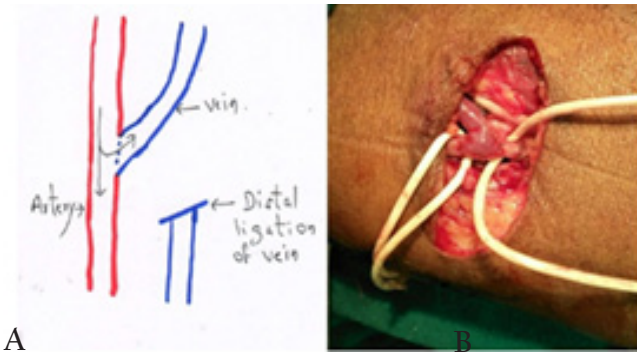


**Figure 1. End to side anastomosis (A) diagrammatic representation; long arrows inside the artery and vein indicate the direction of flow of blood (B) end of the cephalic vein anastomosed to the side of the brachial artery.**

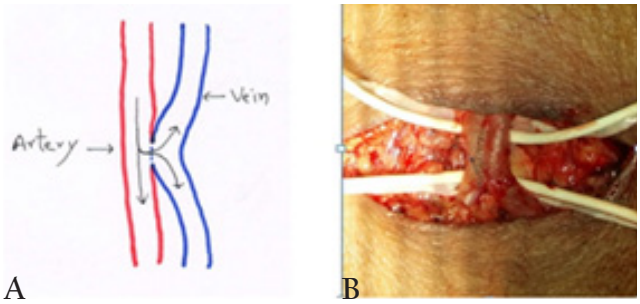


**Figure 2. Side to side anastomosis (A) diagrammatic representation; long arrows inside the artery and vein indicate the direction of flow of blood (B) side of the cephalic vein anastomosed to the side of the brachial artery.**

**Table 2. Functional outcomes of the AVFs according to the site of creation**

| Sites of AVF, N | Functional outcome, N (%) |
|---|---|
| RC (Lt + Rt), 78 | 59 (75.6) |
| BC (Lt + Rt), 76 | 69 (90.7) |
| BB (Lt + Rt), 12 | 12 (100) |

AVF, arteriovenous fistula; N,number; RC, radiocephalic; BC, brachiocephalic; BB, brachiobasilic; Lt, left; Rt, right

**Figure 3. Lymphocele formation following creation of left brachiocephalic arteriovenous fistula**

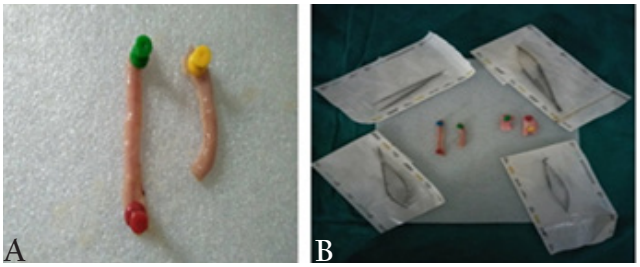


**Figure 4. (A) parts of chicken intestine to practice vascular anastomosis, (B) parts of chicken intestine and aorta of a goat along with surgical instruments (fine forcep, crestro needle holder, potts scissors) needed to practice vascular anastomosis**

## DISCUSSION

Surgical creation of AVFs has been described by nephrologists worldwide. Ravani and colleagues from Italy reported that 197 consecutive patients from 1995 to 2001 received a fistula as a first permanent access, 22% of their patients were diabetic. The primary patency was 64% and 55%, respectively at 1-year and 2-year.[4]

Konner and colleagues from Germany in 2002 published outcomes of fistula created in 748 consecutive patients from 1993 to 1998, 24% of the total patients were diabetic. Primary access survival was 67%, 69%, 85% and 70% for patients who were under 65-years of age and were female non-diabetic, female diabetic, male non diabetic and male diabetic patients, respectively. Primary access survival for similar group of patients but who were 65-years or older was73%, 78%, 77% and 81% respectively.[5]

Nephrologists began performing AVF surgery at the Tirunelveli Kidney Care Center, India since 1996. The initial experience of the center with 265 patients was presented at the World Congress of Nephrology in Berlin in 2003. The study reported no difference in the outcome of AVFs created by the nephrologists and surgeons.[6]

In our study 166 AVFs were created by a single nephrologist over a 3-year period. 78(47%) were radiocephalic, 76(45.7%) were brachiocephalic and 12(7.3%) were brachiobasilic AVFs. The higher number of proximal AVF was due to inability to evaluate the vessels pre-operatively with Doppler ultrasonography. The proximal upper arm veins were easily visible on clinical examination resulting in more number of proximal AVFs. In the study from the United States, higher number of proximal AVFs was created compared to distal arm. The authors questioned the dictum 'distal is better', if the goal is to achieve a higher prevalence of AVFs in the chronic hemodialysis patients.[8]

In our study, brachiobasilic AVF was created in 12 patients, without superficializing the basilic vein. The leaner patient population allows cannulation without this additional surgery. The author intends to learn this advanced surgical skill in future as transpositioning of basilic vein by nephrologists has been described in literature.[9]

Both end to side anastomosis and side to side anastomosis of the vessels was performed in this series. The first surgical description of AVF was a side to side anastomosis.[2,3] There is no superiority of one technique over another. The author believes that it is better to learn both techniques because when the artery and vein are farther apart from each other, an end to side anastomosis may be optimal. However, when the vessels are in close proximity, a side to side anastomosis is technically easier and less time consuming.

About 84% of AVFs created in our study were functional within 3-months post creation and were used for hemodialysis. The functional outcomes of radiocephalic AVFs and brachiocephalic AVFs were 75.6% and 90.7% respectively at 3 months. All 12 brachiobasilic AVFs were successful in supporting dialysis; however these brachiobasilic AVFs did not require any transposition of the vein due to lean patient arm and clinically easily accessible segment for cannulation during hemodialysis. We did not analyze the primary patency rate at one year as a significant number of patients were referred from other centers for AVF creation and long term follow up was unavailable. Our results are comparable to that reported by surgeons. In a study published in 2020 by vascular surgeons from Bir Hospital, Nepal, 304 AVFs (including both radiocephalic and brachiocephalic) were created. Overall early patency rate of AVF in the study was 85.85%.[13] Similarly plastic surgeons from India have reported an overall success rate of 72.3% in 271 AVFs; proximal fistulas had higher success rate than distal fistulas (76% versus 70%).[14]

Surgical creation of AVFs can sometimes be a turf issue between nephrologists and surgeons. The general surgeons are skeptical of the surgical skills of a nephrologist.[15] However, nephrologists from different parts of the world have acquired these surgical skills and have reported their successful outcomes.[3,4,8,9,11]

It is particularly difficult for the nephrologists to get the required surgical training of AVF creation. The author (SS) has piecemealed his training. Initially by assisting willing general surgeons, vascular surgeons and urologists in two different centers at two different time points. The experience allowed him to observe closely strengthening his belief of acquiring the surgical skills without having completed a formal surgical residency. At one of these centers he was trained in a wet laboratory with intestines from a chicken or an aorta from a goat to simulate vascular anastomosis (fig. 4). The author never got to operate on patients, which obviously was the next step in his training.

The author's next step was to train with a nephrologist who performed AV surgery. As a fellow of the Asian Pacific Society of Nephrology the author (SS) spent 6 months in a center in India under the supervision of a nephrologist (SSS) who routinely creates AVF (approximately 20 surgeries each month). The training was vigorous and structured, initially as an observer and first assistant followed by becoming a primary operator with the mentor assisting and finally as an independent operator. At the end of 6-months a total of 100 AVF surgeries were performed with assistance and 20 independently.

A nephrologist creating AVF helps with shortening the time to surgery, increase the rate of pre-emptive AVF placement and reduce the dependence on catheter to initiate hemodialysis. Surgical treatment of a dysfunctional AVF and aneurysms/pseudoaneurysm warrants further training. In our study, two patients with pseudoaneurysms were referred to a vascular surgeon, emphasizing the need to build a vascular access team that works in harmony.

This was a single centre study and the operating nephrologist was well trained in the surgical skills of AVF creation before he started doing the surgeries independently. Other nephrologists willing to do the AVF surgeries need to undergo similar type of structured training to reproduce similar results.

## CONCLUSION

The outcomes of AVFs created by a single nephrologist in Nepal are similar to those reported in the literature. A nephrologist with passion, perseverance and supervised training can successfully acquire the surgical skills of AVF creation.

## REFERENCES


1. Konner K. A primer on the av fistula Achilles' heel, but also Cinderella of haemodialysis. *Nephrology Dialysis Transplantation*. 1999;14(9):2094-8.
2. Brescia MJ, Cimino JE, Appel K, Hurwich BJ. Chronic hemodialysis using venipuncture and a surgically created arteriovenous fistula. *N Engl J Med*. 1966;275(20):1089-92.
3. Mishler R. Autologous arteriovenous fistula creation by nephrologists. *Advances in chronic kidney disease.* 2009;16(5):321-8.
4. Ravani P, Marcelli D, Malberti F. Vascular access surgery managed by renal physicians: the choice of native arteriovenous fistulas for hemodialysis. *American journal of kidney diseases*. 2002; 40(6): 1264-76.
5. Konner K, Hulbert-Shearon TE, Roys EC, Port FK. Tailoring the initial vascular access for dialysis patients. *Kidney international.* 2002;62(1):329-38.
6. Vachharajani TJ, Balasubramaniam J, Abraham G, editors. The current state of interventional nephrology in India. Seminars in dialysis; 2012: Wiley Online Library.
7. Sampathkumar K, Lobo V, Balasubramaniam J, Mahaldar A, Yevzlin AS, Kumbar L. Vascular Access Creation and Care Perspective From India. *Advances in chronic kidney disease*. 2015;22(6):466-70.
8. Mishler R, Yevzlin AS. Outcomes of arteriovenous fistulae created by a US interventional nephrologist. Seminars in dialysis; 2010: Wiley Online Library.
9. Mishler R, Yang Z, Mishler E. Arteriovenous fistula creation by nephrologist access surgeons worldwide. *Advances in chronic kidney disease*. 2015;22(6):425-30.
10. Bonucchi D, D'Amelio A, Capelli G, Albertazzi A. Management of vascular access for dialysis: an Italian survey. *Nephrology Dialysis Transplantation.* 1999;14(9):2116-8.
11. Stanziale R, Lodi M, D'Andrea E, D'Andrea T. Vascular access for hemodialysis: experience of a team of nephrologists. *Hemodial Int.* 2008;12(3):328-30.
12. Aida L. Alexis Carrel (1873-1944): visionary vascular surgeon and pioneer in organ transplantation. *J Med Biogr.* 2014 Aug; 22(3): 172-5. doi:10.1177/0967772013516899. Epub 2014 Apr 15. PMID: 24737197.
13. Magar DT, Kiran Shrestha K, Chapagain D, Shrestha K, Thapa S. Factors affecting the patency of arterio venous fistula for dialysis access. *JKISTMC*. 2020;2(1)3: (49-54)
14. Sahasrabudhe P, Dighe T, Panse N, Patil S. Retrospective analysis of 271 arteriovenous fistulas as vascular access for hemodialysis. *Indian J Nephrol.* 2013 May;23(3):191-5. doi: 10.4103/0971-4065.111845. PMID: 23814417; PMCID: PMC3692144.
15. Georgiadis GS, Polychronidis A. Access surgery and the role of nephrologists. *American journal of kidney diseases*. 2003;41(5):1126.