Can We Create an Arteriovenous Fistula for Hemodialysis through 0.5–1.0 cm Incision without Using Vascular Clamps?

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Indian J Plast Surg 2021;54:186–191.

Abstract

Background A native arteriovenous fistula (AVF) is a gold standard for renal replacement therapy, where regular hemodialysis is the mainstay of survival in the majority of patients suffering from end-stage renal disease. Appropriate vascular clamps are routinely used to occlude an artery and a vein before an arteriotomy or a venotomy is done to prevent blood loss and have a clear field and an ease of anastomosis. The title makes one wonder, is it then possible to create an AVF without using vascular clamps? And through incisions as small as 0.5to 1.0 cm? This is made possible by a very simple new technique, presented here, that helps to occlude vessels to create an AVF through minimal access, and minimize blood loss and postoperative pain.

Material and Method Total 622 AVFs were created between 1998 and 2019. With regular forceps or an AVF platform (design given), an AVF was created without using a vascular clamp. Total 321 cases were operated with 0.5 to 1.0 cm and 215 cases within 1.5 cm skin incision approach.

Results There were ~85% successful functional fistulas. The blood loss was negligible, and only one in three required pain killer in postoperative period.

Conclusion A simple new technique described here makes it possible to create a functional AVF through a small incision, without using vascular clamps.

Keywords
► ESRD
► hemodialysis
► arteriovenous fistula
► chronic kidney disease
► minimal access surgery
► vascular access

Introduction

Arteriovenous fistula (AVF) is a life-saving procedure for long-term survival of patients with chronic kidney disease.[1-4] Today minimal access surgery (MAS), with advantages of quick recovery, reduction in pain, bleeding, and hospitalization, is at the forefront of surgical advances. Can we then create an AVF through a 0.5, 1.0, or a 1.5 cm skin incision approach? If so, how? With vascular clamps occupying certain space, such a possibility would be unthinkable. Here a very simple innovative idea is presented that creates an AVF through minimal access without using vascular clamps.

Material and Method

From 1998 to 2019, 622 AVFs were created without using a vascular clamp, by an innovative concept presented here, in an age group ranging from 15 to 82 years. Male to female ratio in this group was ~2:1.

published online
June 28, 2021

DOI https://doi.org/10.1055/s-0041-1729503
ISSN 0970-0358

Thieme Medical and Scientific Publishers Pvt. Ltd. A-12, 2nd Floor, Sector 2, Noida-201301 UP, India

Zeiss OPMI II or Leica microscope was used to develop the technique, with 33 cases operated with 0.5 cm skin incision; later, most of the cases were done with a Zeiss ophthalmic loupe with 4x magnification, with 288 cases within 1 cm and 215 cases within 1.5 cm skin incision approach, at distal forearm, including 3 cases of ulnar AVF. The series also includes 57 cases of AVF done at the elbow.

The Method

The *first method* involved side-to-side radial artery cephalic vein AVF creation[5] through a minimal access approach without using vascular clamps.

A skin incision is taken at a suitable site, proximal to the wrist between radial artery and cephalic vein, where they are closest to each other. Color Doppler is used to choose the site when the vein is not visible or palpable and collapsible. After the dermis is cut, a segment of cephalic vein is isolated with a small blunt tip scissor and a fine tip bipolar cautery. While preserving the radial cutaneous nerve, a buttonhole is created into the soft tissue below the vein and a vascular loop is passed around to bring the segment of the vein toward the incision, excess soft tissue is stripped off, and tributaries if any are cauterized or ligated and divided. Then the skin opening is shifted medially over the position of the radial artery, and the soft tissue is cleared till the deep fascia. Next, a small pinch of deep fascia over the radial artery is elevated and snipped to create an opening in the deep fascia. The artery is then separated and protected while the deep fascia is divided under vision by exposing it with a small right-angle retractor pulling the corner of the skin incision proximally or distally as needed. This prevents kink and compression by the edge of the deep fascia when the artery is elevated from its bed. With a blunt round tip dissecting scissor, the radial artery is separated from its venae comitantes, and after ligating or cauterizing any fine branches excess adventitia is removed. Now, there are two ways of preparing for an AVF without using a vascular clamp: one with "forceps," and the other with an "AVF platform"—a simple device designed by the author, which is a long and flat device, slightly curved on the flat surface from side to side, with round borders, with narrow tapering rounded tip at one end that broadens gradually going toward the other end (►**Fig. 1**). In "forceps technique," both the prongs of the forceps are inserted under the freed segment of the radial artery and then the freed segment of cephalic vein is brought over them with the help of the vascular loop; the tips of the prongs are brought out of the incision and rest across the incision. Then a needle cap is inserted between the two prongs of the forceps and slid backward toward the fulcrum to widen the gap between its two prongs till the vessels are sandwiched gently but adequately between the outer surface of the forceps prong and the soft tissue around it, occluding the vessels (►**Fig. 2**). In the other technique, the narrow blunt rounded end of the AVF platform is pushed under the freed arterial segment and the venous segment is brought over it with the help of the vascular loop. Then the tip of the AVF platform is brought out on the other side of the incision to rest across the incision. It is then gradually pushed forward till the arterial and venous segments get gently sandwiched between the soft tissue and the broader rounded edges of the AVF platform to block the lumen

Fig. 1 Arteriovenous fistula platform.

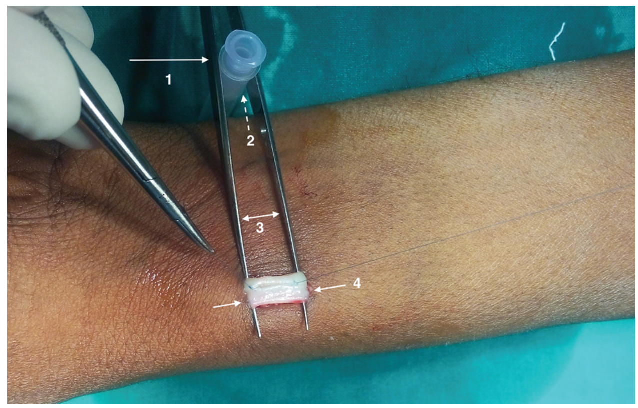

Fig. 2 Forceps technique for arteriovenous fistula creation.

to prevent any blood flow with optimal pressure. The artery and vein segments thus brought out of the incision are now lying side by side abutting each other. The arterial and venous segments are then carefully stripped off of excess loose adventitia. Two well-matched, parallel venotomy and arteriotomy, of anywhere between 5 and 10 mm length, are created. One notices that as the walls of the artery and vein lie abutting each other, the inner cut edges are in end-to-end contact, which makes suturing easy. The side-to-side anastomosis is created with 7–0 Prolene sutures (►**Fig. 3**). After starting at one corner, care is taken that the second and the subsequent continuous stitches over the posterior wall edges are close enough to prevent leakage, and the site is repeatedly sprayed with a solution of Heparin 500 units diluted in 100 cc of 0.9% normal saline to prevent drying and for intimal protection (Video 1).

Video 1

Dr. Gajiwala's technique of arteriovenous fistula creation without using vascular clamps through minimal access. Online content including video sequences viewable at: https://www.thieme-connect.com/products/ejournals/html/10.1055/s-0041-1729503.

After ensuring hemostasis, the proximal venous outflow is examined to release any kink or compression or a band of

Fig. 3 Completed arteriovenous fistula.

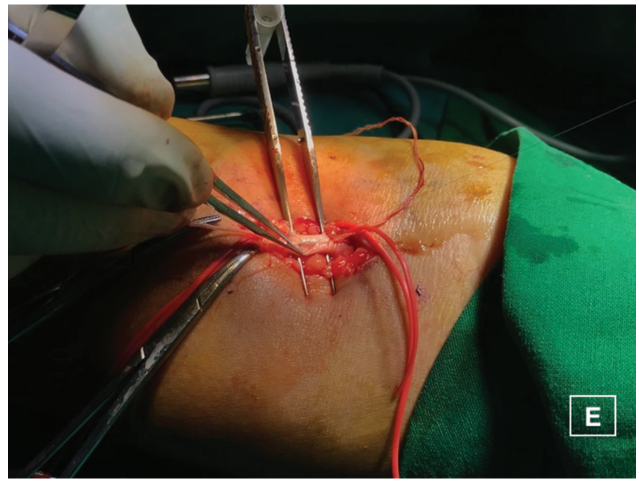

Fig. 4 Arteriovenous fistula being done at the elbow, over the forceps.

tissue across. Aim is to see that proximal outflow is larger and smoother than the distal one. Rarely, one may tie off the distal end converting it into a side-to-end AVF.

The *second method* involved creating brachial artery–antebrachial vein/proximal radial or ulnar artery and antebrachial or a perforating vein[6] AVF without using vascular clamps—a different challenge.

Here the surgery is performed under medial antebrachial cutaneous nerve block with 3 to 4 cm vertical incision parallel to the vessels between the artery and vein. After isolating antebrachial vein, the biceps aponeurosis is divided lateral to medial just sufficient enough to expose and isolate the brachial artery and its branches, radial and ulnar, with gentle blunt dissection. A perforator vein connecting antebrachial vein to deep vein is either ligated or used for AVF anastomosis and then disconnected from deep vein to prevent diversion of AVF blood flow into a deep vein creating a useless left to right shunt. The advantage of minimal access, creating optimal condition for skin and soft tissue pressure that occludes arteriovenous segments, is missing at elbow as the artery is deep and needs larger incision. Here the trick is to create a smaller button hole in soft tissues below the arterial and venous segments that would allow AVF platform or prongs of the forceps to pass though and stretch gently, but the surrounding soft tissues will push the vessels downward creating an occlusion of the lumen. However, before starting both brachial arteries and antebrachial vein are secured with a double loop of a linen or a vascular loop (►**Fig. 4**), which if needed can be tightened to prevent bleeding. Brachial artery (or proximal radial or ulnar division)–antecubital vein (or deep perforator vein) is similarly occluded with AVF platform or prongs of the forceps and 4 to 5 mm linear window is created to do the anastomosis. A larger AVF may cause very large diversion of blood flow into the vein leading to relative ischemia of the forearm and the hand or a huge left to right shunt with high chances of cardiac failure.[7]

Results

In a functioning AVF dialysis, blood flow rate of 250 to 350 mL per minute was achieved on an average and patients received dialysis for 3 to 4 hours per session on usually twice- or thrice-a-week schedule. One of the first two cases done in the month of August 2002 with 0.5 cm incision approach (►**Figs. 5**) a very tiny window, is still functional after 18 years. This incision, half the width of an adult finger nail, is quite challenging and took an average of 3 hours. But for a larger incision of 0.8 to 1.5 cm, the time required was around 45 to 90 minutes. In general fistula first approach, before superficial veins were punctured, had a better outcome. Also, it was found useful if patients, nurses, medical colleagues, and anesthesiologists were educated regarding preserving cephalic vein, renaming it as a "future kidney or a dialysis vein." Early presurgery exercise of forearm muscles developed better venous channels and ensured higher success rates.

Discussion

Recent advances in surgeries have focused on MAS due to advantages of less pain, shorter hospitalization, faster recovery, and smaller scars. A small incision is used as a port of entry for an endoscope to view or to insert an instrument to manipulate, dissect, coagulate, cut, and take a biopsy, requiring many ports to complete a surgery. Reduction in pain seen in MAS leads to an idea of creating a successful functional

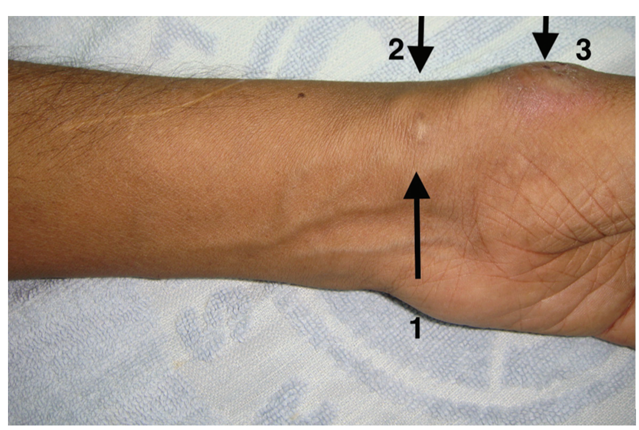

Fig. 5 5-mm approach: 18 years of follow-up.

Table 1 Results: arteriovenous fistula (AVF) through minimal access

	0.5 cm (33)	0.5–1.5 cm (503)	>1.5 cm (29)	At elbow (57)	Total (622)
LMWH	2	49	4	6	61
Thrombosis	1	23	2	2	28
Failure to mature*	1	52	5	4	62
Bleeding	–	3**	1	–	4
Infection	–	–	–	–	–
Wound gap	–	–	–	3#	3
Hematoma	–	9	1	2	
Pain killers needed	2*	154*	12	57	168/565
Venous hypertension	1	13	1	3	18
Vascular steal phenomenon	–	–	–	–	–
Aneurysm	–	1*	–	–	1

Abbreviations: AVF, arteriovenous fistula; LMWH, low-molecular-weight heparin; VAES, vascular access ecosystem.
Notes:

- VAES, enhanced by regular exercise, was used for two-needle hemodialysis after adequate flow was established, mostly between 4 and 8 weeks. AVF was considered matured if there were at least six consecutive successful dialysis.
- With ~90% having hypertension and 40% diabetes, 70% had some form of atherosclerosis. Severe cases of atherosclerosis were given low-molecular-weight heparin postoperatively at least for 5 days. All atherosclerotic patients were put on antiplatelet agents.
- Two cases of thrombosis that occurred within a day were explored and redo surgery were done. Other thrombosis occurred much later.
- Bleeding occurred in four cases, following heparinized hemodialysis, which were explored and controlled with protamine spray. No AVF leakage was seen.
- Mild wound gap of ~2 mm occurred in three patients near elbow, due to postoperative edema that later healed spontaneously.
- An infected aneurysm occurred 2 years later, following infective endocarditis.
- Painkillers were given on demand in ~168 out of 565 cases of minimal access, except in surgery at elbow.
- Six out of 18 cases were of severe venous hypertension and 2 needed ligation of AVF. Others needed ligation of distal venous outflow.

AVF through just 0.5 cm skin incision in 31 of 33 cases, with the use of a microscope. This opened the possibility of creating successful AVF routinely through 1 to 1.5 cm skin incisions mostly under ophthalmic loupe magnification, which was used later. This is not possible with vascular clamps, which occupy a certain space. The idea presented here, to occlude the lumen without using vascular clamps, is very simple indeed. The pressure to occlude lumen comes from surrounding soft tissues, which is safer and least harmful to the vessels, akin to soft tissue pressure-occlusion of different vessels when a tourniquet is applied. Another advantage is that the technique brings a segment of artery and vein in close proximity abutting each other, which makes anastomosis very easy and gives an uncluttered, focused, bloodless surgical field where only a completely isolated anastomotic site stabilized on a platform is seen. Further, the AVF platform or the forceps separate the rest of the tissue away from the anastomotic field and avoid soft tissue being caught up into the sutures while suturing the posterior wall. And since the posterior cut edges are abutting each other, it makes it easier to suture the posterior walls together without any struggle, pull, or much handling with the forceps, and also avoids tension on the suture line and tears in the wall. With a small incision, lesser number of cutaneous sensory nerve endings are cut and therefore there is less pain. Painkillers are given only on patient demands, given to about one out of three patients in this series, except for an AVF created at elbow. Bleeding is less. And there has been no infection in this series. Wound gap is rare. Also, there is less likelihood of creating a very high-flow fistula that can lead to cardiac failures and steal phenomena.[7-12] The problem does, however, arise when one comes across a very thick atherosclerotic blood vessel. Here a proper dissection and freeing of a longer segment of blood vessels and gentle stretching is a key to prevent tears and disruptions in intima. At times one finds that intima does crack and cholesterol plaques are jutting out of the edge of an arteriotomy. Handling this vessel is fraught with danger of further damaging the intima.[13] Intravenous heparin has very rarely been used in the postoperative period except when there is severe atherosclerosis and is followed by low-molecular-weight heparin and antiplatelet agents (►**Table 1**). It is the high flow across the fistula that saves the day. Therefore, it is important that patients do not become dehydrated. And with the help of a nephrologist adequate fluid intake be calculated and instructions given to the patient. Most cases of early thrombosis or failures have been due to atherosclerosis, small diameters of vein and the artery, poor venous channels or veins with partial blockage due to intraluminal thrombus due to previous intravenous infusions, dehydration that reduces blood flow, compression of operative site, smoking, or some form of coagulopathy.[14-18] With small size of fistula, there are less chances of developing eddy currents and thrombosis. On an average these fistulas develop between 400 and 800 mL of flow over a period of time and are adequate for dialysis at the flow rate of 250 to 350 mL/minute. But since all AVFs are a left-to-right shunt, this leads to an effective reduction in ejection fraction. And many of these patients of end-stage renal disease along with diabetes and hypertension also have associated cardiac problems like ischemic heart disease, arrhythmias, and diabetes-related cardiac autonomic neuropathy and poor cardiac function.[11,12] The small AVF rarely develops 1,500 to 2,000 mL/minute of flow rate, which is a major cause of recurrent congestive heart failure in patients on maintenance hemodialysis.[12,19,20] There has been not a single case of steal syndrome. It may simply be that distal venous outflow with arterialized blood provides alternate retrograde flow to the digits, which is quite often seen in cases of venous hypertension. Another advantage of side-to-side fistula is seen quite often, when due to repeated venipuncture a proximal venous outflow shuts down, and the distal venous outflow creates another circuit through dorsal venous arch. Or at times it provides two enlarged veins providing double access. There are also disadvantages and difficulties, like the technique is time consuming specially with 0.5 cm approach, which requires microscope, microsurgical skills, and patience. Edema, obesity, scarring due to previous intravenous fluid extrusions, and patients on blood thinners do pose a challenge in dissection through this small window and a confined space. Also, one is unable to ligate number of venous tributaries to prevent diversion, and relies on the principle that the venous flow will occur through the path of least resistance. Also, there are higher chances of venous hypertension.[21,22] And one needs to at times ligate the distal venous outflow or its tributaries, to redirect the flow. As with vascular clamp technique, in these series too there were cases of either early thrombosis or failure of AVF to develop a good flow. Failure to develop can best be explained in Dixon's words, "maturation requires a compliant and responsive vasculature capable of dilating in response to the increased velocity of blood flowing into the newly created low-resistance circuit."[23]

Conclusion

A new simple innovative concept is presented here to create an AVF through minimal access without using vascular clamps that helps simplify surgery by bringing vessels in juxtaposition thereby reducing tension at suture line, giving a clear unencumbered field isolated from the surrounding tissues, with added benefit of less bleeding and less postoperative pain.

Conflict of Interest

None.

References

1 Vascular Access 2006 Work Group. Clinical practice guidelines for vascular access. Am J Kidney Dis 2006;48(Suppl 1):S176–S247

2 Besarab A. Resolved: fistulas are preferred to grafts as initial vascular access for dialysis. Pro. J Am Soc Nephrol 2008;19(9):1629–1631

3 Santoro D, Benedetto F, Mondello P, et al. Vascular access for hemodialysis: current perspectives. Int J Nephrol Renovasc Dis 2014;7:281–294

4 Ravani P, Palmer SC, Oliver MJ, et al. Associations between hemodialysis access type and clinical outcomes: a systematic review. J Am Soc Nephrol 2013;24(3):465–473

5 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):1089–1092

6 Gracz KC, Ing TS, Soung LS, Armbruster KF, Seim SK, Merkel FK. Proximal forearm fistula for maintenance hemodialysis. Kidney Int 1977;11(1):71–75

7 Zamboli P, Lucà S, Borrelli S, et al. High-flow arteriovenous fistula and heart failure: could the indexation of blood flow rate and echocardiography have a role in the identification of patients at higher risk? J Nephrol 2018;31(6):975–983

8 Schmidli J, Widmer MK, Basile C, et al. ESVS Guidelines Committee; ESVS Guidelines Reviewers. Editor's choice - vascular access: 2018 clinical practice guidelines of the European Society for Vascular Surgery (ESVS) Eur J Vasc Endovasc Surg 2018;55(6):757–818

9 Gibbons CP. Primary vascular access. Eur J Vasc Endovasc Surg 2006;31(5):523–529

10 Di Lullo L, House A, Gorini A, Santoboni A, Russo D, Ronco C. Chronic kidney disease and cardiovascular complications. Heart Fail Rev 2015;20(3):259–272

11 Schiffrin EL, Lipman ML, Mann JF. Chronic kidney disease: effects on the cardiovascular system. Circulation 2007;116(1):85–97

12 Di Lullo L, Floccari F, Polito P. Right ventricular diastolic function in dialysis patients could be affected by vascular access. Nephron Clin Pract 2011;118(3):c257–c261

13 Gołębiowski T, Weyde W, Letachowicz K, et al. The sleeve method for creation of radiocephalic arteriovenous fistulas in patients with calcified vessels. J Vasc Access 2017;18(5):384–389

14 Smith GE, Gohil R, Chetter IC. Factors affecting the patency of arteriovenous fistulas for dialysis access. J Vasc Surg 2012;55(3):849–855

15 Pirozzi N, Apponi F, Napoletano AM, Luciani R, Pirozzi V, Pugliese F. Microsurgery and preventive haemostasis for autogenous radial-cephalic direct wrist access in adult patients with radial artery internal diameter below 1.6 mm. Nephrol Dial Transplant 2010;25(2):520–525

16 Kordzadeh A, Chung J, Panayiotopoulos YP. Cephalic vein and radial artery diameter in formation of radiocephalic arteriovenous fistula: a systematic review. J Vasc Access 2015;16(6):506–511

17 Ja YL, Young OK. Pre-existing arterial pathologic changes affecting arteriovenous fistula patency and cardiovascular mortality in haemodialysis patients. Korean J Intern Med (Korean Assoc Intern Med) 2017;32(5):790–797

18 Chitalia N, Ross L, Krishnamoorthy M, et al. Neointimal hyperplasia and calcification in medium sized arteries in adult patients with chronic kidney disease. Semin Dial 2015;28(3):E35–E40

19 Saleh MA, El Kilany WM, Keddis VW, El Said TW. Effect of high flow arteriovenous fistula on cardiac function in hemodialysis patients. Egypt Heart J 2018;70(4):337–341

20 Asif A, Roy-Chaudhury P, Beathard GA. Early arteriovenous fistula failure: a logical proposal for when and how to intervene. Clin J Am Soc Nephrol 2006;1(2):332–339

21 Das S. Comparison of side to side vs end to side arteriovenous fistula in upper limb for hemodialysis. JMSCR 2018;6(11):DOI:, https://dx.doi.org/10.18535/jmscr/v6i11.02
22 Moini M, Rasouli MR, Williams GM, Najafizadeh S, Sheykholeslami G. Comparison of side-to-side brachiocephalic arteriovenous fistula with ligation of the perforating vein with end-to-side brachiocephalic arteriovenous fistula. EJVES 2009;17:7–10
23 Dixon BS. Why don't fistulas mature? Kidney Int 2006; 70(8):1413–1422

