

Results of Prompt Surgical Intervention in Hemodialysis Radiocephalic Fistula Secondary Dysfunction

Iyad Fansa¹, Mesut Kösem², Celalettin Karatepe¹, Adem Sezen³, Hilal Kuşcu Karatepe⁴, Onur Selçuk Göksel⁵

¹Mustafa Kemal University, Faculty of Medicine, Department of Cardiovascular Surgery, Hatay, Turkey

²Acibadem University, Department of Cardiovascular Surgery, Istanbul, Turkey

³Istanbul Bilim University, Health School, Istanbul, Turkey

⁴Korkut Ata University, Health School, Osmaniye, Turkey

⁵Istanbul University, Istanbul Medical Faculty, Department of Cardiovascular Surgery, Istanbul, Turkey

Radiocephalic fistula (RCF) dysfunction is a common problem due to low maturation and patency rates of these fistulas. The most common procedure in such cases is to place a temporary catheter for the dialysis. Temporary catheter placement and undergoing dialysis with this catheter cause complications, reduce the chance for fistula, and deteriorate the quality of life. The aim of this study was to demonstrate that immediate intervention in RCF dysfunctions can increase fistula success for the patient and can reduce the need for a catheter. Furthermore, the hemodialysis treatment can continue without affecting the quality of life. A total of 295 patients who were admitted for RCF dysfunction and who underwent early surgical intervention without any catheter placement were evaluated for postoperative complications, patency rates, and rates and durations of temporary catheter use over a mean time of 47 months of follow-up (range: 4–79 months). Of the patients, 77.2% (n = 228) underwent new proximal anastomosis (NEO; the radial artery and cephalic vein were reached with an incision created proximal to the previous anastomosis), 14.2% (n = 42) underwent brachiocephalic arteriovenous fistula (AVF), 8.4% (n = 25) underwent side-to-side brachio basilic AVF + super-

Corresponding author: Celalettin Karatepe, MD, Mustafa Kemal University, Department of Cardiovascular Surgery, Serinyol-Antakya, Hatay, Turkey.

Tel.: +905052379295; Fax: ±90 326 2455305; E-mail: drcelalettin@hotmail.com

ficialization of the basilic vein. In 88.8% (n = 262) of the patients, successful cannulations were performed within the first 24 to 48 hours without any catheter requirement or complications. Temporary catheter was used for 15.1 ± 10.7 days in 11.2% (n = 33) of the patients. In RCF dysfunctions, early surgical interventions performed in the forearm and elbow provide early cannulation and thus decrease the catheter requirement, also prevent the complications of temporary catheters (infection, decreasing the fistula success, vascular injuries, *etc.*), increase the autogenous fistula success, and allow for the continuation of dialysis without disturbing the quality of life.

Key words: Radiocephalic fistula – Vascular access dysfunction – Early surgical intervention – Temporary catheter

End-stage renal disease (ESRD) incidence and the number of patients undergoing dialysis are on the increase throughout the world.¹ Vascular access is the prerequisite for hemodialysis treatment and is directly related to morbidity and mortality in hemodialysis patients.² Autogenous arteriovenous fistulas (AVFs) provide longevity for hemodialysis patients with high dialysis efficiency and quality of life with low morbidity. The National Kidney Foundation's Kidney Disease Outcome Quality Initiative (NKF-K DOQI) recommends that the first choice of vascular access in hemodialysis patients should be autogenous AVF, and radiocephalic fistulas (RCFs) should be the first among them.³ RCFs are AVFs that are easy to create and use. They cause less complications, protect the proximal vessels, and provide the ideal blood flow for hemodialysis.

Besides their known advantages, RCFs have such disadvantages as high primary failure rate, maturation problems, or low patency rates.⁴⁻⁹ It is believed that these disadvantages will become more important as the population of elderly people increases. For the quality of life in patients with RCF dysfunction, it is crucial to provide RCF refuction and hemodialysis continuation and thus to prevent catheter placement, and when not possible, to shorten the use of a catheter, to protect the limited vascular structure and to perform an operation with high success and patency.¹⁰ To achieve all these, surgical or endovascular procedures are being used at present. In surgical procedures, the routine practice is revisions performed in the forearm. Early AVF-saving operations in the upper arm can also yield the same benefits.

Materials and Methods

Inclusion criteria for the study were: (1) a RCF created at least 3 months previously, (2) sufficient

blood flow (>300 mL/min) in the hemodialysis for at least 1 month, and (3) a surgical intervention for RCF dysfunction at the level of snuff box or wrist without catheter placement. Between June 2005 and February 2011, 1303 patients underwent AVF or AV graft operations in Acibadem University Hospital and Mustafa Kemal University Hospital. Of these, 295 patients who met the criteria were evaluated retrospectively.

An AVF use procedure was created in our clinics and dialysis nurses (nurses who have certification for hemodialysis cannulation and treatment follow-up), dialysis physicians, and hemodialysis patients were educated by vascular surgeons about AVF use procedures. In this context, the protocols to be followed in AVF dysfunctions were determined. With the coordinated work of the patients, the dialysis center and our surgical clinics, after patients, physicians, or nurses experienced AVF problems (such as thrill loss), patients were enabled to reach our surgical clinics as soon as possible. Patients who developed RCF dysfunction were routinely evaluated by a surgeon by physical examination (PE) and color Doppler ultrasonography (USG). With these procedures, arterial and venous anatomy and stenosis or thrombosis areas were evaluated, and thus the site and method of the operation were determined.

According to the surgical protocol used in our clinics for RCF dysfunction, the patients who were detected to have perianastomotic stenosis or thrombosis underwent new proximal anastomosis (NEO) if they had a suitable venous structure in the forearm. In the proximal NEO procedure, the radial artery and cephalic vein were reached with an incision created proximal to the previous anastomosis. Thus, the patients could enter dialysis through this newly created NEO 24–48 hours after the procedure. When the patients did not have enough

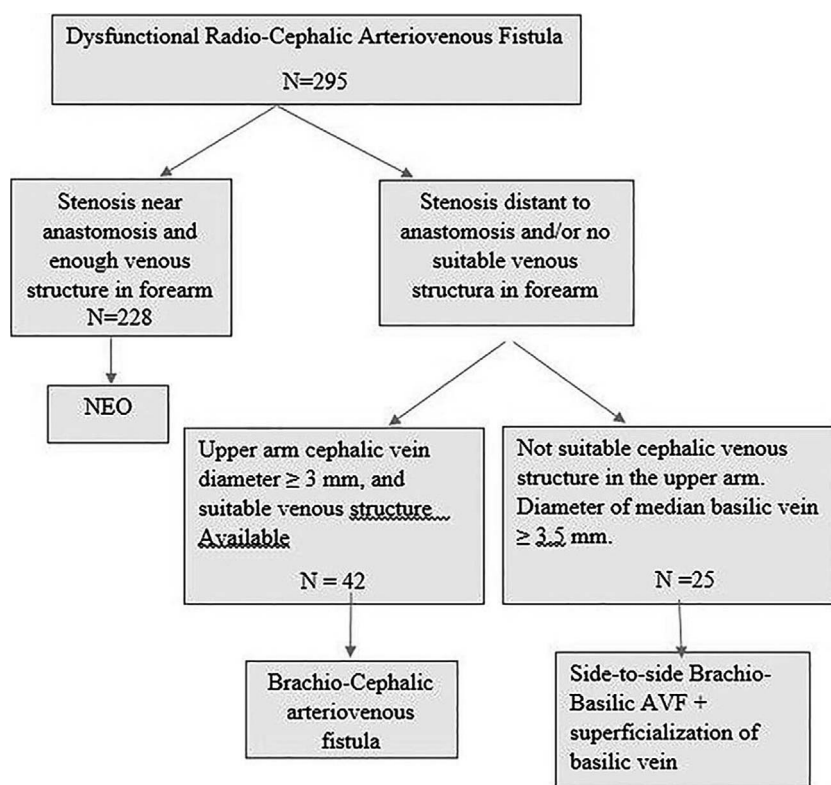


Fig. 1 Choosing surgical treatment in dysfunctional radiocephalic arteriovenous fistulas.

or suitable venous structure, brachiocephalic AVF was performed if their upper arm cephalic vein diameter was over 3 mm in the evaluation with a tourniquet, and if the vein structure was suitable. These patients were evaluated for the thrill, and if thrill was established, they began to have hemodialysis through the newly created AVF 24–48 hours after the operation. In patients whose fistula was considered immature, a temporary catheter was placed surgically in internal jugular veins and the hemodialysis was performed through this catheter. During the follow-up, if the AVF was believed to be mature, the hemodialysis was performed through the AVF, and the catheter was removed after 3 trouble-free dialyses. In patients who were not suitable for brachiocephalic AVF but had a median basilic vein diameter of 3.5 mm or larger, side-to-side brachiobasilic AVF + basilic superficialization was performed and the patients were able to have hemodialysis within 24–48 hours (Fig. 1).

Surgical Techniques

Operations were performed routinely under local anesthesia; five-twenty mL Citanest 2% Flakon (agent

prilocaine) was used as local anesthetic. Uncooperative patients underwent intravenous sedoanalgesia with Dormicum (midazolam) and or fentanyl.

In the proximal NEO procedure, the radial artery and cephalic vein were reached with an incision created proximal to the previous anastomosis. The branches of the cephalic vein were first ligated and incised, then the vein was ligated at the distal end and incised. If the patient was thought to have a thrombus in the vein, the thrombus was removed by pressing out at the proximal end of the venotomy. When the thrombus could not be removed completely, the complete removal was achieved with thrombectomy using a 4 F Fogarty catheter. After these procedures, a 14 F cannula was placed on the open end of the vein. The vein was then washed with a solution of 100 mL physiological saline (PS) and 5000 IU heparin and was dilated. If any resistance was encountered during PS administration, vein passage was controlled with vascular dilators. In patients with vein stenosis, venous dilatation was performed with vascular dilators. All the accessible branches of the radial artery were ligated and incised. To provide arterial dilatation during the operation, Papaverine and Citanest were administered locally. In all cases, anastomosis was performed

Table 1 Patient characteristics

	NEO		BC AVF		BB AVF		Total	
	N	%	N	%	N	%	N	%
Sex								
Male	152	66.7	32	76.2	18	72.0	202	68.5
Female	76	33.3	10	23.8	7	28.0	93	31.5
Age (yr)								
Mean	54.42		62.69		59.68		58.45	
Range	22–68		39–78		42–80		22–80	
Fistula age (months)								
Mean	19.4		18.6		16.8		18.9	
Range	4–28		7–33		6–31		4–33	
Associated disease								
Hypertension	174	76.3	27	64.3	18	72.0	219	74.2
Diabetes	153	67.1	24	57.1	16	64.0	193	65.4
PVD	55	24.1	12	28.6	6	24.0	73	24.7
CAD	39	17.1	6	14.3	5	20.0	50	16.9
Smoking	69	30.2	11	26.2	9	36.0	89	30.2

BB AVF, brachio basilic arteriovenous fistula + superficialization of basilic vein; BC AVF, brachiocephalic arteriovenous fistula; CAD, coronary artery disease; NEO, new proximal anastomosis; PVD, peripheral vascular disease.

with a side-to-side method using 7/0 Prolene. In patients with an adequate thrill, detected by palpating the venous outflow from the anastomosis, the distal end of the vein is ligated and the anastomosis was converted into an end-to-side type. In patients with weak or no thrill, the artery was entered through the distal end of the open vein with vascular dilators (2.5–3.0–3.5 mm), and the artery was dilated. But if sufficient thrill still could not be provided, the arterial system was dilated with a 4 F Fogarty thrombectomy catheter starting from the elbow area. When it was detected that there was enough thrill, the distal end of the vein was ligated at the end of the anastomosis and converted into an end-to-side type.

In the operation of conversion into brachiocephalic AVF, the cephalic vein was prepared as was done in the proximal NEO operation. Side-to-side anastomosis was performed in all patients and the anastomosis was converted into an end-to-side type. In brachiocephalic AVF, if the cephalic vein could not be freed sufficiently, brachiocephalic AVF was created using a 6 mm short interposition polytetrafluoroethylene graft between the brachial artery and the cephalic vein.

In the brachio basilic AVF + basilic vein superficialization operation, after the preparation of the brachial artery and median-basilic vein, side-to-side anastomosis was performed using a 7/0 Prolene continuous suture. After anastomosis, basilic vein superficialization was performed through a second incision 8–10 cm in length.

Definitions

Primary patency

The interval from the time of access creation until first access thrombosis or any intervention to maintain or restore blood flow [North American Vascular Access Consortium and Society for Vascular Surgery (SVS) definition].

Secondary patency

The time from access creation until access abandonment. Secondary patency was not terminated by surgical or interventional radiology procedures to maintain or restore patency (NAVAC and SVS definition).

Statistics

Data were entered into a Microsoft Excel (Microsoft Corporation, Redmond, Washington) spreadsheet for analysis. Statistical analysis was performed using the SPSS software (version 15, SPSS Inc, Chicago, Illinois). Kaplan–Meier analysis was used to determine the primary and secondary patency rates.

Results

Of the patients, 68.5% (n = 202) were male and 31.5% (n = 93) were female. The mean age was 58.4 (range: 22–80). Of these patients, 74.2% (n = 219) had

Table 2 Postoperative early and late complications

	NEO		BC AVF		BB AVF		Total	
	N	%	N	%	N	%	N	%
Early complication (before 72 hours)								
Bleeding	3	1.3	3	7.1	2	8.0	8	2.7
Wound infection	5	2.2	1	2.4	1	4.0	7	2.4
Early thrombosis	4	1.7	2	4.8	0	0	6	2.0
Poor flow	7	3.0	1	2.4	0	0	8	2.7
Ischemic steel	1	0.4	0	0	2	8.0	3	1.0
Edema	1	0.4	2	4.8	3	12.0	6	2.0
Late complication (after 72 hours)								
Late thrombosis	10	4.4	4	9.5	2	8.0	16	5.4
Poor flow	3	1.3	2	4.8	1	4.0	6	2.0
Ischemic steel	1	0.4	0	0	1	4.0	2	0.7
Pseudoaneurysm	2	0.9	2	4.8	2	8.0	6	2.0

BB AVF, brachio basilic arteriovenous fistula + superficialization of basilic vein; BC AVF, brachiocephalic arteriovenous fistula; NEO, new radiocephalic anastomosis.

hypertension (HT), 65.4% (n = 193) had diabetes mellitus (DM), 24.7% (n = 73) had peripheral arterial disease (PAD), 16.9% (n = 50) had coronary artery disease (CAD), and 30.2% (n = 89) had smoking history (Table 1).

Of the 295 patients who underwent surgical intervention for RCF dysfunction between June 2005 and February 2011, 77.28% (n = 228) underwent proximal NEO, 14.23% (n = 42) underwent brachiocephalic AVF, and 8.47% (n = 25) underwent brachio basilic AVF + basilic vein superficialization.

A total of 95.6% (n = 218) of the 228 patients who underwent NEO started to have trouble-free dialysis within 24 to 48 hours. In 4.4% (n = 10) of the patients, a temporary catheter was placed and dialysis was performed through this catheter. Five of these catheters were placed due to complications (vascular injury, hematoma, *etc.*) that developed during the operation or service follow-up to allow healing in the surgical area. The other 5 NEOs were placed in patients whose NEO operations were unsuccessful, or whose NEOs could not be used due to complications (thrombosis, low flow, *etc.*) that developed during follow-up (Table 2). In these patients, an AVF was created in the elbow area 5–15 days later. When the AVF matured, temporary catheters were removed. In NEO performed patients, the rate of the temporary catheter was 4.4%, and the mean duration of temporary catheter use was 18.8 ± 13.8 days (range: 5–40 days).

Within the follow-up period, 51 patients were withdrawn from the study. Some were excluded due to death or transplantation, and some were excluded because they could not be reached. The surgical success in patients who underwent NEO was 98.7%.

The primary patency rates for 1, 2, and 3 years were 91.2%, 85.3%, and 77.9% and the secondary patency rates were 92.7%, 88.8%, and 82.8%, respectively.

The 61.9% (n = 26) of 42 patients who underwent brachiocephalic AVF started to have trouble-free dialysis within 24 to 48 hours. A temporary catheter was placed in 38.1% (n = 16) of the patients. Thirteen of these catheters were placed due to complications (vascular injury, hematoma, *etc.*) that developed during the operation or follow-up to allow the surgical area to heal. In 1 patient, the catheter was placed due to the thrombosis that developed in the AVF during the follow-up. The catheter was kept in place until the AVF created in the other arm in another session became mature. Since the vein diameters were not suitable, catheters were used in 2 patients for longer times. In brachiocephalic AVF performed patients, the rate of the temporary catheter was 38.1%, and the mean temporary catheter use duration was 12.8 ± 9.7 days (range: 7–45 days).

Within the follow-up period, 15 patients were withdrawn due to death or transplantation, and some were withdrawn because they could not be reached. The surgical success in patients who underwent brachiocephalic AVF was 100%. The primary patency rates for 1, 2, and 3 years were 86.1%, 74.2%, and 59.3%, and the secondary patency rates were 91.6%, 83.8%, and 74.0%, respectively.

The 72% (n = 18) of 25 patients who underwent brachio basilic AVF + basilic vein superficialization started to have trouble-free dialysis within 24 to 48 hours. To provide this, the arterial needle was inserted at the distal end of the anastomosis, and the venous needle was inserted into the other

Table 3 Rate and duration of temporary catheter use in dysfunctional radiocephalic arteriovenous fistulas after intervention

	NEO		BC AVF		BB AVF		Total	
	N	%	N	%	N	%	N	%
Catheter								
No	218	95.6	26	61.9	18	72.0	262	88.8
Yes	10	4.4	16	38.1	7	29.2	33	11.2
Duration of catheter (day)								
Mean	18.8 ± 13.8		12.8 ± 9.7		15.1 ± 6.8		15.1 ± 10.7	
Range	5–40		7–45		7–25		5–45	

BB AVF, brachiobasilic arteriovenous fistula + superficialization of basilic vein; BC AVF, brachiocephalic arteriovenous fistula; NEO, new radiocephalic anastomosis.

superficial veins in the arms or feet. The superficialized basilic vein segment became ready for use in about 3 weeks. Thus, both needle entries became suitable for AVF creation. The rate of temporary catheter placement in patients with brachiobasilic AVF + basilic vein superficialization was 29.2% and the mean duration of catheter use was 15.1 ± 6.8 days (range: 7–25; Table 3).

Within the follow-up period, 13 patients were excluded due to death or transplantation, and some were excluded because they could not be reached. The surgical success in patients who underwent brachiobasilic AVF + basilic vein superficialization was 100%. The primary patency rates for 1, 2, and 3 years were 80.0%, 62.5%, and 41.7% and the secondary patency rates were 85.0%, 68.8%, and 50.0%, respectively (Table 4).

In total, 88.5% (n = 262) of the 295 patients who underwent the aforementioned operations due to RCF dysfunction were able to continue trouble-free dialysis without catheter placement. In 11.2% (n = 33) of the patients, catheter placement was performed and the mean period of catheter use was 15.1 ± 10.7 days (range: 5–45).

The surgical success of the interventions performed due to RCF dysfunction was 98.9%. The primary patency rates for 1, 2, and 3 years were 91.8%, 85.9%, and 77.9%, and the secondary patency rates were 94.1%, 90.6%, and 84.5%, respectively (Figs. 2, 3).

Discussion

In the meta-analysis of 8 prospective and 30 retrospective studies conducted on RCFs by Albee *et al* in 2013, the 12-month primary patency rate of the RCFs was reported to be 62.5% (95% CI, 54.0%–70.3%), and the secondary patency rate was reported to be 66.0% (95% CI, 58.2%–73.0%).¹¹ According to the results of this meta-analysis, RCFs had medium patency rates, and one third of the RCFs became irreversibly dysfunctional within a year.¹² Additionally, in the results of the meta-analysis, the primary and secondary patency rates were very close to each other, and this indicates that the revision procedures that make the RCFs functional again were rarely performed or not performed effectively.

Table 4 Primary and secondary patency rates in dysfunctional radiocephalic arteriovenous fistulas after intervention

	NEO		BC AVF		BB AVF		Total	
	N	%	N	%	N	%	N	%
Primary patency (year)								
1	188	91.2	31	86.1	16	80.0	235	91.8
2	168	85.3	23	74.2	10	62.5	201	85.9
3	145	77.9	16	59.3	5	41.7	166	77.9
Secondary patency (year)								
1	191	92.7	33	91.6	17	85.0	241	94.1
2	175	88.8	26	83.8	11	68.8	212	90.6
3	154	82.8	20	74.0	6	50.0	180	84.5
Surgical success	225	98.7	42	100	25	100	292	98.9

BB AVF, brachiobasilic arteriovenous fistula + superficialization of basilic vein; BC AVF, brachiocephalic arteriovenous fistula; NEO, new radiocephalic anastomosis.

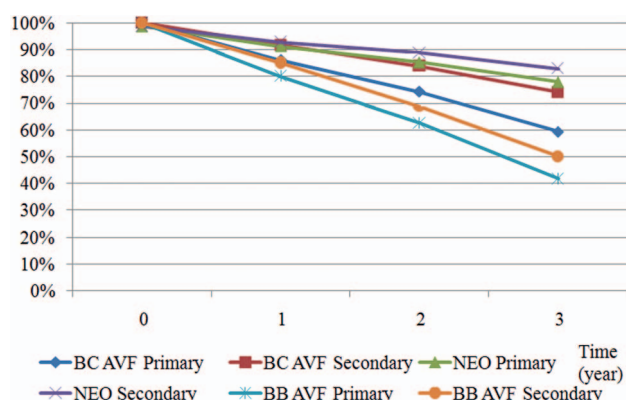


Fig. 2 Primary and secondary patency rates of BS AVF, NEO, and BB AVF in dysfunctional radiocephalic arteriovenous fistulas after intervention.

RCFs often require a second intervention due to low maturation rates and medium patency rates.^{13,14} Since they are time-saving, practical, and relatively successful, endovascular procedures have attracted technical interest and have been used more widely in recent years. The technical advances in endovascular procedures have increased the success rates and decreased the rates of complications, such as thrombus migration, vessel rupture, infection, hand ischemia, remote or local bleeding, and pseudoaneurysm.^{15–17} Despite the high technical success, endovascular treatment has low patency rates. Furthermore, comparative studies revealed that in endovascular treatment, the restenosis rates and pulmonary embolism risk are higher than the surgical intervention.^{15,18,19} There are very few studies that compare surgical and endovascular treatment of thrombosed AVFs. The most extensive study on this issue was made by Turmel-Rodrigues *et al*¹⁶ In this study, published results are given from 93 endovascular interventions applied to 73 patients. The thrombosis in these patients was reported as 56 in the forearm and 17 in the upper arm. According to these results, the technical success rate was 93% for the forearm, and 76% for the upper arm. The 1-year primary and secondary patency rates were 49% and 81%, respectively.

Tordoir and colleagues compared endovascular treatment to surgical treatment of thrombosed AVF. In this meta-analysis study, the technical success rate of endovascular treatment varied between 73% and 93%, and the 1-year primary patency rate ranged from 18% to 70%, with the 1-year secondary patency rate ranging from 44% to 89%.

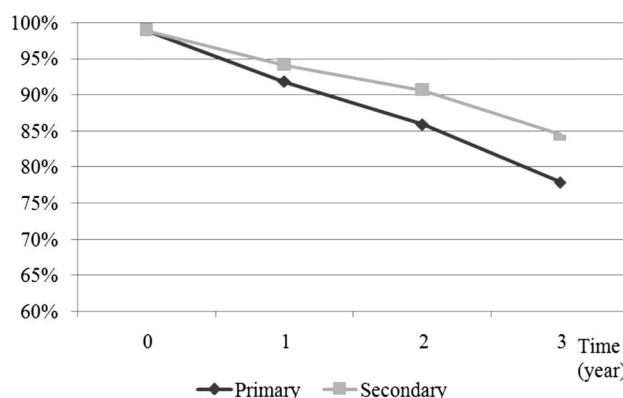


Fig. 3 Primary and secondary patency rates in dysfunctional radiocephalic arteriovenous fistulas after intervention.

In the same study, surgical treatment in patients ranged from 82% to 100% technical success rate and the 1-year primary patency rate ranged from 51% to 93%, with the secondary patency rate ranging from 69% to 95%. In the study of Tordoya *et al*, in autologous AVFs both surgical treatment and endovascular treatment had technical achievement over 90%, but the primary and secondary patency rates as compared with surgery in endovascular treatment was very low.¹⁸ In our study, the success of the operation was 98.9%. The primary patency rates for 1, 2, and 3 years were 91.8%, 85.9%, and 77.9%, and the secondary patency rates were 94.1%, 90.6%, and 84.5%, respectively, consistent with the results of other studies.

Treatment of RCF dysfunction is controversial due to the variable treatment choices. According to the international guidelines, each center should establish its own treatment protocols on the basis of its own resource and the experience of its employees.²⁰ Although randomized studies on the ideal treatment method to be used in saving RCFs are quite few, the available evidence suggests that surgery is better.^{21–23} The procedures used in saving dysfunctional AVFs can successfully be performed in immature fistulas as well as obstructed RCFs. In our clinic, our preference for RCF dysfunctions is to use surgical methods due to high surgical success and good clinical results in the long term.

NEO is the routinely performed surgical method for RCF dysfunctions. There are publications reporting that this method has been performed with high success and low restenosis rates.^{24–26} The procedure to create a new anastomosis at the proximal end of the radial artery using the mature cephalic vein is called NEO. This surgical procedure provides the re-

use of the invaluable forearm veins, and prevents switching to the elbow area.

The main cause of RCF dysfunctions is the problem in the perianastomotic area. The creation of a new anastomosis with NEO using mature radial artery and cephalic vein allows us to bypass the problem in the perianastomotic area. The ideal fistula flow can immediately be reached with this procedure, and the venous bed is ready for early use, and thus the patients can have dialysis without catheter placement or without setting back their sessions. Additionally, new fistula chances, which are crucial for hemodialysis patients, would not be wasted.

Similarly, RCFs provide favorable conditions for early surgical interventions in the vascular structure of the upper arm. In patients whose forearm anatomy is not suitable for NEO, upper arm-saving operations would provide a chance for early use, and thus would decrease the catheter requirement and the duration of catheterization.

A catheter is the only choice for hemodialysis in patients without permanent vascular access.^{27–29} However, catheters lead to complications, such as infection, thrombosis, venous stenosis, or vascular injury.³⁰ Furthermore, catheter placement deteriorates the quality of life. Central venous stenosis that develops due to the catheter is associated with the duration of catheter use, and can eliminate the chances of AVF or AV grafts that can be performed in that extremity. Besides the known complications, a patient who has lost his/her AVF is in a serious psychologic trauma. The catheter placement procedure is the most feared and anxiety-creating procedure for dialysis patients. Hemodialysis with a catheter leads to inadequate dialysis, decreases the quality of life, and reduces the desire to live.

Avoiding catheter use in hemodialysis patients is crucial, but if not possible, shortening the length of use is also important.

One of the most important factors in dysfunctional AVFs is the intervention time. Intervention in a dysfunctional AVF within the first 24 to 48 hours would prevent catheter placement, and thus the quality of life would improve and survival would increase.^{15,21,31,32} Delayed intervention can lead to thrombus, make the intervention more difficult and reduce the rate of success. Studies on this subject have shown that the success rates in interventions carried out within the first 48 hours reach up to 96%.¹⁵ In conclusion, interventions in the early period increase the chance to save the AVF and decrease the catheter requirement of the patient.³¹

The increase in the number of vascular surgeons is important for early intervention. It is also important to diagnose the AVF dysfunction as early as possible and direct the patient to a surgeon. Therefore, the patient, the dialysis team, and the vascular surgeon should work in close cooperation. In our clinic, patients with RCF dysfunction can be intervened within 24 to 48 hours due to the education given to the patients and dialysis staff.

To provide patients with all these advantages, patient and dialysis staff education, and patient, dialysis team, and surgeon cooperation are crucial in the early intervention. In patients with RCF, the vascular system of the entire arm should be evaluated with USG before catheter placement, and if there is no chance for forearm revision, the upper arm AVF choices, brachiocephalic or brachio-basilic AVF operations, should be performed in patients whose vascular structure is suitable.

Although the effectiveness and success rate of early intervention are known, early intervention is not a routine practice. This indicates that there is a need to develop a new point of view in evaluating AVF dysfunctions. In the near future, RCF dysfunctions must be considered as a clinical condition requiring immediate surgical intervention.

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References

1. Coresh J, Selvin E, Stevens LA, Manzi J, Kusek JW, Eggers P *et al*. Prevalence of chronic kidney disease in the United States. *JAMA* 2007;**298**(17):2038–2047
2. Annual Data Report. *Atlas of End-Stage Renal Diseases in the United States, in US Renal Data System*. Bethesda, MD: National Institute of Health, National Institute of Diabetes and Digestive and Kidney Diseases, 2006
3. National Kidney Foundation. KDOQI Clinical Practice Guidelines and Clinical Practice Recommendations for 2006 Updates: Hemodialysis adequacy, peritoneal dialysis adequacy and vascular access. *Am J Kidney Dis* 2006;**48**:S1–S322
4. Lee T, Mokrzycki M, Moist L, Maya I, Vazquez M, Lok CE. Standardized definitions for hemodialysis vascular access. *Semin Dial* 2011;**24**(5):515–524

5. Lok CE, Sontrop JM, Tomlinson G, Rajan D, Cattral M, Oreopoulos G *et al.* Cumulative patency of contemporary fistulas versus grafts (2000-2010). *Clin J Am Soc Nephrol* 2013; **8**(5):1-9
6. Palder SB, Kirkman RL, Whittemore AD, Hakim RM, Lazarus JM, Tilney NL. Vascular access for hemodialysis. Patency rates and results of revision. *Ann Surg* 1985;**202**(2):235-239
7. Fernström A, Hylander B, Olofsson P, Swedenborg J. Long and short term patency of radiocephalic arteriovenous fistulas. *Acta Chir Scand* 1988;**154**(4):257-259
8. Bitker MO, Rottembourg J, Mehama R. Early failures in the creation of arteriovenous fistulas for hemodialysis in adults. *Ann Urol* 1984;**182**(2):98-102
9. Kherlakian GM, Roedersheimer LR, Arbaugh JJ, Newmark KJ, King LR. Comparison of autogenous fistula versus expanded polytetrafluoroethylene graft fistula for angioaccess in hemodialysis. *Am J Surg* 1986;**152**(2):238-243
10. Clark TW, Hirsch DA, Jindal KJ, Veugelers PJ, LeBlanc J. Outcome and prognostic factors of restenosis after percutaneous treatment of native hemodialysis fistulas. *J Vasc Interv Radiol* 2002;**13**(1):51-59
11. Mousa AY, Dearing DD, Aburahma AF. Radiocephalic fistula: review and update. *Ann Vasc Surg* 2013;**27**(3):370-378
12. Golledge J, Smith CJ, Emery J, Farrington K, Thompson HH. Outcome of primary radiocephalic fistula for haemodialysis. *Br J Surg* 1999;**86**(2):211-216
13. Nassar GM, Nguyen B, Rhee E, Achkar K. Endovascular treatment of the "failing to mature" arteriovenous fistula. *Clin J Am Soc Nephrol* 2006;**1**(2):275-280
14. Spergel LM, Ravani P, Roy-Chaudhury P, Asif A, Besarab A. Surgical salvage of the autogenous arteriovenous fistula (AVF). *J Nephrol* 2007;**20**(4):388-398
15. Moossavi S, Regan JD, Pierson ED, Kasey JM, Tuttle AB, Vachharajani TJ *et al.* Non-surgical salvage of thrombosed arterio-venous fistulae: a case series and review of the literature. *Semin Dial* 2007;**20**(5):459-464
16. Turmel-Rodrigues L, Pengloan J, Rodrigue H, Brillet G, Lataste A, Pierre D *et al.* Treatment of failed native arteriovenous fistulae for hemodialysis by interventional radiology. *Kidney Int* 2000;**57**(3):1124-1140
17. Aruny JE, Lewis CA, Cardella JF, Cole PE, Davis A, Drooz AT *et al.* Quality improvement guidelines for percutaneous management of the thrombosed or dysfunctional dialysis access. Standards of Practice Committee of the Society of Cardiovascular & Interventional Radiology. *J Vasc Interv Radiol* 1999;**10**(4):491-498
18. Tordoir JH, Bode AS, Peppelenbosch N, van der Sande FM, de Haan MW. Surgical or endovascular repair of thrombosed dialysis vascular access: is there any evidence? *J Vasc Surg* 2009;**50**(4):953-956
19. Liang HL, Pan HB, Chung HM, Ger LP, Fang HC, Wu TH *et al.* Restoration of thrombosed Brescia-Cimino dialysis fistulas by using percutaneous transluminal angioplasty. *Radiology* 2002; **223**(2):339-344
20. National Kidney Foundation. K/DOQI clinical practice guidelines for vascular access, update 2000. *Am J Kidney Dis* 2001;**37**(1)Suppl 1:s137-s181
21. Vascular Access 2006 Work Group. Clinical practice guidelines for vascular access. *Am J Kidney Dis* 2006;**48**(suppl 1):S176-S247
22. Berman SS, Gentile AT. Impact of secondary procedures in autogenous arteriovenous fistula maturation and maintenance. *J Vasc Surg* 2001;**34**(5):866-871
23. Hingorani A, Ascher E, Kallakuri S, Greenberg S, Khanimov Y. Impact of reintervention for failing upper-extremity arteriovenous autogenous access for hemodialysis. *J Vasc Surg* 2001; **34**(6):1004-1009
24. Lipari G, Tessitore N, Poli A, Bedogna V, Impedovo A, Lupo A *et al.* Outcomes of surgical revision of stenosed and thrombosed forearm arteriovenous fistulae for haemodialysis. *Nephrol Dial Transplant* 2007;**22**(9):2605
25. Tessitore N, Mansueto G, Lipari G, Bedogna V, Tardivo S, Baggio E *et al.* Endovascular versus surgical preemptive repair of forearm arteriovenous fistula juxta-anastomotic stenosis: analysis of data collected prospectively from 1999 to 2004. *Clin J Am Soc Nephrol* 2006;**1**(3):448-454
26. Georgiadis GS, Lazarides MK, Lambidis CD, Panagoutsos SA, Kostakis AG, Bastounis EA *et al.* Use of short PTFE segments (<6 cm) compares favorably with pure autologous repair in failing or thrombosed native arteriovenous fistulas. *J Vasc Surg* 2005;**41**(1):76-81
27. Mickley V. Central venous catheters: many questions, few answers. *Nephrol Dial Transplant* 2002;**17**(8):1368-1373
28. El Minshawy O, Abd El Aziz T, Abd El Ghani H. Evaluation of vascular access complications in acute and chronic hemodialysis. *J Vasc Access* 2004;**5**(2):76-82
29. Sivanesan S, How TV, Bakran A. Sites of stenosis in AV fistulae for haemodialysis access. *Nephrol Dial Transplant* 1999;**14**(1):118-120
30. Rajan DK, Bunston S, Misra S, Pinto R, Lok CE. Dysfunctional autogenous hemodialysis fistulas: outcomes after angioplasty—are there clinical predictors of patency? *Radiology* 2004; **232**(2):508-515
31. Ponikvar R. Surgical salvage of thrombosed arteriovenous fistulas and grafts. *Ther Apher Dial* 2005;**9**(3):245-249
32. Rajan DK, Clark TW, Simons ME, Kachura JR, Sniderman K. Procedural success and patency after percutaneous treatment of thrombosed autogenous arteriovenous dialysis fistulas. *J Vasc Interv Radiol* 2002;**13**(12):1211-1218