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The outcome of radiocephalic after brachiocephalic and redo arteriovenous fistula

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Abstract

Introduction: When created in appropriately selected patients, arteriovenous fistula requires fewer interventions and costs compared to arteriovenous graft. The outcome of radiocephalic after brachiocephalic and redo arteriovenous fistula is not studied well in the literature, and this study highlights the outcome of these arteriovenous fistulae.

Methods: The retrospective, single-center study, based on patient record analysis of 1040 arteriovenous fistula, was created between January 2017 and October 2021. Thirty-nine (3.37%) patients met the inclusion criteria for radiocephalic after brachiocephalic arteriovenous fistula group, and 42 (4.04%) met the inclusion criteria for the redo arteriovenous fistula group. Preoperative Doppler ultrasound was performed by the operating surgeon in all patients. All patients were scheduled for a visit 2 months after surgery for assessment—only 34 of radiocephalic after brachiocephalic arteriovenous fistula and 35 of redo arteriovenous fistula patients presented for follow-up. The arteriovenous fistula was assessed for patency, maturation, and complications. SPSS version 22 (Chicago, USA) was used for data entry and analysis.

Results: The redo arteriovenous fistula has a significantly lower maturation rate at 2 months of follow-up (62.85%) when compared to other brachiocephalic arteriovenous fistula (79.18%) (p-value = 0.0245). The radiocephalic after brachiocephalic arteriovenous fistula has no significant difference in maturation rate at 2 months of follow-up (61.67%) when compared to other distal forearms radiocephalic arteriovenous fistula (68.18%) (p-value = 0.5173). The incidence of some early complications was higher in the redo group.

Conclusion: The feasibility of doing radiocephalic arteriovenous fistula after failed brachiocephalic arteriovenous fistula is generally overlooked. The redo arteriovenous fistula is more technically challenging, associated with higher complications, but it provides reliable access in a specific group of patients.

Keywords

Hemodialysis, vascular access, arteriovenous fistula, redo arteriovenous fistula, native arteriovenous fistula, failed arteriovenous fistula

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Introduction

Renal failure is a growing worldwide problem.[1] Despite the increase in renal transplant surgery, hemodialysis (HD) remains the primary therapy. The National Kidney Foundation's Kidney Disease Outcomes Quality Initiative (KDOQI) recommends a native arteriovenous fistula (AVF) or arteriovenous graft (AVG) in preference to a central venous catheter (CVC) in most HD patients due to the lower complications.[2] Inadequate vascular access and complications related to vascular access were found to be the cause of death in an estimated 25% of all patients starting HD.[3,4,5] The risk of death was found two to three times higher in patients who started dialysis with a central venous line than patients who began with AVF.[6] Tunneled cuffed catheters also carry 5–10 times increased risk of a serious infection, increased hospitalization, inadequate dialysis, and an increased number of vascular access procedures.[7] Catheter use for HD is

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associated with increased mortality. This risk rises in parallel with the increase in the duration of catheterization.[8] This is why central venous catheters should be avoided whenever it is possible.[9]

The angio-access surgeon should put more time and effort into creating a functional fistula in the first attempt because early AVF creation before starting HD is associated with reducing the risk of sepsis and death.[10] The history of failed access is associated with a 2.56 times risk of failure compared with patients with the first AVF.[11]

The surgery of AVF creation should not be considered a minor procedure. It should be carried out by surgeons dedicated to angio-access procedures or at least under their supervision. The surgeon should do a preoperative duplex examination by himself/herself for accurate assessment and planning of the surgery.[12]

The primary failure rate of the AVF may reach 23%, and the 1-year patency rate may be as low as 60%. The previous data form a barrier against the creation of more AVF.[13]

Vascular access complications are a major cause of the hospitalization of patients on HD and significantly contribute to their overall morbidity and mortality.[14] When created in appropriately selected patients, AVF requires fewer interventions and costs compared to AVG.[15]

Material and methods

The retrospective, single-center study, based on patient record analysis of 1040 AVF, was created between January 2017 and October 2021 by a single surgeon who is dedicated to angio-access procedures. Four hundred eighty-one (46.25%) of the AVF wear created in Al-Sadir Medical City, while 559 (53.75%) were in a private clinic. Both sites are located in the Najaf governorate in the middle of Iraq. All cases were referred by ten nephrologists from the City of Najaf and five nearby governorates. The diagnosis of chronic kidney disease stages 4/5 was made by a nephrologist before referral. Two hundred forty-three (23.36%) cases were not yet on dialysis, 396 (38.07%) cases were on dialysis less than 1 month, and 401 (38.55%) cases were on dialysis for more than 1 month.

Inclusion and exclusion criteria

The inclusion criteria for radiocephalic after brachiocephalic AVF group were as follows:

1. The patient has a history of thrombosed or failed brachiocephalic AVF on the same side as the creation of new radiocephalic AVF.
2. The cephalic vein is patent with a diameter of more than 3 mm.
3. Cases with obliterated cephalic vein at the elbow and the upper arm should have more than 6 cm of patent vessel joining the deep system without obstruction.
4. The radial artery diameter is more than 2 mm without extensive calcification on the Doppler study.

The inclusion criteria for redo-AVF group were as follows:

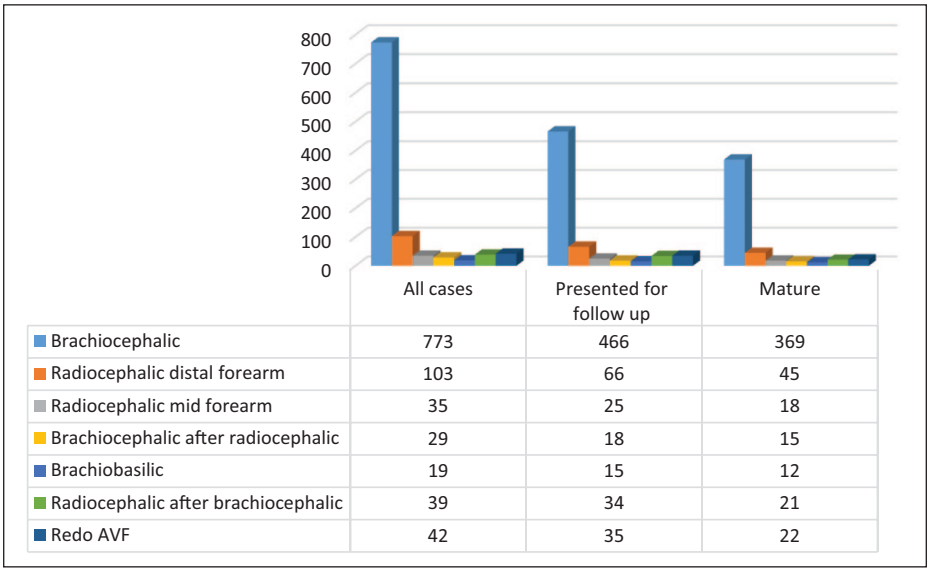
1. The patient has a history of thrombosed or failed brachiocephalic AVF on the same side.
2. The creation of the new AVF involves dissection of the scar of the previous AVF.
3. The cephalic vein is patent with a diameter of more than 3 mm.

Thirty-nine (3.37%) patients met the inclusion criteria for radiocephalic after brachiocephalic AVF group, and 42 (4.04%) met the inclusion criteria for the redo-AVF group.

Preoperative assessment and surgical technique

The 2019 update to the KDOQI Clinical Practice Guideline for Vascular Access suggested using ultrasound mapping in patients at high risk of AVF failure.[2] We performed a preoperative Doppler ultrasound examination in all patients to assess the adequacy of blood vessels and decide the site of AVF creation. Our cut-offs were a vein diameter of more than 3 mm and an artery diameter of more than 2 mm. The Doppler ultrasound (Samsung Madison MySono U 6) is equipped with a linear probe with a minimum frequency of 7 MHz for B-mode examination, with a setup for vascular access. The examination by Doppler ultrasound was carried out in a comfortably warm room. Patients were seated in front of the doctor with the forearm resting on a stand. A tourniquet was placed in the upper arm during measurement of vein diameter, and the blood vessels were evaluated with transverse and longitudinal scans. The patency of the cephalic vein was assessed by compressibility and examed to the shoulder region to exclude any obstruction or stenosis. In cases where there was previous central line insertion, the patency of the central veins was also ensured by ultrasound at the same time, and computed tomography (CT)-venography was ordered when there was any doubt. The site of the vein, the artery, and the proposed skin incision were marked by a skin marker.

The creation of AVF was performed under local anesthesia (2% Lidocaine-Xylocaine). A transverse 2–5 cm skin incision (depending on the distance between the vein and the artery) was used. After the adequate release of the cephalic vein, it was dilated with a metal dilator. Then flushed with heparinized-normal saline before construction of the anastomosis. The vein patency was rechecked by a probe and easy passage of flushing fluid. When the radial artery was used as the inflow vessel, dilation of the vessel was done by metallic dilator—then flushed with heparinized-normal saline before the commencement of the anastomosis. An end-to-side anastomosis was created between the cephalic vein and the radial or brachial artery, using



	All cases	Presented for follow up	Mature
Brachiocephalic	773	466	369
Radiocephalic distal forearm	103	66	45
Radiocephalic mid forearm	35	25	18
Brachiocephalic after radiocephalic	29	18	15
Brachiobasilic	19	15	12
Radiocephalic after brachiocephalic	39	34	21
Redo AVF	42	35	22

Figure 1. The AVF configurations.

continuous polypropylene sutures (6/0 Prolene) with the aid of 3.5× magnifying loupes. The length of anastomosis was 10 mm for (radiocephalic) and 5 mm for (brachiocephalic) fistulae. A palpable thrill was regarded as an indicator for successful AVF creation.

In the redo cases, careful dissection of the adherent patent part of the cephalic vein and the brachial artery was done. After the adequate release of both vessels, end-to-side anastomosis is performed in the usual fashion but avoids the previous arteriotomy site whenever possible. We used excessive dissection and release to compensate for the length of the thrombosed part of the vein. No vein or graft interposition technique was used.

Follow-up

Before the COVID-19 pandemic, all patients were seen on the second day, fourteenth day, and 2 months after surgery. The AVF were assessed for patency, maturation, and complications. The patient skin was marked for the ideal cannulation site. Considering most of our patients live in far cities, after the pandemic and travel ban, we canceled the first two visits. We relied on the nephrologist's assessment for the need for vascular surgeon consults. Thirty-four (87.18%) of radiocephalic after brachiocephalic AVF and 35 (83.33%) of redo-AVF patients were presented for follow-up while only 590 patients (61.5%) of the other operated on patients were presented (Figure 1). The remaining patients were considered lost to follow-up.

Adequate maturation of AVF was defined as successful cannulation of AVF by large gauge needle for efficient HD. The rule of 6s was used to determine the adequacy of maturation; a more than 600 mL/min blood flow, an outflow vein diameter of more than 6 mm, an outflow vein depth of less than 6 mm from the skin surface, and a vein length more than 6 cm. Generally, an experienced dialysis nurse can reliably determine whether the fistula is mature and ready for cannulation. In obese patients and patients with slow-maturing fistulae, the AVF may not appear mature based on inspection alone. In these cases, the ultrasound study can help determine the suitability for cannulation and mark the best site for puncture.

Ethical approval and patient consent

Written informed consent was obtained from all the patients or their legally authorized representatives of those less than 18 years old, for participating in this study, and was conducted according to the ethical standards established by the 1964 Declaration of Helsinki. The Medical Ethical Committee of Kufa University and Al-Sadir Medical City approved this study (code: 2021AMC24).

Statistical analysis

We used the mean value and standard deviation to represent the data while describing variables presented using numbers and percentages. A two-sided paired *t*-test for variables was used. SPSS version 22 (Chicago, USA) was used for data entry and analysis. *p*-value was considered significant if <0.05.

Results

The mean age of patients in the redo-AVF group was not significantly different from the other brachiocephalic AVF (*p*-value = 0.3295). Similarly, there was no significant difference in mean age between the radiocephalic after

Table 1. The demographic details of the patients who have different AVF configurations.

AVF configuration (*N*)	The mean age and SD in years	Percentage of females
Brachiocephalic (773)	48.12 ± 17.8	38.93%
Radiocephalic distal-forearm (103)	51.6 ± 13.1	33.98%
Radiocephalic mid-forearm (35)	47.33 ± 14.3	37.14%
Brachiocephalic after radiocephalic (29)	44 ± 15.67	41.37%
Brachiobasilic (19)	41 ± 16.1	47.36%
Radiocephalic after brachiocephalic (39)	49.3 ± 15.5	28.2%
Redo-AVF (42)	45.4 ± 13.1	28.57%

AVF: arteriovenous fistula; SD: standard deviation.

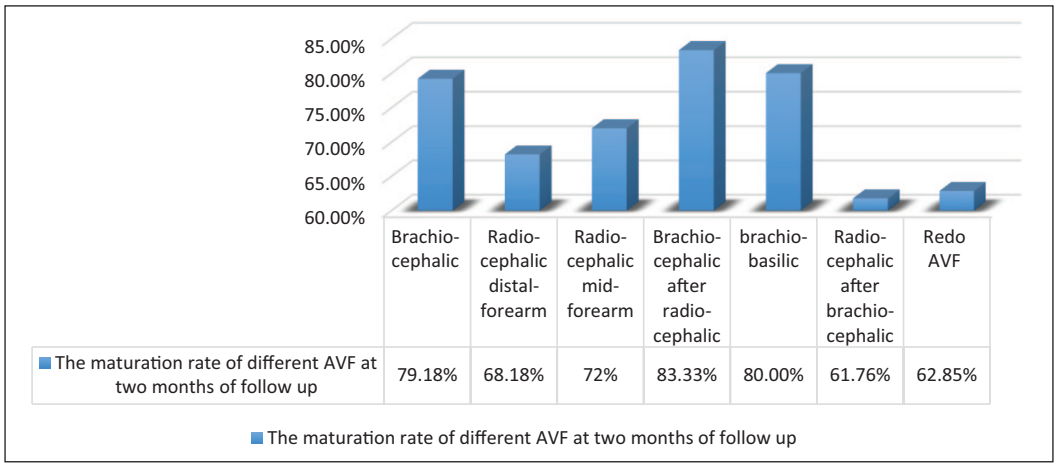


Figure 2. The maturation rate of different AVF configurations at 2 months of follow-up.

brachiocephalic AVF group and distal forearm radiocephalic group (p-value = 0.3766) (Table 1).

The redo-AVF have significantly lower maturation rate at 2 months of follow-up (62.85%) when compared to other brachiocephalic AVF (79.18%) (p-value = 0.0245, difference = 16.33%, and 95% CI from 1.8131% to 33.2045%) (Figures 1 and 2).

The radiocephalic after brachiocephalic AVF have no significant difference in maturation rate at 2 months of follow-up (61.67%) when compared to other distal forearms radiocephalic AVF (68.18%) (p-value = 0.5173) (Figures 1 and 2).

The redo brachiocephalic AVF group operative time was 61.51 ± 11.3 min, significantly higher than other brachiocephalic AVF operative time 47.6 ± 15.1 min (p-value < 0.0001, difference = −13.910, standard error = 2.364, and 95% CI from 18.5509 to −9.2691). While the mean operative time of radiocephalic after brachiocephalic was 49.2 ± 13.2, which is not statistically different from the other radiocephalic AVF operative time 48.1 ± 14.7 (p-value = 0.6738, difference = −1.100, standard error = 2.609, and 95% CI from −6.2495 to 4.0495). A higher rate of postoperative complications was found in the redo-AVF group (Table 2).

All the patients who were planned for redo-AVF have at least two AVF constructions prior the redo-AVF surgery. We report one patient who has been on dialysis for 15 years and had five previous AVF constructions prior the redo-AVF surgery (left radiocephalic, left brachiocephalic, right snuff box, right distal radiocephalic, and right brachiocephalic) and despite that she still has good size cephalic vein in the scar of previous surgery. We did her sixth AVF successfully.

Discussion

Although the dictum of "fistula first" was violated in some patients populations,[16] the relatively younger age of this study participants and lower cost of native AVF creation compared to AVG in our country have catalyzed us for the creation of redo-AVF and radiocephalic after brachiocephalic AVF.

ZU Rehman[17] published a case of ipsilateral radiocephalic AVF creation in a patient with failed brachiocephalic AVF. Still, no large series of such types of surgery have been reported in the literature.

Comparing maturation rate after 2 months according to the anatomical site, the highest patency rate was for brachiocephalic AVF 79.18%, then mid-arm radiocephalic AVF 72%, followed by distal arm radiocephalic AVF 68.18%. These findings can be attributed to the difference in diameter of the inflow artery which is already noted in the literature.[18]

Table 2. The postoperative complications of different AVF presented for follow-up.

Postoperative complication	Brachiocephalic (*N* = 466)	Radiocephalic distal-forearm (*N* = 66)	Radiocephalic mid-forearm (*N* = 25)	Brachiocephalic after radiocephalic (*N* = 15)	Brachiobasilic (*N* = 15)	Radiocephalic after brachiocephalic (*N* = 34)	Redo-AVF (*N* = 35)
Bleeding	22 (4.72%)	2 (3.03%)	1 (4%)	1 (6.6%)	1 (6.6%)	2 (5.88%)	4 (11.4%)
Wound infection	15 (3.21%)	2 (3.03%)	0 (0%)	0 (0%)	1 (6.6%)	1 (2.94%)	2 (5.71%)
Steal syndrome	24 (5.15%)	1 (1.5%)	1 (4%)	0 (0%)	0 (0%)	0 (0%)	1 (2.85%)
Venous hypertension	35 (7.51%)	1 (1.5%)	1 (4%)	1 (6.6%)	2 (13.3%)	2 (5.88%)	5 (14.28%)
Temporary limb swelling	112 (24.03%)	5 (7.57%)	4 (16%)	3 (20%)	6 (40%)	9 (26.47%)	19 (54.28%)
Seroma	17 (3.64%)	0 (0%)	1 (4%)	0 (0%)	4 (26.6%)	1 (2.94%)	5 (14.28%)
Thrombosis	17 (3.64%)	6 (9.09%)	2 (8%)	1 (6.6%)	1 (6.6%)	3 (8.82%)	3 (8.57%)

AVF: arteriovenous fistula.

Other surgeons have done all the previous AVF in the redo-AVF group and radiocephalic after brachiocephalic AVF group. We speculate that the reason for their decision to do brachiocephalic may be the lack of ultrasound assessment by the surgeon himself. In addition, the brachiocephalic AVF they created may have enhanced the growth of the radial artery and cephalic vein, making them suitable at the time of our assessment. Unfortunately, we lack the data to enable us to make any conclusion.[19]

Four patients in the radiocephalic after brachiocephalic group and three patients in the redo-AVF group have been considered candidates for brachiobasilic AVF. We avoided basilic vein transposition AVF because of the possibility of the need for other types of anesthesia rather than local, the need for more extensive dissection with its associated complications, and the difficulties in its cannulation encountered in our experience. Future studies are needed to compare the outcome of brachiobasilic AVF with redo-AVF or radiocephalic after brachiocephalic AVF.

Some early complications were higher in the redo-AVF group, like venous hypertension, wound infection, seroma formation, and bleeding, but other complications were seen less like steal syndrome. Most of the increased complications in the redo-AVF group may be attributed to the longer duration kept on dialysis and longer catheter time, but we did not calculate the catheter time in our patients. Superior vena cava, brachiocephalic, or subclavian vein stenosis due to prolonged catheter use may cause the increased development of venous hypertension and temporary limb swelling in the redo-AVF group.[20] Further studies are needed to prove the previous speculations. In our series of patients, duplex ultrasound was used to assess deep vein patency, and CT-venography was rarely requested, which may contribute to missing cases of central vein stenosis.[21] In the four cases of venous hypertension of the redo-AVF group, three of them had moderate limb swelling, which the patients tolerated. The fourth had severe symptoms, mandating percutaneous angioplasty of the stenosed brachiocephalic vein. The patient had some improvement of his painful limb swelling and had less trouble in dialysis.

A possible cause of increased bleeding, seroma formation, and wound infection in the redo-AVF group is the dissection in distorted anatomy and scar tissue of the previous surgery. Although this issue has been emphasized in carotid surgery, further studies are needed to prove this because the behavior of the vessels and complications may differ in different vascular sites/procedures.[22]

The meticulous excessive dissection needed in the redo-AVF group may explain the longer operative time in this group. Our operative time in the remaining groups was comparative to what Kumar et al.[23] reported in their series.

Limitations

The short follow-up time and the small number of patients in the radiocephalic after brachiocephalic and redo-AVF groups

question the validity of our results. Also the power analysis for sample size calculation was not done. Another comparative study is needed to compare the redo-AVF with brachiobasilic AVF and other rescue HD access options like AVG or tunneled HD catheter.

Conclusion

The feasibility of doing radiocephalic AVF after failed brachiocephalic AVF is generally overlooked. The redo-AVF is more technically challenging, associated with a higher complication rate and a less favorable outcome than the usual AVF. Still, despite all that, it provides reliable access to a specific group of patients. The short follow-up time and the disparity in numbers enrolled in the primary and secondary groups question our results as clinically valuable data.

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Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethical approval

Ethical approval for this study was obtained from The Medical Ethical Committee of Kufa University and Al-Sadir Medical City (code: 2021AMC24).

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Informed consent

Written informed consent was obtained from all the patients or their legally authorized representatives of those less than 18 years old.

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