ORIGINAL ARTICLE

THE CHALLENGE OF COVID19 IN THE MANAGEMENT OF VASCULAR ACCESS FOR HEMODIALYSIS IN AN UNIVERSITARY HOSPITAL

Beatriz Afonso*[1], Leandro Nóbrega[2,3], Ricardo Castro-Ferreira[2,4]

[1] Faculty of Medicine, University of Porto, Oporto, Portugal
[2] UniRISE, Department of Surgery and Physiology, Faculty of Medicine of the University of Porto, Portugal
[3] Angiology and Vascular Surgery department, Centro Hospitalar Universitário de São João, Portugal
[4] Angiology and Vascular Surgery department, Centro Hospitalar Vila Nova de Gaia/Espinho, Portugal

*** Corresponding author**: beatriz11afonso@gmail.com

Abstract

Introduction: *Chronic kidney disease prevalence has been increasing worldwide, with an increasing need to deliver an effective treatment. During the first months of the coronavirus disease 2019 (COVID-19) pandemic healthcare systems around the world were under stress. Therefore, the aim of this study is to report a single center experience with arteriovenous fistula (AVF) creation while also evaluating the impact of COVID-19.*

Methods: *Procedures for AVF creation in a tertiary hospital between March 2017 and December 2020 were included in this study and their case records were retrospectively analyzed and data retrieved.*

Results: *A total of 582 procedures were performed and a total of 568 accesses were created (506 being made pre-COVID onset and 62 post-COVID onset). The period between the referral to the vascular surgery consultation was significantly longer for the COVID group [18 (23) days vs 28 (44) days; p<0,001] while the period between the consultation to the surgery was significantly shorter [76 (77) days vs 40 (57) days; p<0,001]. This resulted in significantly less time between referral to surgery in the COVID group [103 (77) days vs 88 (55) days; p=0,008].*

Conclusion: *The ability of hospitals to adapt their resources was paramount to mitigate COVID impact. In the institution where the study took place, the time from referral to consultation was increased significantly during the first months of COVID but the time from consultation to surgery was significantly reduced. Overall, these results show that there was a successful effort to expedite the creation of a vascular access.*

Keywords*: Arteriovenous Fistula (AVF); venous access (VA); Covid19; maturation; cannulation; referencing time.*

INTRODUCTION

Chronic kidney disease (CKD) has been increasing in the general population worldwide. This may be related to the rising prevalence of several risk factors such has diabetes mellitus (DM) and hypertension (HTA). With the progression of CKD, it may be necessary to implement renal replacement therapy (RRT) for which the hemodialysis (HD) remains one of the main options. In 2017, the global prevalence of the population undergoing HD was estimated at 0.07%, which refers to approximately 5 million people, although this number can be up to 9.7 million people[1]. Another important aspect is that HD is a significant financial burden on healthcare systems, being responsible for 2-3% of the healthcare budget in some countries[2,3].

Furthermore, the world has been recently stricken with the coronavirus disease 2019 (COVID-19) pandemic that has disrupted healthcare systems capacity for a timely response in

many pathologies. In a survey, over 90% of vascular surgeons reduced or ceased performing elective procedures[4]. This may have a significant impact on the population under HD as it can limit and delay the access to an AVF. In a study of three Spanish regions, there was an increase in central venous catheter (CVC) placement and significantly higher number of patients started HD through a CVC[5]. There is still scarce evidence regarding this subject.

Therefore, the aim of this study is to primarily report a single center experience with AVF creation regarding the time elapsed between the referral date and the presurgical consultation, the presurgical consultation and surgery and between surgery and postsurgical consultation while also evaluating the impact of COVID-19 on these.

METHODS

Patient Selection

Procedures for AVF based on ICD-9 and ICD-10 codes in a tertiary hospital between March 2017 and December 2020 were included in this study and their case records were retrospectively analysed and their data retrieved. The patients were divided into two groups according to date when the procedure was made. Pre-COVID onset group ranged between March 2017 and March 18th 2020 (March 18th2020 was the day that the first emergency state due to COVID-19 was declared in Portugal) and the post-COVID onset group from March 18th2020 until December 2020. The present study was reported accordingly to the STROBE criteria. The study protocol was approved by the local Ethics Committee and respects the Declaration of Helsinki.

Data collection

The data was collected from the hospital patient's record system with information regarding demographics, cardiovascular comorbidities, risk factors (stroke, heart failure, coronary disease, DM, HTA, dyslipidaemia, obesity, peripheral arterial disease, and smoking at the time of the surgery), referral and vascular surgery consultation date, pre-surgical evaluation, US evaluation, date of surgery, VA configuration, date of first post-surgical evaluation, date of cannulation, access complications and last date of follow-up were retrieved.

Study Endpoints

The primary endpoints were evaluating the time elapsed between the referral date for vascular surgery and the pre-surgical consultation, between pre-surgical consultation and access creation and between access creation and first post-surgical evaluation. Furthermore, the impact of Covid-19 on primary study endpoints was also evaluated.

The secondary endpoints were the rate of working AVFs at the first post-surgical evaluation and the rate of successful cannulation at the end of follow-up.

The VA was considered as working accordingly to the first post-surgical recorded evaluation, irrespective of the timing of the evaluation. The terms mature or functional were not used because we cannot guarantee that their definitions according to the European Society for Vascular Surgery guidelines were followed due to the retrospective nature of our work[6]. The cannulation date was defined as the first date that the patient's records mentioned ongoing HD through the AVF. Re-intervention was defined as any intervention in index access, thus excluding any surgery for a new access after primary failure. Patency was defined as a working access at the last hospital evaluation, irrespective of the cannulation state.

Statistical analysis

SPSS (IBM, Version 27) was the tool used to perform the statistical analyses. Continuous variables were descripted as averages with standard deviation and categorical variables were descripted as frequency counts and percentages. The

Table 1 **Demographic data and Comorbidities of the Pre- and Post-COVID onset populations**

Characteristics	Pre-COVID (N=520)	Pre-COVID (N=62)	*p* value
Male, n (%)	335 (64.4%)	33 (53.2%)	0.084
Age	65.37 ± 14.54	63.87 ± 15.89	0.322
Stroke, n (%)	95 (18.3%)	5 (8.1%)	0.044
Coronary artery disease, n (%)	96 (18.5%)	8 (12.9%)	0.280
Heart failure, n (%)	115 (22.1%)	10 (16.1%)	0.278
Peripheral obstructive arterial disease, n(%)	64 (12.3%)	10 (16.1%)	0.393
Diabetes Mellitus, n (%)	247 (47.5%)	23 (37.1%)	0.121
Hypertension, n (%)	427 (82.1%)	48 (77.4%)	0.367
Dyslipidemia, n (%)	340 (65.4%)	36 (58.1%)	0.255
Tobacco, n (%)	65 (12.5%)	9 (14.5%)	0.652
Obesity, n (%)	99 (19.0%)	8 (12.9%)	0.238

Table 2 **Etiology of Chronic Kidney Disease of the Pre- and Post-COVID onset groups**

Characteristics	Pre-COVID (N=520)	Post-COVID (N=62)
Chronic Glomerulonephritis, n (%)	17 (3.2%)	2 (3.2%)
Vasculitis, n (%)	18 (3.4%)	1 (1.6%)
Chronic Pyelonephritis, n (%)	9 (1.7%)	1 (1.6%)
Nephropathy of IgA, n (%)	32 (6.1%)	4 (6.5%)
Diabetes Mellitus, n (%)	122 (23.3%)	11 (17.7%)
Hypertension, n (%)	28 (5.3%)	4 (6.5%)
Autosomal Dominant Polycystic Kidney Disease, n (%)	53 (10.1%)	9 (14.5%)
Undetermined, n (%)	92 (17.6%)	
Multifactorial, n (%)	53 (10.1%)	6 (9.7%)
Ischemic, n (%)	6 (1.1%)	9 (14.5%)
Urologic Obstruction, n (%)	13 (2.5%)	1 (1.6%)
GESF, n (%)	5 (1.0%)	2 (3.2%)
Pharmacological	8 (1.5%)	3 (4.8%)
Amyloidosis	8 (1.5%)	
DM+ Hypertension	12 (2.3%)	
DM + Urologic Obstruction	5 (1.0%)	
Others, n (%)	43 (8.3%)	
Total, n (%)	520 (100%)	8 (13.0%)
		62 (100%)

GESF - segmental and focal glomerulosclerosis; DM - Diabetes Mellitu

Mann-Whitney U-test was applied to continuous variables and the Kolmogorov-Smirnov test was used to verify the normal distribution on continuous variables. The P-value chosen to be the cut-off for statistical significance was <0.05.

RESULTS

A total of 582 procedures were performed between March 2017 and December 2020, with 520 (89%) in the pre-COVID onset period and 62 (11%) in the post-COVID onset period. These led to a total 568 accesses, divided in 506 in the pre-COVID period and 62 in the post-COVID period. In the other 14 procedures, vascular access creation was deemed not possible intra-operatively. Additionally, seven (1,3%) of the pre-COVID onset group and seven of the post-COVID onset group (11,3%) procedures were performed while patients were admitted in the ward for other pathologies.

Table 1 summarizes patients characteristics and comorbidities in the studied population. The two groups (pre-COVID onset and post-COVID onset) were similar regarding patients' characteristics and comorbidities, except for the history of stroke (p=0.044). Both groups mostly consisted of male patients, with 64.4% (n=335) in the pre-COVID onset group and 53.5% (n=33) in the post-COVID onset group. The most common comorbidities in the two groups were HTA and dyslipidemia. HTA was present in 82.1% (n=427) of the patients in the pre-COVID group and 77.4% (n=48) in the post-COVID onset group. Dyslipidemia was present in 65.4% (n=340) of the patients in pre-COVID onset group and 58.1% (n=36) in the post-COVID onset group.

Regarding CKD etiology, the most common was DM. It was the cause for CKD in 23.3% (n=122) of patients in the pre-COVID onset group and 17.7% (n=11) in the post-COVID onset group. Other important causes were polycystic kidney disease, IgA nephropathy and HTA. In 10.1% (n=53) of pre-COVID onset patients and in 14.5% (n=9) of post-COVID onset patients, there was a multifactorial etiology. These results are shown in table 2.

The pre-surgical evaluation was complemented with US in 37.5% (n=195) of patients in the pre-COVID onset group and in 51.6% (n=32) of patients in post-COVID onset group. Over 75% of accesses in both groups were primary and the most common type was radio-cephalic with 49.6% (n=258) and 56.5% (n=35) in the pre and post-COVID onset groups, respectively. The information regarding the accesses is present in table 3.

The results of the primary outcomes are shown in table 4. The time in days (presented as median (interquartile range)) between the referral and the vascular surgery consultation was significantly longer in the post-COVID onset group when compared with the pre-COVID onset group (28 (44) vs 18 (23); p<0.001). There was also a significant difference in the days elapsed between consultation and surgery between the groups, with a shorter time in the post-COVID onset group (40 (57) vs 76 (77); p<0.001). Overall,

Table 3 **Vascular characteristics of the Pre- and Post-COVID onset population**

Outcomes	Pre-COVID (N=520)	Post-COVID (N=62)
Presurgical ultrasonography, n (%)	195 (37.5%)	32 (51.6%)
Primary AVF, n (%)	395 (76.0%)	49 (79.0%)
Location		
Radio-cephalic, n (%)	258 (49.6%)	35 (56.5%)
Brachio-cephalic, n (%)	188 (36.3%)	16 (25.8%)
Brachio-basilic, n (%)	41 (7.9%)	9 (14.5%)
Others, n (%)	19 (3.7%)	2 (3.2%)
Impossibility of Intrasurgical Construction, n (%)	14 (2.7%)	0 (0%)
Anastomosis		
Side to end, n (%)	217 (41.7%)	27 (43.5%)
Side to side, n (%)	111 (21.3%)	15 (24.2%)
End to end, n (%)	2 (0.4%)	1 (1.6%)
No information, n (%)	189 (36.3%)	19 (30.6%)
Laterality		
Left, n (%)	406 (78.1%)	48 (77.4%)
Right, n (%)	114 (21.9%)	14 (22.6%)

AVF - Arteriovenous fistula

this resulted in less days between referral and surgery in the post-COVID onset group (88 (55) vs 103 (77); p=0.008). There was no significant difference in time between surgery and first post-surgical evaluation.

Data regarding follow-up is present in table 5. The working rate was 76.2% (n=386) in the pre-COVID onset group and 67.7% (n=42) in the post-COVID onset group and this difference was statistically significant (p=0.004). The cannulation rate was 39.7% (n=201) and 19.4% (n=12) in pre and post-COVID onset groups, respectively. The patency rate at the end of the follow-up period was 71.7% (n=363) in the pre-COVID onset group and 69.3% (n=43) in the post-COVID onset group. The main complication in the pre-COVID onset group was access thrombosis (10.9%; n=41). The re-intervention rate was similar in both groups.

DISCUSSION

Evidence regarding the impact of the COVID pandemic in VA creation is lacking and, analyzing the available literature, this is the first study to delve deeper into this subject. In the studied population, the time between referral and consultation increased significantly in the post-COVID onset group while the time between consultation and access creation decreased significantly in the same group. The first may be explained due to the fact that consultations were significantly reduced during the first months of the pandemic, thus leading to a delay in the consultation scheduling. Also, the first consultation in the post-COVID onset group was May 16th, nearly two months after the emergency state was declared in Portugal which further emphasizes the slow restart of consultations. Paradoxically, this may also help explain why the time between consultation and surgery was significantly lower in the post-COVID onset group as this meant that there were fewer overall patients in the consultations and less patients to perform surgery. There was also less patients being admitted through the emergency department. Even with a not fully functional operation theatre until the end of the summer, this allowed to expedite surgery scheduling in the post-COVID onset group. In the end, this allowed that the time between referral and surgery was significantly lower in the post-COVID onset group reflecting a successful adaptation of the hospital to the new reality.

On the other hand, the time between surgery and first postsurgical evaluation was similar between the two groups. The average period that most AVF need to mature[7] is between four to six weeks. However, in most evaluations, records only referred to the AVF as working or not working and this did not allowed a true evaluation of matured AVFs as defined by the European Society of Vascular Surgery (ESVS)[7]. This evaluation can also be done six to eight weeks after surgery through physical examination or US[7]. The working rate in the pre-COVID onset group was significantly higher when compared with the post-COVID onset group. This might be explained by the fact that 11,3% (n=7) of the post-COVID onset patients underwent surgery while admitted in the ward for other pathologies while this only happened in 1,3% (n=7) of the pre-COVID onset group, as these patients may not be fully stabilized to maximize AVF maturation.

In this study there was a low rate of complications and a low rate of re-interventions. This can be explained by the fact that after a successful AVF in the public healthcare system, the responsibility for care and management of most complications belongs to private HD clinics and hospitals. This compromises the ability to truly evaluate the re-intervention rate and AVF's complications in this population. The low cannulation rate can also be explained by this healthcare organization.

Table 5 **Secondary Outcomes and other follow-up data**

Outcomes	Pre-COVID (N=520)	Post-COVID (N=62)	p value
Follow up time, days	597 ± 383	114 ± 59	-
Working, n (%)	386 (76.2%)	42 (67.7%)	0.004
Patent, n (%)	363 (71.7%)	43 (69.3%)	-
Cannulated, n (%)	201 (39.7%)	12 (19.4%)	-
Complications			
-Thrombosis, n (%)	41 (10.9%)	0 (0%)	
-Hemorrhage, n (%)	4 (0.8%)	0 (0%)	
-Aneurysm, n (%)	5 (1.0%)	0 (0%)	
Others	17 (3.4%)		
Re-intervention, n (%)	44 (8.5%)	4 (6.5%)	

Table 4 **Primary outcomes**

Outcomes	Time	p value
Referral-consultation time, days		
- Pre-COVID	18 (23)	<0.001
- Post-COVID (n=53)	28 (44)	
Consultation-surgery time, days		
- Pre-COVID	76 (77)	**<0.001**
- Post-COVID (n=53)	40 (57)	
Referral-surgery time, days		
- Pre-COVID	103 (77)	**0.008**
- Post-COVID	88 (55)	
Surgery-evaluation time, days		
- Pre-COVID	35 (38)	**0.150**
- Post-COVID	43 (32)	

Time presented as median (interquartile range)

Despite AVF being the most studied type of VA and having the better outcomes, the maturation rate of vascular access can vary significantly in the literature. The majority are between 50-80%[8-12]. Although not directly comparable as stated above, the global working rate obtained in the present study (75.4%) is in the upper half of this interval. This is also true regarding the global patency rate obtained in the present study (71.5%) at the end of follow-up, even though it was not possible to evaluate the primary patency, assisted primary patency and secondary patency for the reasons stated above. There are several factors that can have a negative influence in access maturation, such as female gender, AVF in the lower limbs, older age, Caucasian and African ethnicities, cardiovascular diseases, DM, being institutionalized and deteriorated functional state[13,14]. On the other hand, the presence of HTA, larger vein diameter and Asian and native American ethnicities are related to a higher probability of access maturation[14,15]. The influence of such factors in the considered population is beyond the scope of the present study.

The evaluation of an AVF is normally done solely by physical examination. However, there some individual characteristics that can limit its accuracy such as obesity, prior cannulation and other comorbidities[16]. US can be used without discretion, but it is especially useful in these cases. Other advantages include the non-invasive nature, its effectiveness and it can also be made the bed side. Disadvantages include being operator-dependent and time consuming[16]. Its use in the presurgical study can help to identify morphologic and functional characteristics of the vessels in order to optimize the procedure[16]. Despite this, the available literature isn't conclusive about the role of US in the presurgical evaluations and the results are mixed[16]. It can also be important in the postsurgical follow up and there are studies that show that it can lead to higher maturation rates[12,17,18]. Independent predictors of maturation in US include vascular flow, presence of stenosis, depth and diameter of AVF [12,17]. In this study, the registered use of presurgical US was relatively low, but it can be higher than the reported rate as in most cases it is performed right before surgery, and these aren't usually registered.

There are some limitations to consider in the present study. This was a single center study that limits its external validity. Also, the retrospective nature of the study implies inherent shortcomings that come from this analysis such as the inability to exclude selection bias and the incapacity to determinate a true maturation rate. During the period of the study, there was a lack of protocol in institution that the study occurred regarding pre- and post-surgery evaluation of VA patients. During the elaboration of this study, a working group of VAs was created that included a vascular surgeon and a nephrologist. This may lead to the creation of a protocol in the future and improve outcomes of VAs. Other limitation is the fact that the evaluation in the first post-surgery consultation is defined according to the surgeon preference and sometimes can be just 1-2 weeks after surgery. Considering the Clinical Practice Guidelines of the European Society for Vascular Surgery[7] most maturations occur in the first 4-6 weeks after surgery and because of what was stated above regarding AVF evaluation, it was not possible to determine a true maturation rate. As also stated above, an important limitation to consider is the fact that in Portugal, the responsibility of the initialization and follow-up of HD and VA care belong to private institutions most of the times. This limited the ability to retrieve valuable data regarding maturation, cannulation and complications of VA created on the considered institution.

CONCLUSION

Patients with CKD usually have several comorbidities and need a variety of treatments from healthcare systems, and among them, the VA is one the most important. The ability to perform the treatments in a timely manner is paramount to the quality of life of these patients.

In the considered institution, the creation of VA was successfully expedited during the post-COVID onset period, although there was a delay between referral and consultation. This shorter time also did not lead to a better working rate. The global working rate and patency rate were in line with the highest reported in the literature.

The end-result of the process for successful VA creation lies in its cannulation. A timely response as well as a good pre- and post-surgery evaluation can maximize the number of effectively cannulated VAs. In the considered hospital, the creation of a working group can lead to better results and optimize this process. Further studies should be undertaken to better understand the impact of the COVID pandemic and learn how the healthcare systems can be improved.

REFERENCES

1. Himmelfarb J, Vanholder R, Mehrotra R, Tonelli M. The current and future landscape of dialysis. Nat Rev Nephrol. 2020;16(10):573-85.
2. Kosa SD, Al-Jaishi AA, Moist L, Lok CE. Preoperative vascular access evaluation for haemodialysis patients. Cochrane Database of Systematic Reviews. 2015(9).
3. Li PK-T, Chan GC-K, Chen J, Chen H-C, Cheng Y-L, Fan SL-S, et al. Tackling Dialysis Burden around the World: A Global Challenge. Kidney Diseases. 2021;7(3):167-75.
4. Basile C, Lomonte C, Combe C, Covic A, Kirmizis D, Liakopoulos V, et al. A call to optimize haemodialysis vascular access care in healthcare disrupted by COVID-19 pandemic. Journal of Nephrology. 2021;34(2):365-8.
5. Arenas Jimenez MD, Méndez A, Furaz K, Botella A, Yetman D, Cazar R, et al. Impact of the COVID pandemic on vascular access creation for haemodialysis in 16 Spanish haemodialysis centres. Clin Kidney J. 2022;15(7):1340-7.
6. Eckstein H-H. European Society for Vascular Surgery guidelines on the management of atherosclerotic carotid and vertebral artery disease. European Journal of Vascular and Endovascular Surgery. 2018;55(1):1-2.
7. Schmidli J, Widmer MK, Basile C, de Donato G, Gallieni M, Gibbons CP, et al. Editor's choice–vascular access: 2018 clinical practice guidelines of the European Society for Vascular Surgery (ESVS). European Journal of Vascular and Endovascular Surgery. 2018;55(6):757-818.
8. Jemcov TK. Morphologic and functional vessels characteristics assessed by ultrasonography for prediction of radiocephalic fistula maturation. The journal of vascular access. 2013;14(4):356-63.
9. Lee KG, Chong TT, Goh N, Achudan S, Tan YL, Tan RY, et al. Outcomes of arteriovenous fistula creation, effect of preoperative vein mapping and predictors of fistula success in incident haemodialysis patients: A single-centre experience. Nephrology. 2017;22(5):382-7.
10. Voorzaat BM, van der Bogt KE, Janmaat CJ, van Schaik J, Dekker FW, Rotmans JI. Arteriovenous fistula maturation failure in a large cohort of hemodialysis patients in the Netherlands. World journal of surgery. 2018;42(6):1895-903.
11. Bylsma LC, Reichert H, Gage SM, Roy-Chaudhury P, Nordyke RJ, Fryzek J, et al. Clinical Outcomes of Arteriovenous Access in Incident Hemodialysis Patients with Medicare Coverage, 2012–2014. American journal of nephrology. 2019;49(2):156-64.
12. Farrington CA, Robbin ML, Lee T, Barker-Finkel J, Allon M. Postoperative ultrasound, unassisted maturation, and subsequent primary patency of arteriovenous fistulas. Clinical Journal of the American Society of Nephrology. 2018;13(9):1364-72.
13. Verest S, Logghe P, Claes K, Kuypers D, Fourneau I. Effect of clinical examination and anatomical location on native arteriovenous fistula maturation rate in high risk patients. Acta chirurgica Belgica. 2014;114(5):324-31.
14. Woodside KJ, Bell S, Mukhopadhyay P, Repeck KJ, Robinson IT, Eckard AR, et al. Arteriovenous fistula maturation in prevalent hemodialysis patients in the United States: a national study. American Journal of Kidney Diseases. 2018;71(6):793-801.
15. Kordzadeh A, Askari A, Hoff M, Smith V, Panayiotopoulos Y. The impact of patient demographics, anatomy, comorbidities, and peri-operative planning on the primary functional maturation of autogenous radiocephalic arteriovenous fistula. European Journal of Vascular and Endovascular Surgery. 2017;53(5):726-32.
16. Wong CS, McNicholas N, Healy D, Clarke-Moloney M, Coffey JC, Grace PA, et al. A systematic review of preoperative duplex ultrasonography and arteriovenous fistula formation. Journal of vascular surgery. 2013;57(4):1129-33.
17. Robbin ML, Greene T, Allon M, Dember LM, Imrey PB, Cheung AK, et al. Prediction of arteriovenous fistula clinical maturation from postoperative ultrasound measurements: findings from the hemodialysis fistula maturation study. Journal of the American Society of Nephrology. 2018;29(11):2735-44.
18. Coritsidis GN, Machado ON, Levi-Haim F, Yaphe S, Patel RA, Depa J. Point-of-care ultrasound for assessing arteriovenous fistula maturity in outpatient hemodialysis. The journal of vascular access. 2020;21(6):923-30.