OUTCOMES OF HAEMODIALYSIS ARTERIOVENOUS FISTULA CREATION AND FACTORS THAT AFFECT THE MATURATION OF THE CREATED ARTERIOVENOUS FISTULAE AT KENYATTA NATIONAL HOSPITAL

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A DISSERTATION SUBMITTED AS PART FULFILMENT FOR THE AWARD OF MASTER OF MEDICINE IN THORACIC AND CARDIOVASCULAR SURGERY, UNIVERSITY OF NAIROBI

STUDENT'S DECLARATION

I hereby declare that this dissertation entitled "**OUTCOMES OF HAEMODIALYSIS ARTERIOVENOUS FISTULA CREATION AND FACTORS THAT AFFECT THE MATURATION OF THE CREATED ARTERIOVENOUS FISTULAE AT KENYATTA NATIONAL HOSPITAL"** is my original work and that it has not been presented before either wholly or in part in any institution.

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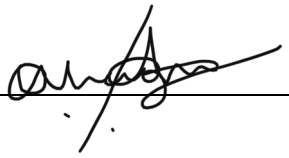
Signed  Date 04/06/2021

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Title of Work: Outcomes of Haemodialysis Arteriovenous Fistula Creation and Factors That Affect the Maturation of the Created Arteriovenous Fistulae at Kenyatta National Hospital

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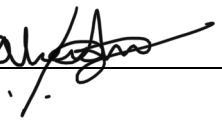
Signature  Date 04/06/2021

DEPARTMENTAL APPROVAL

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LIST OF ABBREVIATIONS

AVF – Arteriovenous fistula

CMS – Centers for Medicare and Medicaid Services

CQI – Continuous quality improvement

CVC – Central Venous Catheter

DM – Diabetes Mellitus

ESRD – End Stage renal disease

ERC – Ethics and Research Committee

FACVT – Forearm cephalic vein transposition

HAART – Highly active antiretroviral therapy

K/DOQI – Kidney Dialysis Outcomes Quality Initiative

KNH – Kenyatta National Hospital

PAD – Peripheral Arterial Disease

TCVS – Thoracic and cardiovascular surgery

UACVT – Upper arm cephalic vein transposition

UABVT – Upper arm basilic vein transposition

UoN – University of Nairobi

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ABSTRACT

Background: The arteriovenous fistula is the preferred long-term vascular access for chronic haemodialysis, due to its prolonged primary patency rates, has the fewest interventions and is associated with decreased morbidity and mortality.

Despite being the preferred choice of haemodialysis access, AVF still has a relatively high primary failure rate related to various factors.

There has been no study done in our institution and in Kenya to determine the outcomes of AVF creation and the factors that affect the maturation of the created AVF.

Objective: To determine the outcomes of AVF creation and the factors that affect the maturation of the created AVFs at KNH in patients with ESRD requiring chronic haemodialysis.

Methodology: The study was a prospective cohort study of patients with ESRD who had an AVF created for haemodialysis at KNH from October 2020 to April 2021. Prior to creation of the AVF, the vein and artery diameters were determined using duplex ultrasonography. These patients were then reviewed at 8 and 12 weeks after creation of the AVF, to determine the diameter of the vein with duplex ultrasonography and also to determine whether they had successful dialysis using the created AVF. This study was conducted at KNH Thoracic and Cardiovascular Surgery unit.

Data was entered and analysed by use of SPSS version 21. The percentage of people who had successful maturation of the created AVF was calculated as a proportion of those who had successful maturation of the created AVF over the total sample size and reported as a percentage.

Patient demographics as well as other patient characteristics was analysed and presented as frequencies and proportions for categorical data, and as means or medians for continuous data.

Results: During this time frame, 114 arteriovenous fistulas were created in 111 patients. Of the AVFs created, 56.1% (n=64) were brachiocephalic fistulas and 43.9% (n=50) were radiocephalic fistulas. The primary failure rate was 21.6% after excluding 3 patients who died during follow-up. Of the AVFs that failed, the radiocephalic fistulas were associated with a higher failure rate as compared with brachiocephalic fistulas, 62.5% (n=15) and 37.5% (n=9) respectively. The risk of primary failure was increased in patients with poor venous outflow and venous distensibility of < 50% as well as patients who had small diameter veins with a cut-off value of 2.25mm.

Conclusion: Primary AVF failure, remains a major issue, since the arteriovenous fistula remains the preferred choice of haemodialysis access. This study has shown that the outcome of arteriovenous fistula creation in our institution is promising. Of note, is that a significant number of the AVFs created were radiocephalic fistulas. Vein internal diameter of greater than 2.25mm and good venous outflow and distensibility were noted to be important predictors of a successful outcome.

INTRODUCTION

The number of patients with ESRD requiring chronic hemodialysis in Kenya has increased. There has also been an increase in the number of dialysis centres and access to haemodialysis. For chronic haemodialysis to be successful, it is paramount that a reliable vascular access is available. There are 3 forms of haemodialysis vascular access: central venous haemodialysis catheters, arteriovenous grafts and arteriovenous fistulas(1,2).

An arteriovenous (AV) fistula for dialysis is a deliberate surgically created anastomosis between an artery and a vein.

It is a form of vascular access used in the ESRD patient needing chronic haemodialysis. After the surgery, the vein which now receives blood under high pressure from its connection to the artery, begins to dilate and thicken. The AVF is said to be 'mature' when the vein is big enough and visible just under the skin where it can now be cannulated and connected to the dialysis machine. Its function and patency are critical in the delivery of effective hemodialysis(2).

The possible configurations of AVF are radiocephalic, forearm basilic, brachiocephalic, brachiobasilic and lower extremity AVF, which is an anastomosis in the thigh between the popliteal/femoral/saphenous vein and the superficial femoral artery(3,4).

There are several characteristics that must be present for an AVF to be successful and be usable. These include, blood flow must be at least 500 to 700 ml/min to support the dialysis prescription(5), a relatively straight segment of 8 to 10cm long needs to be available for cannulation, it must be able to be reliably cannulated repeatedly, it should be within 5 to 6 mm of the skin surface, it should be on the anterior or lateral surface in the upper arm, it should be on the volar surface in the forearm and the AVF must be accessible with the patient in a comfortable sitting position(6).

The factors that increase the risk of primary failure of an AVF are predialysis hypotension, smoking, patients with substantial vascular abnormalities e.g. arteriosclerosis, medical comorbidities e.g. DM and older patients(7). It has been shown that the diameter of a vessel, is key to fistula success and resultant high maturation rates despite significant patient comorbidity(8). Poor vein anatomy and damage to the veins through repeated cannulation and venepuncture for drawing of blood samples also increase the risk of primary failure of an AVF(9).

This study aims to establish the outcomes of AVF creation and the factors that affect the maturation of the created AVF at KNH, in patients with ESRD requiring chronic hemodialysis.

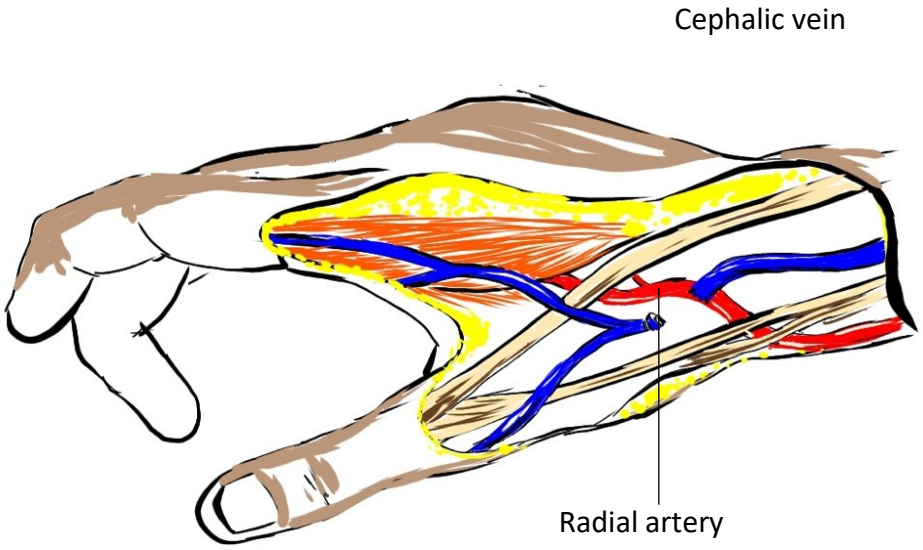


Figure 1: Radiocephalic arteriovenous fistula at the wrist.

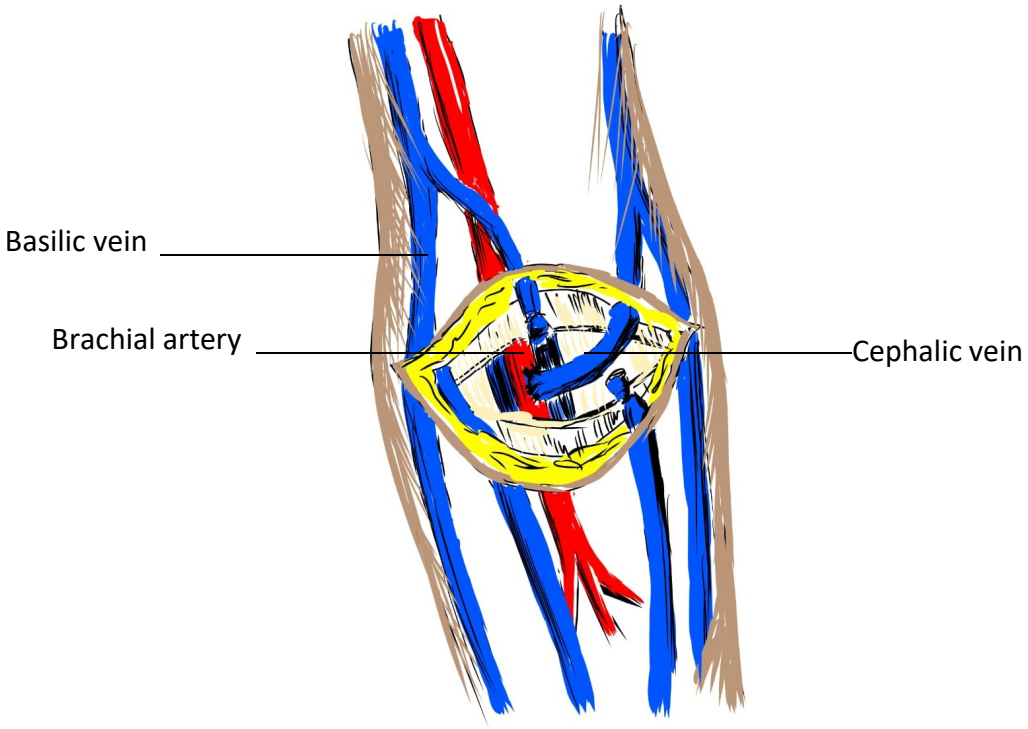


Figure 2: Brachiocephalic arteriovenous fistula at the cubital fossa.

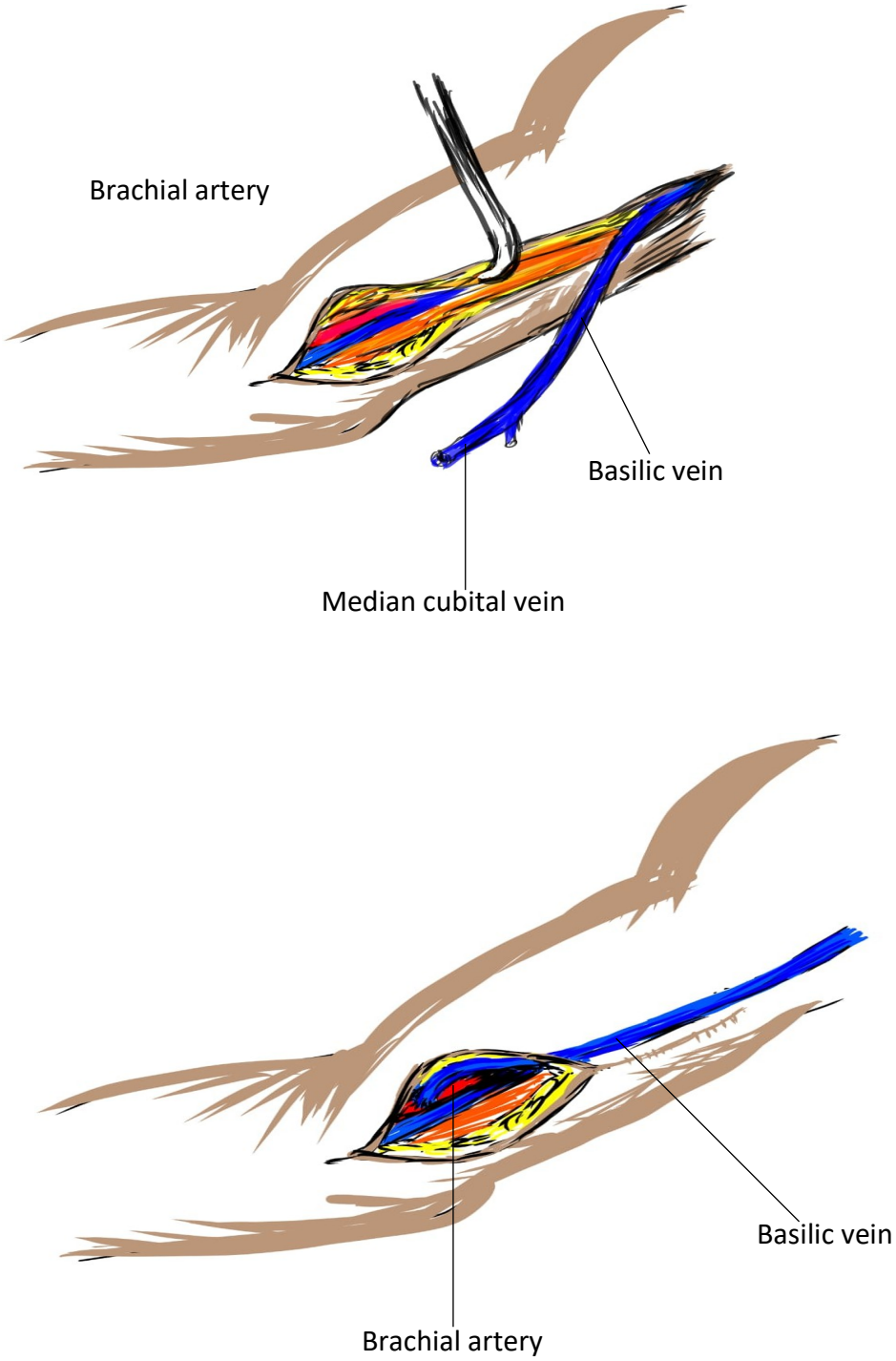


Figure 3: A, Basilic vein dissection in the upper arm. B, Transposed brachiobasilic arteriovenous fistula.

LITERATURE REVIEW

An arteriovenous is a deliberate surgically created connection between a native artery and vein. It is a form of haemodialysis vascular access. Its creation, patency and function are vital in delivery of effective haemodialysis

There are 3 forms of vascular access for chronic haemodialysis, and this include: central venous haemodialysis catheters, arteriovenous grafts and arteriovenous fistulas.

The AVF is the preferred long-term haemodialysis vascular access, because it has the best long-term primary patency rates, requires the fewest interventions of any type of access and is associated with the lowest incidence of morbidity and mortality and hence significantly lowers healthcare costs associated with vascular access procedures and complications.

Epidemiology

According to data from the Health Information Statistics department of KNH, the number of hospitalized patients with ESRD requiring chronic hemodialysis in KNH from 2013 to 2019 stood at 2,440 patients. Of these 396 and 517 patients with ESRD were hospitalized in 2018 and 2019 respectively. The number of AVF created at KNH in 2018 and 2019 were 15 and 99 respectively, representing a prevalence of approximately 4% and 19% respectively.

Haemodialysis vascular access failure causes substantial morbidity and mortality, hence significantly increasing healthcare costs associated with vascular access procedures and complications.

A study by Robin et al, estimated that vascular access procedures for chronic haemodialysis and their associated complications accounted for greater than 20% of hospitalizations of haemodialysis patients and costs of over $1 billion annually in the United States(10).

Outcomes of Arteriovenous Fistula Creation

Primary failure is defined as an arteriovenous fistula that has never been usable for dialysis or that fails during its use before completion of three months after its creation, with emphasis generally being on failure of maturation(11,12). For an AVF to be suitable for dialysis, two variables are required: the AVF should have sufficient blood flow to support the haemodialysis prescription and be large enough to allow repetitive cannulations(11).

Primary AVF failure has always been a problem. The risk of primary AVF failure is high, ranging from 10 to 60% in randomised studies(10,13).

In the Hemodialysis Fistula Maturation Study, which was a prospective observational study, reported a risk of primary failure of 40%(14). A meta-analysis that included 43 studies reported a lower rate at 23%(15).

A 2 year retrospective study at Mayo Clinic in Rochester, Minnesota, involving 293 patients in whom 317 AVFs were fashioned, found a primary failure rate of 37.1% (16).

In another study by A. Salako et al, which was a 10-year retrospective study that involved creation of 80 AVFs in 74 patients, found a primary failure rate of 7.5% (six patients). Primary failure was more common in diabetics and thrombosis was the most common cause of primary failure(17).

It has been shown in other studies, that among radiocephalic fistulas, brachiocephalic fistulas and brachiobasilic transposition, the primary failure rate for radiocephalic fistulas is the highest and for brachiobasilic fistulas is the lowest(18–20). For example, in a study by Hakaim et al, radiocephalic arteriovenous fistulas were associated with a failure rate of 70% as compared to a failure rate of 27% for brachiocephalic arteriovenous fistulas and 0% for brachiobasilic fistulas(18).

In a 6-year retrospective review, of the outcome of three different sites of AVF in 165 dialysis patients, where 77 patients had FACVT, 52 patients had UACVT, and 36 patients had UABVT for dialysis; showed primary access maturation rates of 86%, 90% and 97% respectively. All matured primary AVFs that were transposed, were used without additional interventions after a mean of 9.9 weeks(22).

Factors that affect the Outcome of Arteriovenous Fistula Creation

Age

There is a general lack of concordance in the literature concerning the effect of age on AVF development and patency. There are studies showing that age has an overall negative effect(24), while other studies show that there is no age-related difference in AVF success(4).

The increased burden of comorbidity in the older patient may materially affect patient selection for AVF creation; however, once an AVF is established in these cases, patency appears to be comparable to that of younger age groups as illustrated by the 2016 United States Renal Data System that showed AVF primary failure rates differed only modestly between age groups. The AVF failure rates for age categories 22 to 44, 45 to 64, 65 to 74, and > 75 years were 32, 34, 37 and 40% respectively.

A retrospective study by Wood et al, showed that patients older than 65 years with an AVF, had a 24% lower risk of vascular access failure than patients with an AV graft ($P < 0.02$). The relative risk of AVF failure compared to an AV graft, was 67% at 40 years of age, 54% at 50 years of age, and 24% at 65 years of age. Presence of peripheral vascular disease was associated with an increased risk of AV fistula or graft failure of 24%($P = 0.05$)(25).

Vessel Size

There is no generally recognized minimum threshold of an arterial diameter for the development of a successful AVF, although a 2mm minimum threshold has been most frequently quoted. The K/DOQI Clinical Practice Guideline for Vascular Access: 2019 Update advises against using an absolute minimum threshold, and if a vessel < 2mm is to be used, careful evaluation of its quality and feasibility to result in a functional AVF should be evaluated prior to surgery. Some

investigators have suggested using a different minimum arterial diameter threshold as described below.

Parmar et al, assessed the role of routine radial artery duplex sonography in determining the relationship between radial artery internal diameter and AVF patency before AVF creation and found that when the radial artery internal diameter was < 1.5mm, there was a high AVF primary failure rate. They concluded that when the radial artery was <1.5mm, AVF creation in the upper arm should be considered(26).

A prospective study by V. Wong et al assessed the radial arteries and cephalic veins preoperatively, through examination by an ultrasound colour flow scanner together with a pulse-generated run-off to determine the suitability for fistula fashioning and found that early fistula failure was associated with cephalic vein and radial artery diameter of <1.6mm(9).

As discussed above with arterial size, there is no generally recognized standard for vein diameter, although some investigators have recommended a different minimally acceptable threshold, the minimum venous luminal diameter threshold most often quoted is 2.5mm at the point of anastomosis(27).

A study conducted by Malovrh et al, demonstrated that the vein's potential distensibility was more important than the diameter. They examined the increasing vein internal diameter by duplex ultrasonography before AVF surgery and on the basis of this increase, they were able after construction and at different intervals to anticipate an increase in AVF vein diameter(28).

Diabetes Mellitus

The diabetic state doesn't have a direct effect on the outcome of an arteriovenous fistula, however the comorbidities associated with diabetes e.g., peripheral vascular disease does have an effect. A study be Sedlacek et al showed that there were no significant differences in outcomes of AVF creation for haemodialysis between diabetic and non-diabetic patients. This study reported no significant difference in arterial peak systolic volume and vessel diameter between diabetic and non-diabetic patients despite increased arterial calcification(29).

Peripheral Arterial Disease

Peripheral arterial disease is associated with intimal hyperplasia and calcification and its presence has been associated with an increased risk of AVF failure(30). In a study involving 59 patients with radiocephalic AVF, 45 patients were found to have intimal hyperplasia in their radial artery and AVF failure was observed only in patients with intimal hyperplasia. Of note, was that patients with intimal hyperplasia were older and had a higher incidence of diabetes(31).

Rate of Maturation of a newly created Arteriovenous Fistula

Maturation of an AVF without additional intervention is generally apparent at four to six weeks following creation(11,32). Early evaluation of the AVF enables detection of areas of stenosis in non-maturing fistulas, which then allows appropriate intervention to salvage a failing AVF.

A prospective study of 152 radiocephalic fistulae that were successful, showed an increase in AVF blood flow and cross-sectional area as early as 2 weeks. The increased blood flow and cross-sectional area was seen both in younger patients (age 47.5 ± 11.5 [n = 92] and older patients (age 71.8 ± 5.1 [n = 60]; with blood flow and cross-sectional area at 2 weeks being 750.4 ± 392.2 ml/min [SD] and 11.5 ± 4.0 mm^2 respectively in younger patients and blood flow and cross-sectional area at 2 weeks being 634.2 ± 310.3 ml/min [SD] and 10.4 ± 2.8 mm^2 respectively in older patients with an AVF(33).

Another study (n = 69) confirmed the above findings, that there were significant changes in the diameter and blood flow of the AVF which occurred earlier on after AVF fashioning with blood flow and venous diameter at 4 weeks being approximately 700ml/min and 0.45cm respectively; and at 12 weeks being approximately 675 ml/min and 0.47 cm respectively. This study, helped in predicting the outcomes of AVF, by determining the minimum venous internal diameter and blood flow rates. The findings of this study showed that a venous internal diameter of ≥ 0.4 cm and a blood flow rate of ≥ 500ml/min was sufficient for haemodialysis in 67% and 70% of AVFs respectively. When both the venous internal diameter and blood flow were ≥ 0.4cm and 500ml/min respectively, 95% of the AVFs were adequate for hemodialysis. The venous internal diameter of ≥ 0.4 cm and blood flow rate of ≥ 500ml/min in this study, were seen during the first 2 months and thereafter no significant changes were noted in the second to fourth postoperative month(34).

STUDY JUSTIFICATION

Despite the huge burden of patients with ESRD requiring chronic hemodialysis in Kenya, the number of patients undergoing successful AVF creation surgery is to date unknown. There has been no study done in KNH and in Kenya to determine the outcome of AVF creation and the factors that affect the maturation of the created AVF in our institution.

It is important to determine the factors that affect the maturation of the created AVF, as these will require careful consideration during creation of the AVF, and result eventually in improvement of the outcomes of AVF creation in our institution.

PROBLEM STATEMENT

What is the outcome of AVF creation and the factors that affect the maturation of the created AVF at KNH, in patients with ESRD requiring chronic haemodialysis?

STUDY OBJECTIVE

Broad Objective

To determine the outcome of AVF creation and the factors that affect the maturation of the created AVF at KNH, in patients with ESRD requiring chronic hemodialysis.

Specific Objective

- To determine the outcome of the created AVFs
- To determine the factors that affect the maturation of the created AVFs.

RESEARCH METHODOLOGY

The study was a prospective cohort study of patients with ESRD who had an AVF created for haemodialysis and were followed up to 12 weeks until primary failure or success was assessed

STUDY DESIGN

The study was a prospective cohort study of patients with ESRD who had an AVF created for haemodialysis. Prior to creation of the AVF, the vein and artery diameters were determined using duplex ultrasonography. These patients were then reviewed after 8 to 12 weeks to determine whether they had successful dialysis using the created AVF and the flow rates achieved in the dialysis machine during haemodialysis. Duplex ultrasonography was also performed to determine the diameter of the vein.

STUDY POPULATION

Adult patients with ESRD requiring an AVF for vascular access for chronic haemodialysis.

STUDY AREA

The study was conducted in the consultation rooms of the renal unit where preoperative evaluation and post-operative follow-up was conducted, while the surgical creation of the AVF was done in the main theatres at KNH.

KNH is the largest teaching and referral hospital in Kenya and the East and Central Africa region. It is located in the capital city Nairobi, about 4 kilometres from the city centre and has a bed capacity of 1,800 beds with a high patient turnover. KNH is a teaching hospital for the University of Nairobi, School of Medicine and visiting students from other institutions.

KNH Hospital has a Thoracic and Cardiovascular Surgery Unit within the Department of Surgery as well as renal unit.

STUDY PERIOD

The study was conducted over a period of 7 months. Study end point was 12 weeks from recruitment into the study for every patient or if there was failure of maturation at 8 weeks. There was a 2 week, 8 week and 12 week follow up of the patients after creation of the AVF.

STUDY OUTCOME

We determined the percentage of successful AVFs created based on functional patency and suitability for dialysis.

In addition, we also determined the factors that affected the maturation of the created AVFs.

SELECTION AND ENROLMENT OF PARTICIPANTS

Inclusion Criteria

- Patients with ESRD referred from KNH Renal Unit and other healthcare facilities to the department of Surgery - TCVS unit for AVF creation.
- Informed consent

Exclusion Criteria

- Patients with small calibre vessels unlikely to result in a functional AVF as determined on physical examination and doppler ultrasound (< 1.5mm for both artery and vein).
- Patients with limb swelling or central vein stenosis from previous catheter use as confirmed on doppler studies and physical examination findings suggestive of central stenosis.
- Patients unavailable for follow up
- Patient who were less than 13 years old.
- Patients with terminal illnesses e.g. advanced cancer, severe heart failure

SAMPLE SIZE DETERMINATION

Fisher's formula was used to calculate the sample size;

$$n = \frac{Z^2 x\ P(1 - P)}{d^2}$$

Where,

n = Desired sample size

Z = value from standard normal distribution corresponding to desired confidence level (Z=1.96 for 95% CI)

P = expected true proportion (estimated at 7.5%, from a retrospective study conducted by A. Salako et al (2018) over a period of 10 years at the Obafemi Awolowo University Teaching Hospitals Complex, Ile-Ife Nigeria, which found a primary failure rate of 7.5% from a total of 80 created AVFs in 74 patients.)

d = desired precision (0.05)

$$n" = \frac{1.96^2 x\ 0.075(1 - 0.075)}{0.05^2} = 107$$

The study required a sample size of 107 patients.

But, to cater for patients who were lost to follow-up or died, a loss to follow-up rate of 15% which translates to approximately 16 patients was added to the calculated sample size of 107 patients.

Therefore, a final sample size of 123 patients was required for the study.

SAMPLING TECHNIQUE AND DATA COLLECTION

Convenience sampling method of patients who met the inclusion criteria of the study was done until the sample size was achieved. This method involved recruitment of all patients referred on a day-to-day basis to the TCVS unit for AVF creation and did not have any of the exclusion criteria.

Recruitment and Consent

Participants for the study included those with chronic kidney disease before they developed end stage renal disease as well as those with end stage renal disease and were currently undergoing dialysis through tunnelled haemodialysis central venous catheters both of whom were on follow-up and underwent dialysis respectively at the KNH Renal Unit. Informed consent by the Principal Investigator and a trained research assistant was obtained from them prior to recruitment. The surgery was performed in main theatre within 1 week, after suitability for creation of the AVF was determined during preoperative evaluation.

Study Variables

The dependent variable was the outcome of AVF creation i.e. vein internal diameter of > 4.0mm at 8 weeks after AVF creation and first successful cannulation and dialysis thereafter, while the independent variables was the patients' demographic characteristics, etiology of ESRD, comorbidities, prior history and site of CVC insertion, if patient is on dialysis, history and type of previous dialysis vascular access as well as the location, quality of arterial pulses, blood pressure differences in both arms, the vein and artery internal diameters before creation of the AVF, type of AVF created by anatomic location.

Definition of outcomes

- Primary failure - Primary failure is defined as an arteriovenous fistula that has never been usable for dialysis or that fails during its use before completion of three months, with emphasis generally being on failure of maturation.

- Mature AVF – refers to an AVF with a minimum venous diameter of > 4.0mm at 8 weeks after AVF creation.
- Suitability for haemodialysis – For an AVF to be suitable for dialysis, two variables are required: adequate blood flow through the AVF (> 500ml/min) to support dialysis and be of adequate diameter (> 4.0mm).

Data Collection

Data was collected via a printed questionnaire/data collection sheet, after obtaining informed consent from the patient. Demographic data as well as clinical data relevant for the study was obtained from the patient and their medical records.

Patients with comorbidities such as DM and Hypertension were confirmed by Physicians' treatment notes from the patient records. Peripheral Vascular Disease was confirmed by a CT angiogram report from the patient's medical records.

The data was collected by the Principal Investigator and a research assistant, who was a resident in the TCVS unit.

Study Procedure

Pre-operative Assessment

Data for the medical history and physical examination section was collected by the residents in the TCVS unit and the information filled in the data collection sheets.

This study involved getting a medical history and filling the details into the medical history section of the data collection sheet through a face-to-face interview with the patient and extraction of other relevant data from the patient's medical records.

General physical examination followed with the aim of looking for any physical evidence of scars from prior central venous access and prior neck or thoracic surgery or trauma, presence of collateral or swollen veins in the chest, breast and upper arms.

Vascular evaluation was then done with the examination of the potential target vessels (arteries and veins.

Arterial evaluation involved examination of both upper limb vessels to ensure their patency by assessing the quality of their pulses and the blood pressure differences between the two arms using a sphygmomanometer. If the blood pressure difference suggested subclavian stenosis, then the options would be to move to the opposite arm or initiate a more detailed evaluation of the arterial anatomy through duplex ultrasonography or angiography so as to make a more definitive diagnosis and hence help with making a decision with regards to access options in that arm.

Venous evaluation involved assessment of the entire extent of the vein and its drainage to confirm its patency through palpation of the vein proximally for a tapping sensation after gently stroking the vein distally. Vein distensibility was also assessed by application of a tourniquet above the veins to demonstrate anatomically using duplex ultrasonography, that the vein that was intended to be used was capable of dilating at least 50% of the resting internal diameter.

If physical examination failed to demonstrate the presence of adequate vessels for the creation of an AVF, then the patient was sent to the radiology unit for vascular mapping, thereafter a decision to proceed with the creation of the AVF was made based on the findings of the vascular mapping.

Surgical Creation of the Arteriovenous Fistula

Once the physical evaluation as described above was done and a decision made regarding the type of the AVF to be created (based on anatomical location) then the surgery was performed by the vascular surgery residents and the consultant vascular surgeons. Prior to creation of the AVF, measurement of the internal diameter of the vein and artery was performed using duplex ultrasonography and documented in the data collection sheet. The surgeon afterwards determined the presence of a thrill after creation of the AVF.

Post-operative Follow-up

The patient was then reviewed at 8 weeks after creation of the AVF. During this review, duplex ultrasonography was performed to determine the diameter of the vein.

The patient was then followed-up thereafter, to determine the timing of the first successful cannulation, duration of dialysis and blood flow rates achieved during dialysis.

DATA MANAGEMENT AND ANALYSIS

Prior to data collection, ethical approval was sought. Thereafter, recruitment of a research assistant was done to assist in data collection. The research assistant was trained on maintenance of confidentiality, interviewing techniques, information retrieval and filling of the questionnaire. To maintain confidentiality, all data collection sheets did not have identifying features such as names of the patients but a pre-assigned serial number. The data collection sheets were then checked for completeness prior to storing them in a secure lockable cabinet only accessible to the principal investigator and the research assistant.

Data was entered and analysed by the use of SPSS version 23.

The outcome or rate of maturation of the created arteriovenous fistula was reported as either successful or unsuccessful and was analysed and summarised as frequencies and percentages based on the presence or absence of a venous diameter of > 4.0 mm as well as presence of successful cannulation and dialysis.

Patient demographics and patient characteristics was analysed and presented as frequencies and proportions for categorical data, and as means or medians for continuous data.

The relationship between patient demographics and patient characteristics to the outcome of arteriovenous fistula creation as either successful or unsuccessful was analysed by the use of the Chi-square test and those patient demographics and patient characteristics found to be significant were further subjected to a univariate analysis with the use of logistic regression.

The odds ratio, as well as 95% confidence interval was calculated with all tests being considered significant where p-value is < 0.05.

Hard copies of the data collected were stored in a lockable vault while the soft copies of the data were password protected.

ETHICAL CONSIDERATIONS

Institutional consent and approval were sought from the KNH/UoN Ethics and Research Committee.

The Permission to conduct the study was also sought from the department of Surgery, UoN and the KNH administration.

Patients consent was also sought.

The data collected were under no circumstances shared to third parties and were used for purposes of this research only.

The patients' privacy was ensured by using codes for identification instead of their names.

STUDY RESULTS DISSEMINATION

The study results shall be made available to the department of surgery, both UoN and KNH.

With the consent of KNH the study will also be presented in other fora like conferences or seminars and published online in a peer review journal for access by all relevant medical personnel.

RESULTS

A total of 114 arteriovenous fistulas were created in 111 patients after preoperative assessment and were followed up at 8 and 12 weeks after creation of the AVF. 3 patients died during the follow-up period.

Patients' Characteristics

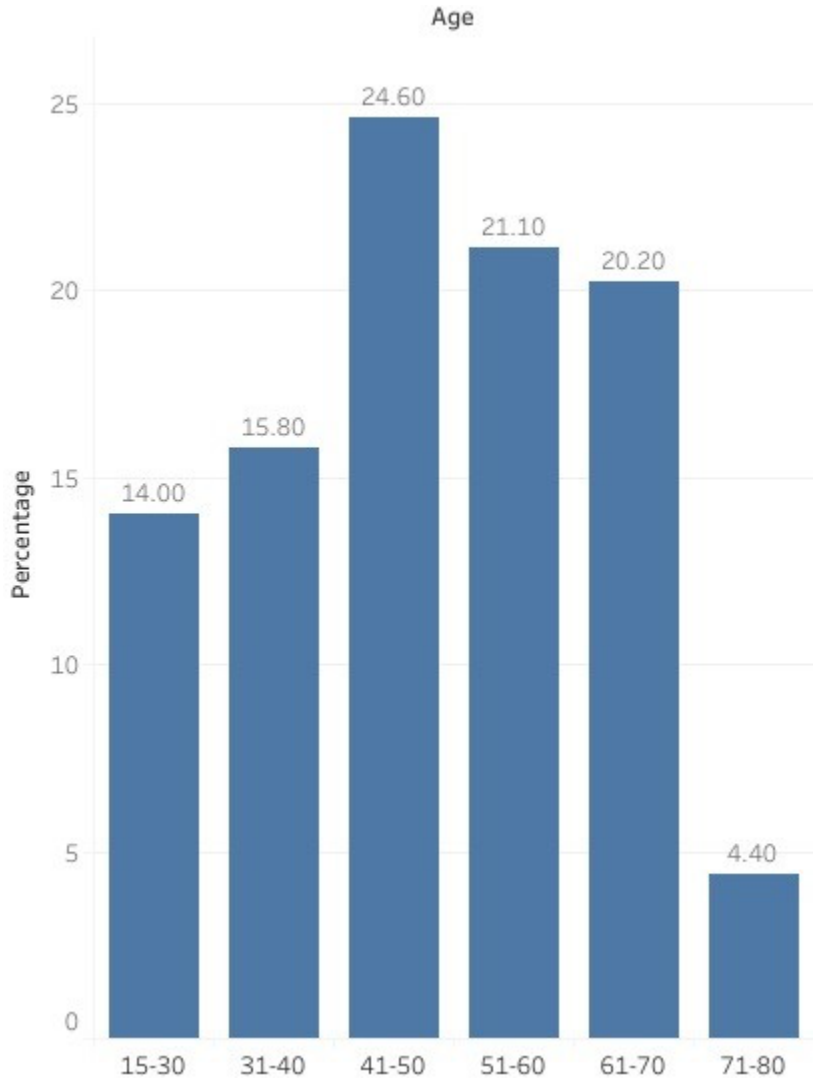
Results of patients' characteristics indicate that male patients were 73 (64.0%), while the female patients were 41 (36.0%). The mean age of the patients was 48.6 (SD 14.4) years, the youngest being 17 years, and the oldest being 77 years. Majority of the patients were between 41-50 years (24.6%). The results are as shown in Figure 1.0.

Table 1: Patients' Characteristics

Age	**Frequency (n=114)**	**Percentage**
≤30	16	14.0
31-40	18	15.8
41-50	28	24.6
51-60	24	21.1
61-70	23	20.2
More than 70	5	4.4
Gender		
Male	73	64.0
Female	41	36.0

Below is a bar graph showing the percentage of the patients in the different age groups.

Figure 4: Patients' Characteristics

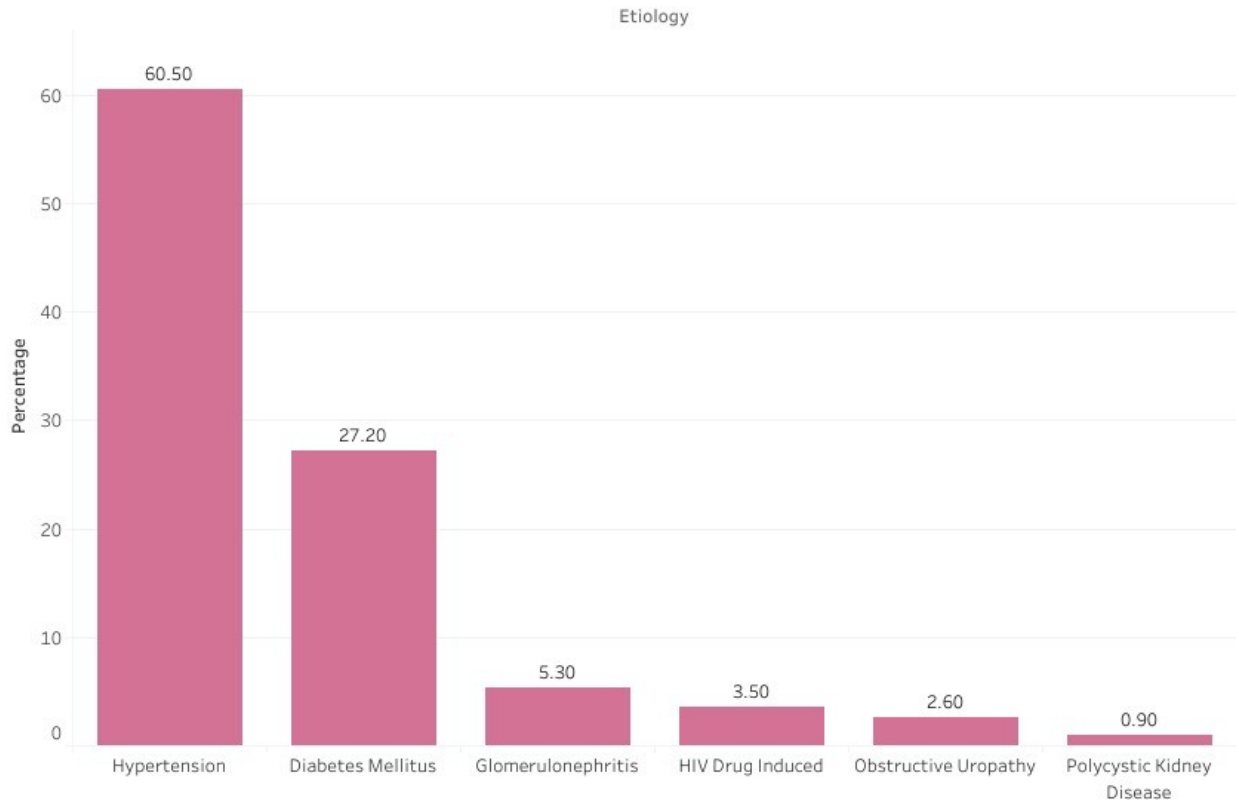


Etiology

Hypertension was the most common cause of ESRD accounting for 60.5% (n = 69). Diabetes Mellitus, which is also considered as a clinical comorbidity, was the second most common cause of ESRD accounting for 27.2% (n=31), this was followed by glomerulonephritis at 5.3% (n = 6), HAART-related nephropathy at 3.5% (n = 4), Obstructive uropathy at 2.6% (n=3) and Polycystic kidney disease at 0.9% (n=1).

Below is a bar graph of the etiological causes of ESRD.

Figure 5: Etiology



Patients on Haemodialysis

The number of patients on dialysis prior to creation of the arteriovenous fistula were 103, representing 90.4%, while those with previous haemodialysis vascular access were 104, representing 91.2% of the patients, as shown in the table below. One of the patients with previous haemodialysis access, had a failed radiocephalic fistula but had not started undergoing haemodialysis.

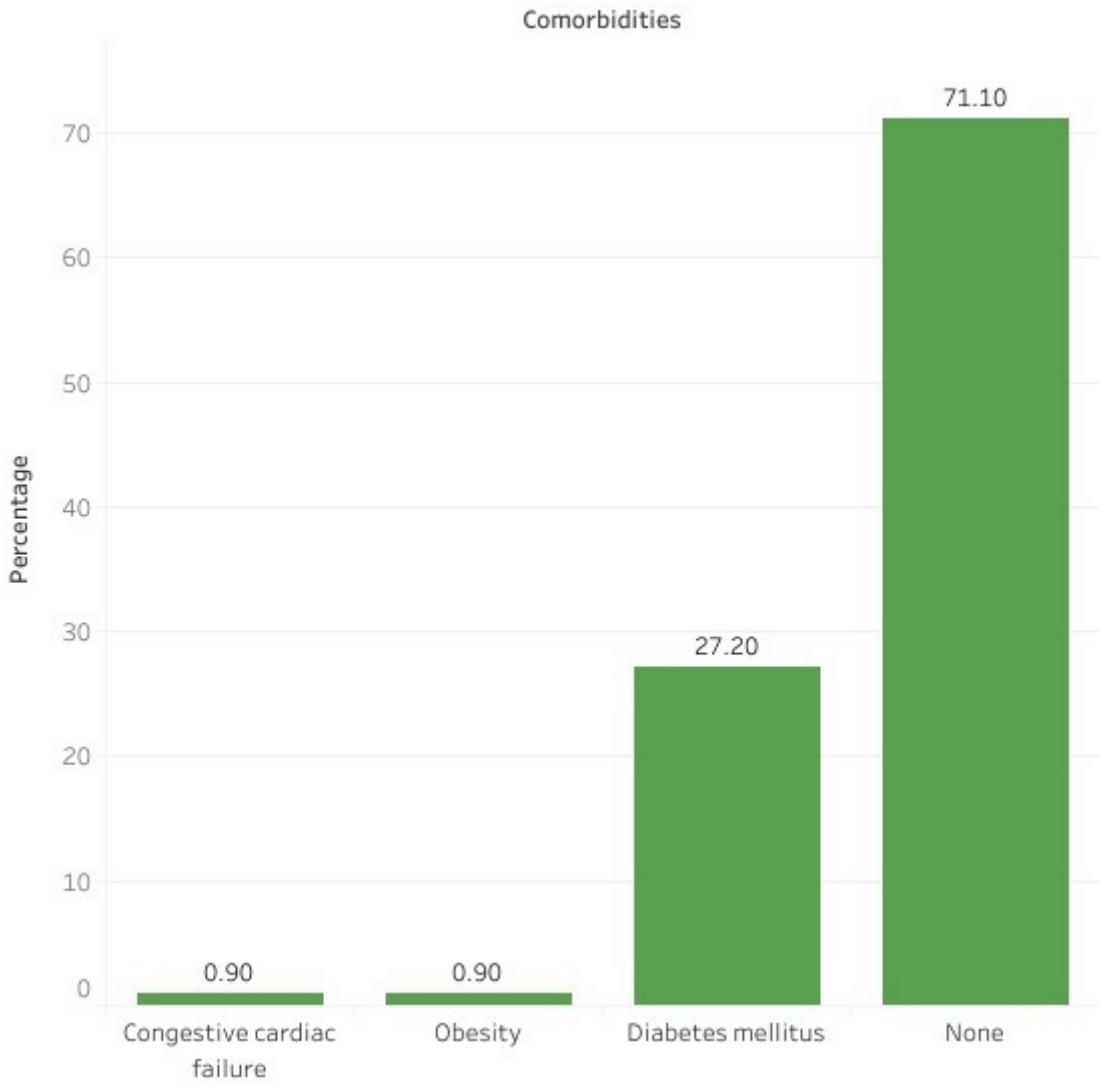
Table 2: Patients on Hemodialysis/Previous Hemodialysis Vascular Access

	Frequency (n=114)	Percentage
On Hemodialysis		
Yes	103	90.4
No	11	9.6
Previous hemodialysis vascular access		
Yes	104	91.2
No	10	8.8

Clinical Comorbidity

71% (n=81) of patients who underwent creation of the arteriovenous fistula did not have any clinical comorbidities with Diabetes mellitus accounting for 27.2% (n=31). Obesity and Congestive cardiac failure accounted each for only 0.9% (n=1) of the clinical comorbidities.

Figure 6: Clinical comorbidity



Vascular Evaluation

1. Physical Examination

All the patients had normal arterial pulses. Absence of collateral veins was also noted in all the patients.

79.8% (n=91) had a normal blood pressure difference between both upper limb i.e. < 10 mmHg, 9.6% (n=11) had an abnormal blood pressure difference i.e. between 10 to 20 mmHg and 10.5% (n=12) had a marginal blood pressure difference i.e. > 20 mmHg.

105 patients representing 92.1% of the patients included in the study, had good venous outflow and distensibility of > 50% of resting internal diameter, with only 7.9% (n = 9) having a venous outflow and distensibility that did not meet the desired AV access characteristics.

The above results are illustrated in the table below.

Table 3: Vascular Evaluation

Arterial Pulses	**Frequency (n=114)**	**Percentage**
Normal	114	100.0
Blood Pressure difference in both Arms		
Normal	91	79.8
Abnormal	11	9.6
Marginal	12	10.5
Good Venous Outflow		
Yes	105	92.1
No	9	7.9
Vein distensibility > 50%		
Yes	105	92.1
No	9	7.9

2. Vascular Mapping

Preoperative venous and arterial mapping using duplex ultrasonography was done for each patient before AVF creation in this study. The mean vein diameter was 2.7 (SD 0.9) mm, while the median was 2.6 (IQR 2.0 – 3.2) mm, and the smallest observed diameter was 1.5 mm, while the largest was 6.3 mm. Below is a table showing the mean and median artery diameters of the brachial and radial artery.

Table 4: Mean and median artery diameter

	Mean	**SD**	**Median**	**IQR**
Brachial artery	4.2	1.0	4.2	3.5 – 4.9
Radial artery	2.7	0.5	2.7	2.2 – 3.0

The table below illustrates the number of veins and arteries within the diameter ranges shown.

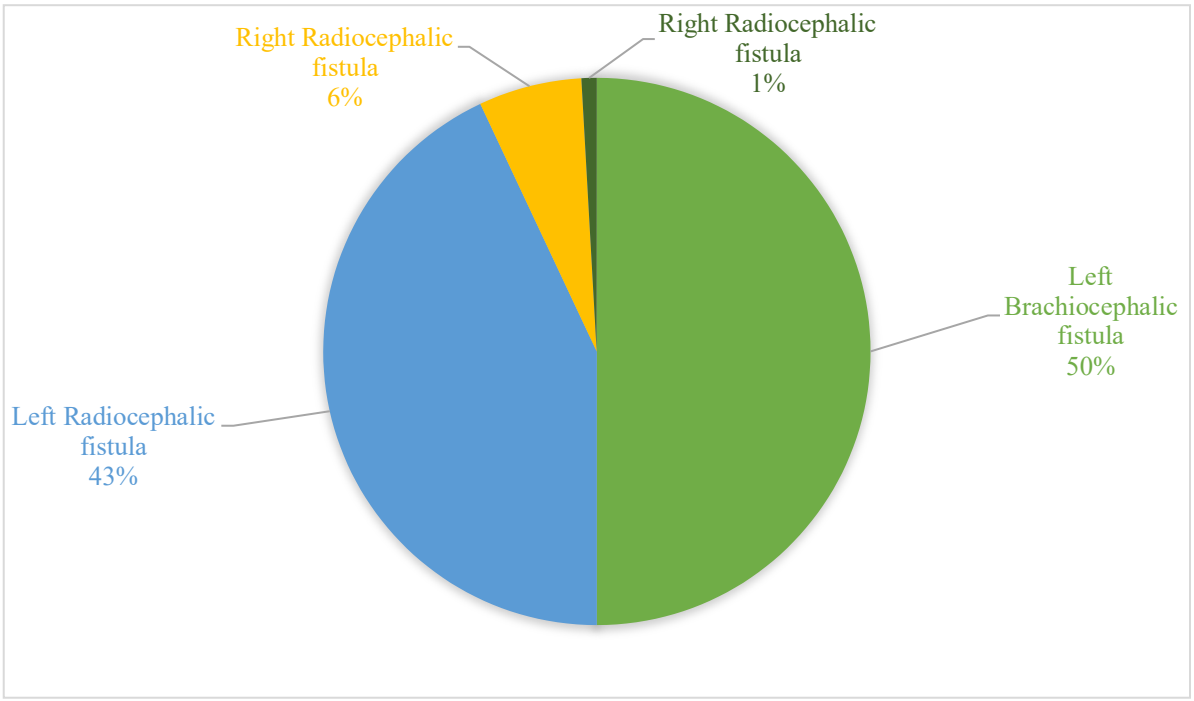
Table 5: Vein and Artery Diameters

Vein Diameter (mm)	**Branchiocephalic, *n (%)***	**Radiocephalic, *n (%)***
1.5-1.9	1 (1.6)	9 (18.0)
2.0-2.4	19 (29.7)	19 (38.0)
2.5-2.9	15 (23.4)	14 (28.0)
3.0-3.4	9 (14.1)	7 (14.0)
3.5-3.9	12 (18.8)	1 (2.0)
4.0-4.4	3 (4.7)	0 (0.0)
4.5-4.9	2 (3.1)	0 (0.0)
5.0-5.4	1 (1.6)	0 (0.0)
5.5-5.9	1 (1.6)	0 (0.0)
6.0-6.4	1 (1.6)	0 (0.0)
Artery Diameter (mm)		
1.5-1.9	1 (1.6)	4 (8)
2.0-2.4	3 (4.7)	14 (28)
2.5-2.9	2 (3.1)	18 (36)
3.0-3.4	5 (7.8)	10 (20)
3.5-3.9	11 (17.2)	4 (8)
4.0-4.4	18 (28.1)	0 (0.0)
4.5-4.9	9 (14.1)	0 (0.0)
5.0-5.4	10 (15.6)	0 (0.0)
5.5-5.9	3 (4.7)	0 (0.0)
6.0-6.4	1 (1.6)	0 (0.0)
6.5-6.9	1 (1.6)	0 (0.0)

Type of Arteriovenous Fistula Created

The most common AVF created was a brachiocephalic fistula, with left brachiocephalic fistula and right brachiocephalic fistula representing 50.0% (n=57) and 6.1% (n=7) respectively. 43.0% were left radiocephalic fistulas (n = 49) and 0.9% were right radiocephalic fistula (n = 1).

Figure 7: Type of AVF created



Post-operative Outcome

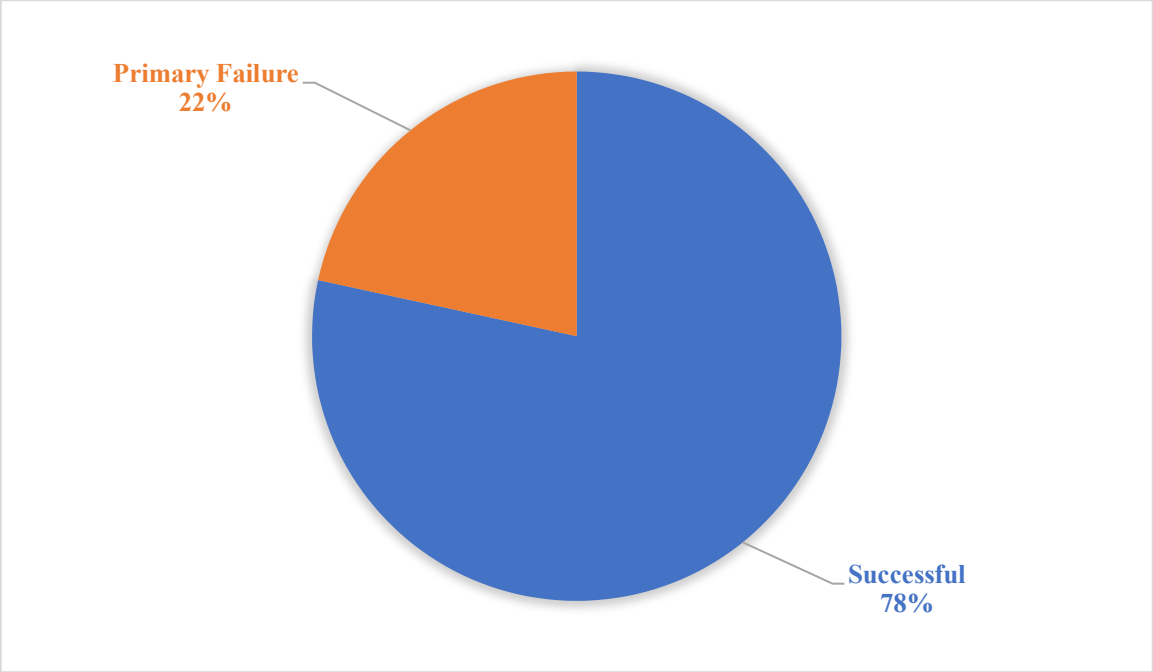
95.6% (n = 109) of the arteriovenous fistulas created had a thrill in the immediate post-operative period, with only 4.4% (n = 5) having no thrill as illustrated in Table 6.0. Of the 5 that didn't have a thrill in the immediate post-operative period, 3 were brachiocephalic arteriovenous fistulas and 2 were radiocephalic arteriovenous fistulas with their vein diameters being less that 2.0mm.

Table 6: Presence of Thrill after Surgery

	Frequency (n=114)	Percentage
Yes	109	95.6
No	5	4.4

Of the 109 patients with a thrill post-operatively and after exclusion of the 3 patients that died, 78.4% (n = 87) of the arteriovenous fistulas were successful on follow-up i.e. they had a vein diameter of greater 4.0mm and underwent successful cannulation and dialysis. 21.6% (n = 24) had primary failure as outlined in the table below.

Figure 8: Outcome of AVF Creation



The mean venous diameter of the AVF was 6.4 (SD 0.9) mm, and the smallest observed diameter was 3.5 mm, while the largest was 17.5 mm at 8 weeks after creation of the AVF.

Table 7: Mean Venous Diameter of the AVF for the groups

	Mean	SD
Brachiocephalic	7.6	2.7
Radiocephalic	5.4	1.3

Below is a table showing the frequencies and percentages for the various venous diameter ranges of both the radiocephalic and brachiocephalic fistulas at 8 weeks of follow-up.

Table 8: Frequencies and Percentages for the Various Venous Diameter Ranges at 8 weeks.

Fistula Diameter (mm)	Branchiocephalic, *n (%)*	Radiocephalic, *n (%)*
3.1-4.0	3 (5.5)	1 (2.9)
4.1-5.0	4 (7.3)	13 (37.1)
5.1-6.0	5 (9.1)	13 (37.1)
6.1-7.0	16 (29.1)	5 (14.3)
7.1-8.0	9 (16.4)	2 (5.7)
8.1-9.0	5 (9.1)	0 (0.0)
9.1-10.0	5 (9.1)	0 (0.0)
10.1-11.0	3 (5.5)	1 (2.9)
12.1-13.0	3 (5.5)	0 (0.0)
14.1-15.0	1 (1.8)	0 (0.0)
17.1-18.0	1 (1.8)	0 (0.0)

Factors that Affect Maturation of the AVF

Results of the factors that affect AVF maturation indicate that the odds of patients aged 40 years and below are 1.4 times less likely than those above 60 years to have unsuccessful outcome, while the odds of those between 41 to 60 years was 1.2 times less likely than those above 60 years, but these were not statistically significant.

Female patients were 1.5 times more likely to have unsuccessful outcome than the male patients, but this was also not statistically significant.

The odds of those patients with diabetes was almost close to 1, but nevertheless their odds of 0.9 means they are less likely (i.e. protective) to have unsuccessful outcome in reference to those without diabetes, but this was also not statistically significant.

Patients with prior hemodialysis vascular access were 2.3 times more likely to have unsuccessful outcome as compared to those without, which was also not statistically significant.

Patients with abnormal blood pressure difference between both arms were 1.4 times likely to have unsuccessful outcome than the patients with normal, while the results also indicate that those with marginal blood pressure difference between both arms had an odds ratio close to 1, but their odds

ratio of 0.8 means they were less likely to have unsuccessful outcome. These findings were also not statistically significant.

Those with vein distensibility of at least 50% of the resting vein internal diameter were also less likely to have unsuccessful outcome with an odds ratio of 0.1 times, and this was statistically significant.

Patients with vein diameter < 2mm were more likely to have primary failure with an odds ratio of 6.9 times, and this was statistically significant.

Also noted, was that patients with an artery diameter of <2mm were more likely to have primary failure with an odds ratio of 6.1 times, although this was not statistically significant.

Brachiocephalic fistulas were less likely to have primary failure with an odds ratio of 0.4 times and this was noted to be statistically significant.

The above results are illustrated in the table below.

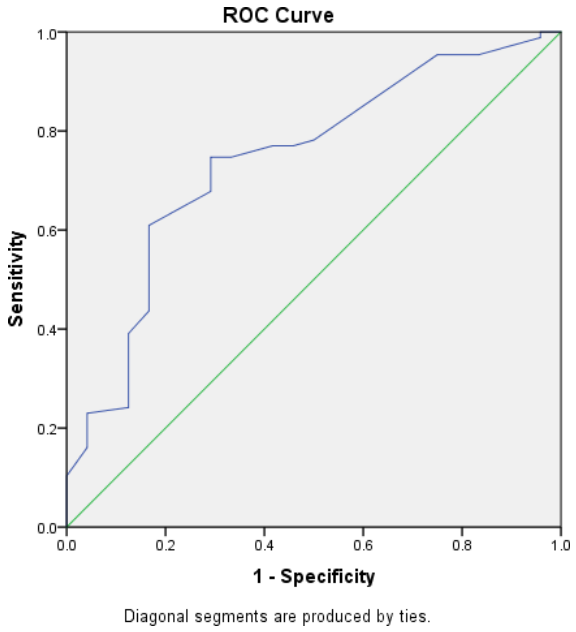
Table 9: Univariate Analysis on Factors associated with unsuccessful outcomes

	Frequency (%)				
	n	**Un-successful**	**Successful**	**OR (95% CI)**	**p-value**
Age					
≤40	33	8 (33.3)	25 (28.7)	1.4 (0.4 – 4.9)	0.593
41-60	51	11 (45.8)	40 (46.0)	1.2 (0.4 – 3.9)	0.751
>60	27	5 (20.8)	22 (25.3)	Reference	
Gender					
Male	73	14 (58.3)	59 (67.8)	Reference	
Female	38	10 (41.7)	28 (32.2)	1.5 (0.6 – 3.8)	0.388
Diabetes Mellitus					
Yes	29	6 (25.0)	23 (26.4)	0.9 (0.3 – 2.6)	0.887
No	82	18 (75.0)	64 (73.6)	Reference	
Prior hemodialysis vascular access					
Yes	102	23 (95.8)	79 (90.8)	2.3 (0.3–19.6)	0.437
No	9	1 (4.2)	8 (9.2)	Reference	
Blood pressure difference in both arms					
Normal	89	19 (79.2)	70 (80.5)	Reference	

Abnormal	11	3 (12.5)	8 (9.2)	1.4 (0.3 – 5.7)	0.656
Marginal	11	2 (8.3)	9 (10.3)	0.8 (0.2 – 4.1)	0.808
Vein distensibility					
Yes	103	19 (79.2)	84 (96.6)	0.1 (0.03–0.6)	**0.010**
No	8	5 (20.8)	3 (3.4)	Reference	
Vein diameter					
< 2mm	10	6 (25.0)	4 (4.6)	6.9 (1.8–27.1)	**0.005**
≥ 2mm	101	18 (75.0)	83 (95.4)	Reference	
Artery diameter					
< 2mm	5	3 (12.5)	2 (2.3)	6.1 (0.9–38.7)	0.056
≥ 2mm	106	21 (87.5)	85 (97.7)	Reference	
Type of AVF created					
Brachiocephalic	62	9 (37.5)	53 (60.9)	0.4 (0.2 – 0.9)	**0.045**
Radiocephalic	49	15 (62.5)	34 (39.1)	Reference	

Cut off Values for Outcome

This section presents the cut off values for the outcome. The receiver operating characteristics curve (ROC) was used for arriving at the cut off values based on sensitivity and specificity, and the area under the curve was examined for significance. An area under the curve (AUC) of 0.5 suggests no discrimination, 0.7 to 0.8 is considered acceptable, 0.8 to 0.9 is considered excellent, and more than 0.9 is considered outstanding. A P value <0.05 was considered statistically significant. As shown in Figure 6.0 below.



Area Under the Curve					
Test Result Variable(s)	**Area**	**Std. Error**	**Asymptotic Sig.**	**Asymptotic 95% Confidence Interval**	
				Lower Bound	**Upper Bound**
Vein diameter (mm)	.741	0.057	.000	.629	.853

	Cut off	**Sensitivity**	**1-Specificity**
Vein diameter (mm)	2.250	74.7%	33.3%

The value for area under the curve (AUC) for vein diameter is acceptable, which suggests that there is a 74.1% chance that the vein diameter will correctly distinguish between the fistula being succesful and unsuccesful, therefore indicating that the cut off value for vein diameter before creation of the AVF is 2.25mm. Vein diameter less than the cut-off was associated with unsuccessful outcomes.

DISCUSSION

The AV fistula is the preferred long-term vascular access for chronic haemodialysis, due to its prolonged primary patency rates, has the fewest interventions and is associated with decreased morbidity and mortality. Despite being the preferred choice of haemodialysis access, AVF still has a relatively high primary failure rate related to various factors.

The aim of this study was to determine the outcomes of AVF creation in our institution.

It was also paramount to determine the factors that affect the maturation of the created AVF, as these would require careful consideration during creation of the AVF and result eventually in improvement of the outcomes of AVF creation in our institution.

In order to achieve the above objective, 111 patients with chronic kidney disease were included in the study and a total of 114 arteriovenous fistulas were created.

There was primary failure in 24 patients, hence a primary failure rate of 21.6%. This primary failure rate is similar to that found in the studies documented in the literature review, that showed that the risk of primary AVF failure was high, ranging from 10 to 60% in randomised studies(10,13–16). Primary failure was seen more in patients with a radiocephalic arteriovenous fistula as compared to those with brachiocephalic fistulas, 62.5% (n=15) and 37.5% (n=9) respectively and this study demonstrated that this finding had statistical significance. This perhaps could be attributed to the reduced calibre of vessels in the forearm. It has been shown in other studies, that among radiocephalic fistulas, brachiocephalic fistulas and brachiobasilic transposition, the primary failure rate for radiocephalic fistulas is the highest and for brachiobasilic fistulas is the lowest(18–20). For example, in a study by Hakaim et al, radiocephalic arteriovenous fistulas were associated with a failure rate of 70% as compared to a failure rate of 27% for brachiocephalic arteriovenous fistulas and 0% for brachiobasilic fistulas. The findings in this study are similar to the findings in our study and could be attributable to the reduced calibre of vessels in the forearm as had been previously alluded to.

In this study, the mean venous diameter of the AVF was 6.4 (SD 0.9) mm, and the smallest observed diameter was 3.5 mm, while the largest was 17.5 mm at 8 weeks after creation of the AVF. 3 of the arteriovenous fistulas that were considered to have failed (1 brachiocephalic fistula and 2 radiocephalic fistulas), had a fistula diameter of less than 4mm and were unable to support the flow rates required for dialysis and hence were considered unsuccessful. These findings were similar to those in a study by Robbin et al, that showed, the venous diameter seen during the first 2 months was ≥ 4.4mm. It also showed that a minimum venous diameter of ≥ 4.0 mm was associated with adequacy for dialysis(34).

As alluded to in the literature review, there is a general lack of concordance in the literature concerning the effect of age on AVF development and patency. There are studies showing that age has an overall negative effect(24), while other studies show that there is no age-related difference in AVF success(4). In this study the effect of age on the outcome was statistically insignificant, as patients with an age of < 40 years and 41 – 60 years were shown to be less likely

to have primary failure as compared to patients > 60 years with an odds ratio of 1.4 and 1.2 respectively and p-values of 0.593 and 0.751 respectively.

The number of male patients to female patients was higher in our institution, with a male to female ratio of 1.8:1 which is in keeping with other studies that have shown that the rate of ESRD was more common in men(35). The risk of primary failure of an arteriovenous failure was likely in women as compared to men in this study, but it was not statistically significant. As with age, many studies have shown differences in outcomes of AVF when comparing males and females, with some studies showing females have a greater risk of primary failure after AVF creation(36), while other studies have shown that females have a lower rate of failure when compared with males(35).

Literature has shown evidence of good outcomes in patients with diabetes mellitus. A study by Sedlacek et al, demonstrated that despite increased arterial calcification; vessel diameters and arterial peak systolic volume were not significantly different between diabetic and non-diabetic patients and subsequent AVF creation in the diabetic patients had similar outcomes to those without diabetes(29). In another study by Konner et al, the primary access survival in diabetic patients compared to non-diabetic patient was similar and, in this comparison, there was increased use of proximal fistulas(2). In our study, primary failure of an AVF was less likely in diabetic patients as compared to those without diabetes, with an odds ratio of 0.9, although this was statistically insignificant.

Of note, is that 90.4% (n=103) of the patients referred for arteriovenous fistula creation in our institution were already on haemodialysis through a central venous haemodialysis catheter. The need for tunnelled central venous catheter for dialysis, can be reduced by early referral to a Vascular surgeon for creation of an arteriovenous fistula, as arteriovenous fistulas have been shown to reduce morbidity and mortality(37). In our study, patients with prior hemodialysis vascular access were more likely to have primary failure after AVF creation but this finding was statistically insignificant. A study done by H. Rayner et al, showed a substantially increased risk of failure in patients with a prior hemodialysis vascular access in the form of a temporary hemodialysis catheter(36).

There was statistical significance in the finding that 92.1% (n=105) patients with vein distensibility of at least 50% of the resting internal diameter were less likely to have primary failure in this study. This finding is in keeping with a study conducted by Malovrh et al, as alluded to in the literature review, that the vein's potential distensibility was more important than the diameter. In the study, they examined increased vein internal diameter by duplex ultrasonography before AVF surgery and on the basis of the increase, they were able after construction and at different intervals to anticipate an increase in AVF vein diameter(28).

As discussed in the literature review, there is no recognized minimum threshold of an arterial or venous diameter for the development of a successful AVF, although a 2mm minimum threshold has been most frequently quoted. A study by V. Wong et al demonstrated that early fistula failure was associated with cephalic vein and radial artery diameter of < 1.6mm(9). This study however, demonstrated with statistical significance that veins with internal diameter < 2.0mm

were more likely to fail as compared with those with an internal diameter of > 2.0mm. However, a vein diameter cut-off of 2.25mm was generated by the ROC curve and suggested with statistical significance that vein internal diameters of less than 2.25mm were likely to result in an unsuccessful fistula. Patients with an artery diameter of < 2mm were more likely to have primary failure with an odds ratio of 6.1 times, although this was not statistically significant in this study.

The use of preoperative vascular mapping using duplex ultrasonography in this study, was noted to be able to predict the successful maturation of an arteriovenous fistula, because arteriovenous fistulas with cephalic veins > 2.25mm proceeded to a functional dialysis access in 74.1% of the cases. It also resulted in the creation of a significant number of radiocephalic fistulas, as we proceeded with the creation of the fistula once duplex ultrasonography confirmed the cephalic vein diameters to be of good caliber in patients in whom physical examination was unable to adequately identify good cephalic veins in the distal forearm.

CONCLUSION

This study has shown that the outcome of arteriovenous fistula creation in our institution is promising and is similar to what is seen in other parts of the world as a primary failure rate of 21.6% was observed. The type of fistula created also affected the outcomes, with radiocephalic arteriovenous fistulas associated with a higher failure rate as compared to brachiocephalic fistulas, 62.5% and 37.5% respectively. Vein distensibility of at least 50% of resting internal diameter and vein internal diameter cut-off of greater than 2.25mm were noted to be important factors in the creation of a successful arteriovenous fistula. Preoperative screening of the vessels with duplex ultrasonography was invaluable in the determination of their patency and diameters, as this led to the exclusion of patients with inadequate vessels on duplex ultrasonography from eventual creation of an arteriovenous fistula, hence reducing our primary failure rates. Age > 60 years, female gender, diabetes, prior hemodialysis vascular access were found to increase the likelihood of primary failure but these were found to be statistically insignificant.

LIMITATIONS OF THE STUDY

The COVID-19 pandemic and the restrictions put in place made it difficult to achieve our sample size, as elective surgical cases were at times restricted when there was a surge in the number of COVID-19 infections in the country; this was done in order to reduce the incidence of exposure to healthcare workers.

The pandemic also made it difficult to follow-up patients, as some of the patients were coming from counties outside Nairobi which was under lockdown for a significant period of time.

RECOMMENDATIONS

1. Proper preoperative screening that includes history and physical examination as well as vascular mapping with ultrasound is invaluable in obtaining successful outcomes especially for radiocephalic fistulas.

2. Nephrologists are advised to send patients with ESRD to the vascular surgeons on time for fashioning of arteriovenous fistulas to avoid the use of central venous haemodialysis catheters by the time the patients require haemodialysis as these will help reduce the morbidity and mortality associated with central venous hemodialysis catheters.
3. Future studies to look into the long-term outcomes of arteriovenous fistulas in our institution is also recommended as this will enable the assessment of the patency rates over a prolonged period of time.

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APPENDICES

Appendix I: Data Collection Sheet

Age: _____
Sex: _____
Race/Ethnicity: _____
Telephone no. _____

Pre-operative Evaluation

Medical History:

1. Etiology of the ESRD _____

2. Prior history of insertion of central venous catheter

   Yes ☐ No ☐

   If 'yes' indicate (site and frequency)
   - Site_____
   - Frequency_____

3. Prior history of insertion of peripheral venous catheter

   Yes ☐ No ☐

   If 'yes' indicate (site and frequency)
   - Site_____
   - Frequency_____

4. Prior history of insertion of arterial catheter

   Yes ☐ No ☐

   If 'yes' indicate (site and frequency)
   - Site_____
   - Frequency_____

5. Prior history of placement of any type of cardiac rhythm device with transvenous leads

   Yes ☐ No ☐

6. Is the patient currently undergoing dialysis

   Yes ☐ No ☐

If 'yes' when did the patient start dialysis _____

7. Any previous dialysis vascular access placement.

   Yes ☐ No ☐

   If 'yes' indicate site _____
   _____
   _____

8. Presence of clinical comorbidities

   Yes ☐ No ☐

   If 'yes' indicate type (cardiac disease, pulmonary disease, PAD, DM, obesity)
   - Type of clinical comorbidities _____

General Physical Examination:

1. Any physical evidence of scars from prior CVC or hemodialysis catheter

   Yes ☐ No ☐

   If 'yes' indicate (site and frequency)
   - Site_____
   - Frequency_____

2. Any physical evidence of scars from prior neck or thoracic surgery or trauma

   Yes ☐ No ☐

   If 'yes' indicate (site and frequency)
   - Site_____
   - Frequency_____

3. Presence of swelling or collateral veins in the chest, breast and upper arms

   Yes ☐ No ☐

   If 'yes' indicate site(s) _____

4. Presence of cardiac rhythm devices

   Yes ☐ No ☐

   If 'yes' indicate (site and frequency)
   - Site_____
   - Frequency_____

Side of access – the handedness of the patient should be noted (if possible, creating an AV access in the nondominant arm is preferred).

Right ☐ Left ☐

Arterial Evaluation

1. Examine axillary, brachial, radial and ulnar pulses (rate as normal, diminished or absent)
    - Axillary artery pulse

      Normal ☐ Diminished ☐ Absent ☐
    - Brachial artery pulse

      Normal ☐ Diminished ☐ Absent ☐
    - Radial artery pulse

      Normal ☐ Diminished ☐ Absent ☐
    - Ulnar artery pulse

      Normal ☐ Diminished ☐ Absent ☐

2. Check blood pressure in both arms. Difference:

   Normal: < 10 mmHg ☐

   Marginal: 10 to 20 mmHg ☐

   Abnormal: > 20mmHg ☐

3. Modified Allen test to check for patency of palmar arch. Return of pulse:

   Normal: < 5 seconds ☐

   Marginal: 5 to 10 seconds ☐

   Abnormal: > 10 seconds ☐

4. Vascular mapping (duplex ultrasonography) NB: If physical examination is insufficient.
    - Arterial size diameter: (mm)
        - Brachial artery _____
        - Radial artery _____

- Ulnar artery _____

- Presence of Stenosis

  - Subclavian artery: Present ☐ Absent ☐
  - Axillary artery: Present ☐ Absent ☐
  - Brachial artery: Present ☐ Absent ☐
  - Radial artery: Present ☐ Absent ☐
  - Ulnar artery: Present ☐ Absent ☐

Venous Evaluation

1. Assess the entire extent of the vein and its drainage and confirm if the venous outflow of the arteriovenous access meets the desired AV access characteristics.

   Yes ☐ No ☐

2. Assess for the presence of vein distensibility of > 50%.

   Yes ☐ No ☐

3. Vascular mapping (duplex ultrasonography), NB: If physical examination is insufficient.
   - Vein diameter and depth (mm)

	Diameter	Depth
Forearm		
• Cephalic vein	_____	_____
• Basilic vein	_____	_____
Arm		
• Cephalic vein	_____	_____
• Basilic vein	_____	_____

   - Distensibility (%)

Forearm		
• Cephalic vein	_____	_____
• Basilic vein	_____	_____
Arm		
• Cephalic vein	_____	_____
• Basilic vein	_____	_____

- Blood flow rates (ml/min)
  - Forearm
    - Cephalic vein _____ _____
    - Basilic vein _____ _____
  - Arm
    - Cephalic vein _____ _____
    - Basilic vein _____ _____
- Presence of Stenosis
  - Forearm
    - Cephalic vein: Present ☐ Absent ☐
    - Basilic vein: Present ☐ Absent ☐
  - Arm
    - Cephalic vein: Present ☐ Absent ☐
    - Basilic vein: Present ☐ Absent ☐

Peri-Operative Data during Creation of AVF

1. Vein Internal Diameter_____mm Cephalic (wrist ☐ elbow ☐); Basilic ☐
   Artery Internal Diameter_____mm Brachial ☐ Radial ☐ Ulnar ☐
2. Date of Surgery _____
3. Name of the Surgeon_____Consultant: ☐ Resident: ☐
4. Type of AVF created, based on anatomical location _____
5. Presence of thrill after completion of anastomosis
   Yes ☐ No ☐

Post-operative Follow-up

1. **Vein Diameter at 8 weeks**

Venous Diameter_____mm

2. **Timing of first successful cannulation and dialysis through the created AVF**

Date: _____
Time: _____
Duration of Dialysis: _____
Flow Rates achieved (ml/min): _____