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Original Article

Surgical Management of Arteriovenous Fistulas at the University Teaching Hospital of Brazzaville: A Comparative Study

Fistules artérioveineuses : techniques chirurgicales réalisées au Centre Hospitalier Universitaire de Brazzaville

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ABSTRACT

Background. AVF is the vascular access of choice in end stage renal disease patients for allowing hemodialysis. The aim of this study, was to evaluate our pratice in AVF confection. **Methods.** We realized analytical cross-sectional study, comparing two surgical techniques, end to side (ETS) and Piggy-back in Brazzaville teaching hospital, from June 2016 to December 2020. All patients operate for AVF were included. Epi info 7.2.2.6 was used for statistical analysis. **Results**. The were 48 and 41 patients respectively in ETS and Piggy-back groups. The mean was 43.3 ± 17.4 years, with a sex-ratio at 1.5. The immediate mean flow across the AVF was 912 ± 518 ml/min, and on maturation it was 1089 ± 512 ml/min (p>0.05). The number of patients receiving secondary intervention was high in ETS group than Piggy-back , respectively 25% and 9.7% p=0.04). Univariate analysis showing female gender, diabetes, and vascular technique are predictive factor of primary fistula failure. However, multivariate analysis, revealed diabetes (HR=2.1 ; 95% IC 1.4-3.2), vascular technique (HR=0.4 ; 95% IC 0.3-0.7) predictive of fistula failure. Fistula rate failure was different between ETS 37.5%, and Piggy-back 14.6% (p=0.03). Piggy-back patients demonstrated significantly decreased juxta-anastomotic stenosis development : early (ETS 13.3%, Piggy-back 3.7%), late (ETS 14%, Piggy-back 2.7%). Juxta-anastomotic stenosis (JAS)would be a major cause of fistula failure. **Conclusion**. AVF confection is necessary for extrarenal purification. Piggy-back approach may have some impact in JAS development.

RÉSUMÉ

Introduction. Fistule artérioveineuse constitue l'abord vasculaire de choix chez les sujets insuffisants rénaux chromiques au stade terminal. L'objectif de cette étude est d'évaluer notre pratique de confection de fistules. **Patients et méthodes.** Il s'agit d'une étude transversale analytique, de deux techniques confection de fistules arterioveineuses, end to side (ETS) et Piggy-back au centre hospitalier universitaire de Brazzaville, Juin 2016 et Décembre 2020. Tout patient opéré pour fistules arterioveineuses ont été inclus. L'analyse statistique a été faite avec le logiciel Epi info version 7.2.2.6. **Résultats.** Au total 48 et 41 patients, respectivement pour le groupe ETS et Piggy-back. L'âge moyen était de 43.3 ± 17.4 ans, sex ratio de 1.5. Le flux post opératoire était de 912 ± 518 ml/min, à maturation de 1089 ± 512 ml/min (p>0.05). La seconde intervention était plus élevée dans le groupe ETS par rapport au Piggy-back, respectivement 25% et 9.7% (p=0.04). L'analyse univariée révèle que le sexe feminin, le diabète, et la technique chirurgicale sont des prédictifs d'échec. Analyse multivariée montre que le diabète (OR=2.1 ; IC 95% 1.4-3.2), technique chirurgicale (OR=0.3 ; IC 95% 0.2-0.7, compared with ETS) sont les deux facteurs prépondérants. Le taux d'échec est plus élevé dans le groupe ETS 37.5% contre 14.6% (p=0.03). Piggy-back montre une dimunition de la sténose juxtanastomotique, par rapport aux ETS, de 13.3% Vs 3.7%, puis 14% Vs 2.7% ; à moyen et long terme. Cause majeure d'échec de maturation serait la sténose juxtanastomotique. **Conclusion.** Fistule artérioveineuse est capitale pour hémodialyse, Piggy-back semble prévenir la sténose juxtanastomotique.

INTRODUCTION

Since the first description by Brescia and Cimino in 1966 in USA, radiocephalic fistula remains the most commonly performed fistulas around the world. Conception of arteriovenous fistula must preceed dialysis. Based on the superior patency and lower morbidity associated with arteriovenous fistula, the recent practice guidelines of American Society for Vascular Surgery as well the Kidney Disease Outcomes

Quality Initiative propose creation of arteriovenous fistula before placement of prosthetic grafts or use of central venous catheter [1,2].

In our pratice since 2016, almost the majority of patients come with central venous catheter (especially femoral catheter). At the beginning of our fistulas activities, end to side (ETS) approach, was the most praticed one. After arteriovenous fistula (AVF) creation, the next important step is the maturation. The early thrombosis and failure to mature continues to be a major problem with arteriovenous creation. A recent multicenter controlled randomized trial conducted by the Dialysis Access Consortium (DAC) and sponsored by the National Institutes of Health (NIH) reported a 60% failure to maturation in AVF [3]. Juxta-anastomotic stenosis (JAS) with a variable reported incidence of 43% to 65% is a major cause for early AVF failure and arrested maturation [4]. Although factors including handling of the tissues, suture technique, physiological changes related to increasing blood flow, rheologic factors, shear stress, and patient- and surgeon-related variables have been implicated, the exact etiology of JAS still remains unclear.

Some authors as Bharat et al, hypothesized that, the JAS may be related to surgical technique [5]. They thought that, the ETS technique necessitates a three-dimensional movement of the vein and hence precipitates torsion of the vein wall in the first few centimeters, producing a torsional stress zone. Piggy back Straight Line Onlay Technique (pSLOT) would prevent JAS and improve AVF maturation [6].

The aim of this study was to compare these two techniques, evaluate AVF maturation, and patency.

METHODS

We realized analytical cross-sectional study, at Polyvalent surgical department of Brazzaville teaching hospital. All patients that underwent AVF by a single operator between June 2016 and December 2020 were included in the study.

Patients underwent a clinical examination and Doppler duplex ultrasound evaluation. Both the size and quality of vessels were taken into consideration. As a guideline, vein diameter of ≥2 mm with a tourniquet and an arterial diameter of ≥2 mm were considered suitable for AVF creation.

Anastomotic technique

The first group of patients underwent the standard the end to side anastomosis (ETS). The second group of patients underwent a "piggy-back" SLOT (pSLOT) technique. In this procedure, the vein that lies in the subcutaneous plan is dissected, marked for orientation, divided, and the cut end is over sewn with 7-0 prolene. It is moved medially over the artery that lies in a deeper plane (underneath the deep fascia). A fistula is created between the posterior aspect of the vein (under-side of the vein) and the anterior (upper) aspect of artery [7]. The outflow vein is dissected further in the subcutaneous tissue to obtain straight line.

Postoperative follow-up

Patients were followed on a regular basis starting 10 to 14 days after the procedure with a thorough clinical examination. At the second visit (4-6 weeks), a Doppler duplex ultrasound was performed to assess the anastomosis, outflow vein, and fistula maturation characteristics. This included brachial artery flow measurement, measurement of length, and diameter and depth of the needle access segment of outflow vein.

The maturation criteria used was similar to that established by the 2005 National Kidney Foundation Kidney Disease Outcomes Quality Initiative Guidelines for Vascular Access and included “The Rule of 6s,” except for the depth (depth to consider a fistula mature was set at <5 mm deep from the skin surface) [8]. If the fistula met these criteria, it was deemed appropriate for use. Failure to reach maturation by 3 months was considered as failure to mature. JAS was evaluated on all patients during the postoperative follow-up visit by Doppler duplex ultrasound. JAS was defined as a stenosis within the first 4 cm of the outflow vein in fistulas that failed to mature. The presence of severity was based on wall thickening and luminal narrowing associated along with access dysfunction measured by duplex (brachial artery) volume flow measurement. JAS was considered early if it occurred within the first 3 months and late if it occurred subsequently.

Statistical analysis

Data were collected by Epi info 7.2.2.6. Qualitatives variables were exprime in percentage, and quantitatives data in mean ± standard deviation. Chi^2 of Pearson test was used for comparison between qualitatives variables, with 95%. $p< 0.05$ was significance threshold.

RESULTS

The study was composed by 48 had ETS, while 41 pSLOT anastomosis. The mean age of the study group was 43.3 ± 17.4 years, the sex-ratio was 1.5.

There were no differences in the clinical and demographic variables between the two study groups (Table). Diabetes has been previously shown to cause radial artery calcifications and significantly increase fistula failure rates, but there was no difference in the prevalence of diabetes in the study groups.

Table I : Clinical and demographic data of study groups.

	ETS (48)	pSLOT (41)	p
Age	43.3 ± 17.4	45 ± 14.2	
Gender			
Male	27(56.2%)	33(80.4%)	
Female	21(43.8%)	8(9.6%)	
Comorbidities			
Hypertension	15(31.2%)	14(34.1%)	
Diabetes mellitus	13(27%)	15(36.5%)	
Flow (ml/min)	910 ± 518	918 ± 510	NS
Median follow-up (months)	15	13	
Juxta-anastomotis stenosis			
Early (≤ 3 months)	13.3	3.7	0.03
Late (> 3 months)	14	2.7	
AVF Thrombosis	12 (25%)	3(7.3%)	0.03
Secondary interventions	12(25 %)	4(9.7 %)	0.04

The primary disease for chronic renal failure was hypertension in x patients (41.4%), followed by diabetes in y patients (39.4%). The mean flow immediately postoperatively was 912 ± 518 ml/min, and on maturation, it was 1089 ± 521 ml/min. This was not statisically different between study groups. Sixteen patients (17.9%) required one or more interventions, in the form of venoplasty, revision, thrombectomy.

The number of patients receiving secondary procedures in each category was as follows : ETS (25%), and pSLOT (9.7%).

Thirty-five patients (39.3%) were dialysis-dependent with central venous catheters. Median follow-up of the entire patients was 12 months. In patients where no additional procedure was required, the mean time to use was 4.5 weeks.

Fistula failure rate was 31%. The overall incidence of early JAS was 7.5% and late 12.6%. Using univariate analysis, female gender, diabetes, and vascular technique were found to be predictive of primary failure of AVF. However, multivariate analysis demonstrated only diabetes (hazard ratio [HR], 2.1; 95% confidence interval [CI], 1.4-3.2) and vascular technique (pSLOT HR, 0.4; 95% CI, 0.3-0.7 ; $P < 0.05$, compared with ETS) predictive of fistula failure.

The median follow-up between the two groups : ETS (15 months), and pSLOT (13 months ; $P > 0.05$) was similar. Overall fistula failure rate was significantly different between the two study groups : ETS (eighteen out of 48, 37.5%), and pSLOT (six out of 41, 14.6% ; $P = 0.03$). The predominant cause of fistula failure was JAS, followed by thrombosis in all groups. pSLOT had a lower incidence of fistula thrombosis (7.3%) compared with ETS (25.2%, p= 0.03 : Table). pSLOT patients demonstrated significantly decreased JAS development : early (ETS 13.3%, pSLOT 3.7%), late (ETS 14%, pSLOT 2.7%).

All patients underwent similar follow-up schedule as described in the methodology. Briefly, the first follow-up was around 10-14 days, the second follow-up around 4 to 6 weeks, and thereafter at monthly intervals or sooner till the fistula was mature or given up. Once the fistula was in use, patients were seen at least every three months or sooner if there were access-related problems.

DISCUSSION

Major problem of AVF regardless of the site, is the maturation for allowing hemodialysis. In the literature, JAS has been incriminated as the predominant cause for fistula failure [9]. Radiocephalic fistula, seems to be the predilected location of JAS. Some study show that, antiplatelet drugs significantly reduced the incidence of AVF thrombosis at six weeks, but did not help fistula maturation [3]. This study included fistula in both upper arm and forearm locations and did not report the specific cause of nonmaturation.

The pathologic feature of JAS suggests an injury response producing an inflammatory reaction, resulting in the development of JAS.

There is now evidence showing that mechanical stress on the vessel wall activates adhesion molecules, growth factors, inflammatory cytokines, reactive oxygen species, and matrix proteins [10,11]. However, while the flow increases and its effect on the vein is not very different in the segments adjacent to the location of JAS, there is no explanation why the intense response is limited to the first 1 to 4 cm.

The variability of JAS within a similar patient population, between different centers in similar geographic areas, within the same centers, within the same patients, and also in the hands of the same surgeon using similar instruments and techniques prompted us to look closely at the configuration of the anastomosis. Anatomically, the cephalic vein and radial artery are in two different tissue planes, with the artery situated below the deep fascia and vein at the level of the investing layer of the superficial fascia. Vein is also situated at a variable distance lateral to the artery. The end-to-side technique relies on anastomosing the end of the vein to side of the artery.

This technique necessitates three different movements of the vein as shown in. These include a) superficial to deep (up to down) ; b) side to side (lateral to medial) ; and c) horizontal axis to vertical axis (vein cut end is vertical axis and the arteriotomy is horizontal axis). Any tubular structure with soft walls (such as a vein), when submitted to these three movements, will end up with a torsional movement on its wall. Based on the anatomy, dissection, and movement necessary for fistula creation, this torsion tends to happen within 1 to 4 cm from the anastomosis. Distribution of this force tends to be very different on the “torsional stress zone” caused by the torsion, which now acts as a noncompliant nondistensible stenotic area on the vein wall (one could easily see this by submitting a penrose drain closed at both ends filled with water to the three above-described movements).

We postulated that the JAS was the end result of the secondary stress caused by the increased flow on the “torsional stress zone” created by the three-dimensional vein movement necessary for an end-to-side technique.

We initially tried to reduce this torsion by altering the conventional technique using SLOT. Further modification of this was the pSLOT, which changes the three-dimensional movement of the vein to a two dimensional movement (only side to side and minimal up and down). This completely eliminates the torsional strain on the vein wall.

This technique also provides a complete cylindrical (circular) outflow segment for the arterial blood. This possibly helps to reduce the turbulence near the anastomosis. Postoperative color Doppler ultrasound of the anastomosis shows a very short segment of turbulent flow changing to a normal boundary separation pattern, indicting vortex or spiral laminar flow close to the anastomosis. The results of the study support our hypothesis. Group pSLOT patients showed a significant increased maturation with a significant decrease in JAS. This difference continued in the long-term follow-up with superior fistula survival in this group of patients.

The study was well balanced in the distribution of patients. We used patients undergoing RC fistulas as the anatomic relationship in this area is constant, allowing us to study the effect of change in the configuration alone on the development of JAS. The ETS technique always predisposes torsional strain. Torsional strain tends to be the greatest when branch points are used to create an anastomotic hood. It can be reduced by spatulating the vein. Some authors advocate creating very long anastomosis [12,13]. This tends to minimize the third movement (vertical to horizontal axis) and may be responsible for the better outcome reported by this group. In a recent study by Van Canneyt et al, it was shown that the angle between the swing point segment and artery can significantly impact the flow and pressure gradient across the anastomosis [14].

They showed that at an angle exceeding 58 degrees, the arterial inflow was not sufficient to deliver enough flow, supporting the importance of vessel alignment in proper functioning of the fistula.

With this, early fistula failure and JAS is an extremely unusual event. The technique necessitates around 4 to 5 cm dissection of the outflow vein to obtain a straight line outflow with a gentle slant up and down and side to side. This is usually achieved with outflow vein dissection before starting the closure. The increased arterial flow makes it easy for the surgeon to straighten the outflow vein lie with dissection along the plane of the investing layer of superficial fascia. The study clearly demonstrates that the pSLOT technique decreases both early and late JAS development. The overall JAS was 14% beyond 3 months with the end-side technique.

The pSLOT, completely eliminates the torsional stress and thereby eliminates the stress point in the outflow vein, which probably is the cause for a majority of JAS development. This is evident by the significantly reduced JAS of only 2.7 beyond 3 months. The decrease in JAS was most likely the cause of improved fistula maturation with this technique.

There are some limitations of this study. First, this was a retrospective analysis and nonrandomized study. Second, our anastomotic technique evolved from end to side to pSLOT. Hence, there was a chronologic difference between patients undergoing these strategies.

Third, although including fistulas performed by a single surgeon prevents interoperator bias, it may make the technique surgeon-specific, lacking the component of reproducibility.

CONCLUSION

AVF confection is crucial for end stage renal disease patients, in this, it facilitates extrarenal purification and improves the quality of life. AVF maturation and patency are key points of surgical success, that surgical approaches are one of the elements condition the result.

CONFLICT OF INTEREST

Authors declare that there is no conflict of interest.

AUTHORS CONTRIBUTIONS

Samuel Moumpala, Jean Claude Edzan : Complete survey forms and collect data

Sylvain Andre Ngounda : Writing discussion and summaries

Reddy Atipo-galloye : Writing the rest of the work

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