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FACTORS PREDICTING OUTCOMES OF UPPER LIMB RADIO-CEPHALIC ARTERIO-VENOUS FISTULA- A PROSPECTIVE OBSERVATIONAL STUDY

Urology

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ABSTRACT

AIMS AND OBJECTIVES: To study the factors predicting outcomes of upper limb radio-cephalic arterio-venous fistula.

MATERIAL AND METHODS: This was an observational prospective study that included all chronic renal failure patients requiring AV Fistula surgery between June 2018 to December 2019. All patients whose vascular anatomy does not permit the construction of a native AV fistula, as detected on preoperative doppler study, were excluded from the study.

RESULTS: Out of 120 cases studied, 88 were male, and 32 were females. In males out of 88 cases, 61 cases had successful outcome (69%) and in 27 cases, fistula failed (31%). No significance on the outcome of the AV fistula noted related to comorbidities. Mean preoperative radial artery diameter of 2.8 and 1.9 mm was associated with successful and failed fistula, respectively. Mean preoperative cephalic vein diameter of 2.2 and 1.9 mm were associated with successful and failed fistulae, respectively. Results suggested a threshold PSV of at least 50cm/sec for fistula success. A fistula diameter of > 0.4 cm and a minimum flow rate of > 58mL/min resulted in a 93% chance that the fistula would be adequate versus 28 % if neither of the minimum criteria were met. Mean post-operative cephalic vein diameter 4.24 and 3.28 mm were associated with successful and failed fistula, respectively.

CONCLUSION: In our study the cephalic vein size, arterial size and flow rate is the predominant factor determining the success of the radio cephalic fistula. There is increasing evidence that routine preoperative duplex USG reduces the rate of primary fistula failure and unnecessary surgical exploration. A minimum arterial diameter of 2mm is associated with successful fistula formation. Below this diameter, the success of the fistula depends on the ability of the artery to dilate. A threshold for the minimal venous diameter is difficult to establish. But most clinical studies use a value of 2.5mm for AFV.

KEYWORDS

Chronic Kidney Disease (CKD), End-Stage Renal Disease(ESRD), Haemodialysis(HD), Ultrasonography(USG)

INTRODUCTION

To establish long-term haemodialysis vascular access in patients with end-stage renal failure, the Cimino-Brescia radio-cephalic arterio-venous fistula is the method of choice. The fistula is relatively simple to perform under local anaesthesia and, when successfully established, is easy to needle and relatively free from complications[1]. However, a significant percentage (up to 30%) of fistulae fail early within three months of surgery[2]. Some fistulae thrombose in the first 24 hours of the operation, usually due to technical errors. Others do not mature, or the blood flow through them is not sufficiently high for haemodialysis. Although the quality of the vessel may play a role, most of the failures have an unclear cause. Small-sized or atherosclerotic radial arteries have been suggested as possible causes. Similarly, small size, stenosed or partially thrombosed cephalic veins may lead to fistula failure[3]. Of the various modalities for evaluation, we are using Doppler Ultrasonography for haemodialysis access evaluation. Ultrasonography (USG) is an excellent modality for haemodialysis access evaluation, as it is readily available, non-invasive, and inexpensive. It avoids the risks associated with iodinated contrast material and ionising radiation. USG is a sensitive modality for the evaluation of haemodialysis synthetic graft stenosis[4]. It can help identify other complications associated with grafts and fistulas, including hematoma, pseudoaneurysm, and abscess [5].

This study aimed to study the factors predicting outcomes of upper limb radio-cephalic arterio-venous fistula.

MATERIAL AND METHODS

This prospective observational study included all chronic renal failure patients requiring AV Fistula surgery who presented to our department between June 2018 to December 2019 after exclusion criteria are applied. All patients with unfavourable vascular anatomy on preoperative doppler ultrasonography , not permitting the construction of a native AV fistula like radial artery diameter at wrist level less than 1.6 mm or presence of stenosis in the main cephalic vein , were excluded. Informed consent for participation in the study was taken from each patient. The patient's vessel status was recorded preoperatively by a Doppler ultrasound. The cephalic vein and radial artery was imaged from wrist to proximal upper arm to note any stenosis/thrombus in the vessel. Radial artery flow was recorded at the wrist level. Post-operative follow up was conducted at the following times: day 1, at eight weeks and at three months (three months being the maximum time interval required for AVF maturation). Preoperative vessel assessment using Colour Doppler USG with 10 MHz linear-array transducer was done. Arteries were evaluated in terms of course, calibre, depth from the skin, direction of flow, patency, doppler spectral wave patterns at the arm, upper forearm, distal forearm levels. Similarly, veins also were evaluated at specific checkpoints. Postoperatively all patients were again examined with colour Doppler USG with 10MHz linear- array transducers.

STATISTICAL ANALYSIS

The data was entered into a Microsoft Excel (Redmond,WA) spreadsheet. Statistical analysis was performed using SPSS software. After compiling all the data, statistical analysis was performed to evaluate the outcomes of AV fistula. Mann Whitney u test or independent t-test was used for analysis depending upon the distribution of variables.Chi-square test was used for comparing categorical variables. P-value <0.05 was considered statistically significant.

RESULTS

Out of 120 cases studied, 88 were male, and 32 were females. The mean age of males was 49.31 ±14.27 years. The mean age of female was 51.2 2 ± 12.01years In males out of 88 cases, 61 cases had successful outcome (69%), and in 27 cases, fistula failed (31%). In females out of 32 cases, 21 cases had successful outcome (66%), and in 11 cases fistula failed (34%). The overall success rate was 68%. The mean age of success in males was 47 years, while females were 49.1 years. The overall mean age of patients with successful results was 47.54 14.27 years.[Fig 1]

Patients with diabetes had a success rate of 68.6 % (48 out of 70 patients) whereas those with diabetes had a success rate of 68% (34 out of 50 patients). Of a total of 78 patients with hypertension, 54 had successful outcome (69.2%), whereas out of 42 patients without

hypertension, 28 had successful outcome. (66.7%). In patients with ischemic heart disease, 7 out of 10 fistulae functioned well (70 %), whereas those without ischemic heart disease, 75 out of 110 fistulae functioned well (68.18 %). There was no significance on the outcome of the AV fistula noted in diabetes mellitus, hypertension and ischaemic heart disease patients[Table 1].

Table 1: Effect of comorbidities on the outcome of fistula (statistical significance not seen, p value> 0.05)

	Diabetes		Hypertension		Ischemic heart disease	
	Present	Absent	Present	Absent	Present	Absent
Success	34 (68%)	48 (68.5%)	54(69.2%)	28(66.6%)	7 (70%)	75 (68.1%)
Failure	16	22	24	14	3	35

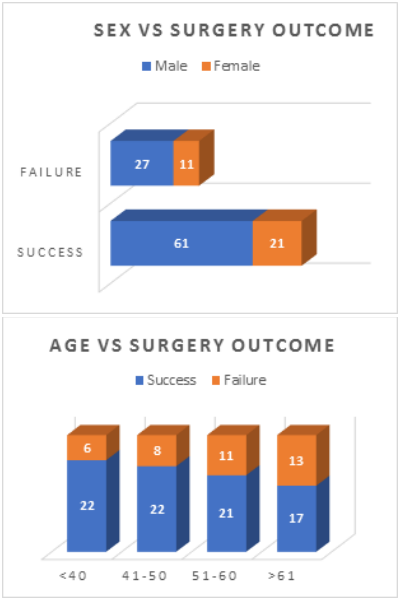

Figure 1: Demographic effect on AV fistula success

In the present study of 120 patients, out of 79 patients with preoperative radial artery diameter less than 2 mm, 32 failed (Success rate of 59.5%) whereas, among those patients with radial artery size more than 2.5 mm, there was only one failure (success rate of 93.75%, p-value < 0.05). The mean preoperative radial artery diameter was 2.8 and 1.9 mm in successful and failed fistulae, respectively. Out of 91 patients with a cephalic vein diameter of less than 2.2 mm, 33 failed (Success rate of 63.7). Out of 29 patients with a diameter of more than 2.2 mm, only five fistulae failed (Success rate of 82.7%) . The mean cephalic vein diameter was 2.2 and 1.9 mm in successful and failed fistulae respectively. [Table 2]

Table 2: Effect of Preoperative Radial Artery and Cephalic vein diameter on the fistula outcome (statistical significance present, p-value < 0.05)

	Radial Artery (in mm)				Cephalic vein(in mm)			
	<2	2.1-2.2	2.3-2.4	>2.4	<2	2.1-2.2	2.3-2.4	>2.4
Success	47	12	8	15	32	26	8	16
Failure	32	5	0	1	23	10	2	3
Total	79	17	8	16	55	36	10	19

PSV of the proposed inflow artery is easier to measure and has also been evaluated as a predictor of a successful AVF; results suggested a threshold PSV of at least 50cm/sec for fistula success. The chances that the fistula would be adequate for dialysis were 84% if the flow was 50 ml/min or greater but only 43% if it was less than this level. A fistula diameter of > 0.4 cm and a minimum flow rate of > 58mL/min resulted in a 93% chance that the fistula would be adequate versus 28 % if neither of the minimum criteria was met. The chances that the fistula would be adequate for dialysis were 92% if cephalic vein flow at eight weeks was >500 ml/min or greater but only 35% only less than that. In the present study on 120 patients, the average post-operative cephalic vein diameter was 4.24 and 3.28 mm in successful and failed fistula, respectively [Table 3, 4].

Table 3: Effect of Cephalic vein flow rate (at 8 weeks) on outcome

Flow Rate(ml/min)	Success	Failure	Total	p-value=0.001
<300	0	34	34	
301-500	0	4	4	
501-700	22	0	22	
>700	60	0	60	
Total	82	38	120	

Table 4: Effect of Cephalic vein diameter at 8 weeks on surgical outcome.

Diameter (mm)	Success	Failure	Total	p-value=0.001
<3	0	24	24	
3-4	18	14	32	
4-5	36	0	36	
>5	28	0	28	

DISCUSSION

Long term hemodialysis in CKD patients depends upon the patent and functioning fistula. Our study focused on demographic factors, comorbidities, arterial diameter, venous diameter, peak systolic flow velocity and flow rate. Two studies have assessed venous diameter and its importance in determining fistula outcome. Brimble et al [6] performed a retrospective study on 106 patients where average cephalic vein diameter was 2.52 and 2.23mm in successful and failed fistulae, respectively. Mendez[7] analysed 44 consecutive patients, and he concluded that venous diameter >2.0mm had a higher success rate. However, a exact cutoff for minimum vein calibre for success of fistulae has not been confirmed. Most clinical studies use a cut off value of 2.5mm for AVF, and 4.0mm for synthetic grafts, as suggested by Silva et al. [8]. The ability of a vein to get dilated is also an important predictor of successful fistulae. Malovrh[9] found that cephalic vein diameter increased by an average of 48% in patients with successful fistulae compared with only 11.8% in fistulae that failed. In our study, also average cephalic vein diameter was 2.2 and 1.9 mm in successful and failed fistulae respectively. There is limited literature on the effect of arterial diameter and vessel quality on fistula success rate. Wong et al. [1] showed that a luminal diameter of <1.6mm was associated with early fistula failure. Malovrh [9] reported that a diameter of <1.5mm was associated with a success rate of only 45%. Lemson et al. [10] also observed smaller mean preoperative radial artery diameter in patients with failed forearm fistulae compared with successful fistulae (1.9 versus 2.8mm). Our study matches these studies with results showing an average radial artery diameter of 1.9 mm or less associated with fistula failure. Adequate arterial inflow is crucial for fistula maturation. However, accurate preoperative flow rates are difficult to measure due to the small diameter of the radial artery. Yerdel et al. [11] reported that a preoperative arterial flow of <40ml/min was associated with a higher rate of immediate failure. Malvorh [9] also reported a mean preoperative flow rate of 54.5ml/min in AVF with a successful outcome and a mean flow rate of 24.1ml/min in those that failed. Robbin et al. [12] found that if the fistula diameter was 0.4 cm or greater, the chance that it would be adequate for dialysis was 89% versus 44% if it was less than 0.4 cm. The fistula's chances would be adequate for dialysis were 84% if the flow was 50 ml/min or greater but only 43% if it was less than this level. In Yerdel et al. [11], the average arterial blood flow preoperatively was 30 $\pm$18 mL/min. Within 24 hours of surgery to create a fistula, the fistula blood flow was up to 472 $\pm$315 mL/min, and by one week, it had increased to 861 $\pm$565 mL/min. In the present study on 120 patients with post-operative cephalic vein diameter 4.24 and 3.28 mm in successful and failed fistulae, respectively. The chances that the fistula would be adequate for dialysis were 92% if flow >500 ml/min or greater but only 35% only less than that. Combining the two variables increased the predictive value of the measurements. A fistula diameter of >0.4 cm and a flow rate of > 58mL/min resulted in a 93% chance that the fistula would be adequate versus 28 % if neither of the minimum criteria was met. PSV of the proposed inflow artery is easier to measure and has also been evaluated as a predictor of a successful AVF, suggested that a threshold PSV of at least 50cm/sec for fistula success.

The limitations of our study are that it is not a randomised control study, surgeon's expertise has not been correlated with the outcome. We assessed only primary failures; secondary failures were not assessed because they needed longer follow up.

CONCLUSION

In our study, the cephalic vein size, arterial size and flow rate were the predominant factor determining the success of the radio cephalic

fistula. Doppler Ultrasonography helps in the correct placement of the fistula. Routine preoperative duplex USG reduces the rate of primary fistula failure and unnecessary surgical exploration. A minimum arterial diameter of 2mm is associated with successful fistula formation, below which the ability of an artery to increase flow and dilate will determine fistula success. A threshold for the minimal venous diameter is difficult to establish, but most clinical studies use a value of 2.5mm for AVF

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