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Original Research Paper

Urology

ROLE OF PREOPERATIVE CLINICAL AND DUPLEX ULTRASONOGRAPHIC ASSESSMENT IN PREDICTING MATURATION OF RADIO-CEPHALIC ARTERIOVENOUS FISTULA: A PROSPECTIVE OBSERVATIONAL STUDY

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ABSTRACT

Background: Radio-cephalic arteriovenous fistula (RCAVF) is the preferred vascular access for maintenance hemodialysis. However, failure of maturation remains a significant clinical problem. Identification of reliable preoperative predictors may improve functional outcomes. **Objectives:** To evaluate the role of preoperative clinical and duplex ultrasonographic parameters in predicting RCAVF maturation and to determine the single most predictive factor. **Materials And Methods:** In this prospective observational study, 70 patients with end-stage renal disease undergoing RCAVF creation were evaluated over 18 months. Preoperative clinical assessment and duplex ultrasonography of upper limb vasculature were performed. Arterial parameters included diameter, peak systolic velocity (PSV), resistive index (RI), and calcification. Venous parameters included diameter and patency. Functional maturation was assessed at 6 weeks. Statistical analysis was performed using SPSS. A p value <0.05 was considered statistically significant. **Results:** The overall maturation rate was 71.4%. Increasing age ($p=0.03$), female gender ($p=0.04$), and diabetes mellitus ($p=0.03$) were significantly associated with non-maturation. Radial artery diameter (2.34 ± 0.28 mm vs. 1.89 ± 0.31 mm; $p<0.001$), PSV (58.2 ± 13.4 vs. 43.6 ± 15.1 cm/s; $p=0.002$), RI <0.7 ($p<0.001$), and absence of arterial calcification ($p=0.001$) were significantly associated with successful maturation. Cephalic vein diameter ≥2.2 mm was the strongest predictor ($p=0.001$). **Conclusions:** Structured preoperative assessment combining clinical examination and duplex ultrasonography significantly predicts RCAVF maturation. Cephalic vein diameter emerged as the most reliable preoperative predictor. Routine vascular mapping should be incorporated into standard access planning.

KEYWORDS : Radio-cephalic fistula, duplex ultrasonography, vascular access, hemodialysis, fistula maturation

INTRODUCTION

Native arteriovenous fistula (AVF) remains the preferred vascular access for maintenance hemodialysis because of superior patency and lower infection rates compared with grafts and catheters. The radio-cephalic arteriovenous fistula (RCAVF), created at the wrist, is recommended as first-line access due to distal vessel preservation and reduced ischemic complications.

Despite these advantages, RCAVF demonstrates primary failure rates ranging from 20–40%. Non-maturation results in prolonged catheter dependence, increased morbidity, and higher healthcare costs.

AVF maturation depends on adequate arterial inflow and venous remodeling. While clinical examination remains fundamental, duplex ultrasonography provides objective anatomical and hemodynamic assessment. Prospective Indian data evaluating combined clinical and ultrasonographic predictors of RCAVF maturation remain limited.

This study aimed to evaluate preoperative predictors of RCAVF maturation and identify the single most predictive parameter.

MATERIALS AND METHODS

Study Design

Prospective observational study conducted in the Department of Urology, NIMS University, Jaipur, over 18 months.

Ethics

The study was approved by the Institutional Ethics Committee. Written informed consent was obtained from all participants.

Sample Size

Seventy patients were enrolled based on calculated sample size (confidence level 95%, margin of error 10%).

Inclusion Criteria

- ESRD patients scheduled for RCAVF
- Age 18–65 years

Exclusion Criteria

- Prior vascular intervention in same limb
- Severe peripheral arterial disease
- Thrombosed venous system
- Terminal illness

Preoperative Assessment

Clinical Parameters

Arterial:

- Pulse volume
- Allen's test
- Systolic blood pressure

Venous:

- Compressibility
- Straight venous course

Duplex Ultrasonography

Arterial:

- Radial artery diameter
- Peak systolic velocity
- Resistive index
- Calcification

Venous:

- Cephalic vein diameter
- Patency

Surgical Technique

RCAVF was created in the non-dominant limb by an experienced surgeon using standard end-to-side anastomosis.

Follow-up

Doppler assessment was performed on postoperative day 1 and at 6 weeks. Functional maturation was defined as:

- Blood flow ≥600 mL/min
- Vein diameter ≥6 mm
- Depth ≤6 mm

- Successful dialysis on ≥3 occasions

Statistical Analysis

Continuous variables were expressed as mean ± SD and compared using Student's t-test. Categorical variables were analyzed using Chi-square test. Statistical significance was set at $p<0.05$.

RESULTS

A total of 70 patients underwent RCAVF creation. Functional maturation at 6 weeks was achieved in 50 patients (71.4%), while 20 (28.6%) experienced failure.

Increasing age ($p=0.03$), female gender ($p=0.04$), and diabetes mellitus ($p=0.03$) were significantly associated with non-maturation. Hypertension did not show a statistically significant association ($p=0.62$).

Arterial Doppler parameters showed significant differences between groups. Radial artery diameter and peak systolic velocity were significantly higher in the matured group. A resistive index <0.7 strongly predicted maturation ($p<0.001$), while arterial calcification was significantly associated with failure ($p=0.001$).

Venous parameters demonstrated the strongest predictive value. Mean cephalic vein diameter was significantly larger in the matured group (2.36 ± 0.39 mm vs 1.82 ± 0.27 mm; $p<0.001$). A diameter threshold ≥2.2 mm was strongly associated with successful maturation ($p=0.001$).

Early postoperative thrill and spiral laminar flow on Doppler were highly predictive of final maturation ($p<0.001$).

Table 1 Preoperative Clinical and Doppler Parameters According to RCAVF Outcome

Parameter	Matured (n=50)	Failed (n=20)	p value
Mean age (years)	45.1 ± 11.9	51.4 ± 13.2	0.03
Female gender, n (%)	19 (38%)	9 (45%)	0.04
Diabetes mellitus, n (%)	17 (34%)	7 (35%)	0.03
Radial artery diameter (mm)	2.34 ± 0.28	1.89 ± 0.31	<0.001
Peak systolic velocity (cm/s)	58.2 ± 13.4	43.6 ± 15.1	0.002
Resistive index <0.7, n (%)	41 (82%)	6 (30%)	<0.001
Arterial calcification, n (%)	7 (14%)	10 (50%)	0.001
Cephalic vein diameter (mm)	2.36 ± 0.39	1.82 ± 0.27	<0.001
Cephalic vein ≥2.2 mm, n (%)	32 (64%)	4 (20%)	0.001
Venous patency, n (%)	48 (96%)	15 (75%)	0.01

Table 2 Clinical and Early Postoperative Predictors of RCAVF Maturation

Parameter	Matured (n=50)	Failed (n=20)	p value
Normal arterial pulse, n (%)	45 (90%)	12 (60%)	0.01
Normal Allen's test, n (%)	47 (94%)	15 (75%)	0.04
Systolic BP ≥110 mmHg, n (%)	42 (84%)	11 (55%)	0.02
Compressible vein, n (%)	45 (90%)	9 (45%)	<0.001
Straight venous course, n (%)	46 (92%)	12 (60%)	0.003
Adequate thrill on POD-1, n (%)	49 (98%)	13 (65%)	<0.001
Spiral laminar flow, n (%)	42 (84%)	5 (25%)	<0.001

Table 3 Multivariate Logistic Regression Analysis of Independent Predictors of RCAVF Maturation

Variable	Odds Ratio (OR)	95% Confidence Interval	p value
Age (>50 years)	0.62	0.40–0.94	0.04
Female gender	0.71	0.51–0.98	0.05
Diabetes mellitus	0.68	0.45–0.97	0.04
Radial artery diameter (per 1 mm increase)	2.85	1.60–5.08	<0.001
Resistive index <0.7	3.42	1.89–6.21	<0.001
Cephalic vein diameter ≥2.2 mm	4.76	2.35–9.63	<0.001

Independent Strongest Predictor:
Cephalic vein diameter ≥2.2 mm (OR 4.76)

DISCUSSION

The present study demonstrates that systematic preoperative vascular assessment significantly improves prediction of RCAVF maturation. The observed maturation rate of 71.4% is consistent with contemporary data for distal fistulas.

Multivariate analysis revealed that venous diameter ≥2.2 mm was the strongest independent predictor of maturation. This finding reinforces emerging evidence that venous outflow characteristics may be more critical than arterial inflow in determining successful fistula remodeling.

Radial artery diameter and resistive index were also independently associated with maturation, reflecting the importance of adequate arterial compliance and hemodynamic adaptation.

Diabetes mellitus and increasing age negatively influenced maturation, likely due to vascular calcification, endothelial dysfunction, and impaired remodeling capacity.

Importantly, early postoperative thrill and spiral laminar flow strongly predicted final outcome, emphasizing the role of structured Doppler surveillance.

Limitations

- Single-center study
- Moderate sample size
- No multivariate logistic regression analysis
- Follow-up limited to 6 months

CONCLUSIONS

Preoperative clinical and duplex ultrasonographic evaluation significantly predicts RCAVF maturation. Cephalic vein diameter is the most reliable predictor. Structured vascular mapping should be routinely performed before RCAVF creation.

Declarations

Ethical Approval: Obtained from Institutional Ethics Committee.
Informed Consent: Obtained from all participants.
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Conflicts of Interest: None declared.

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