



## Assessment of Vein Intima-Media Thickness in Determining Maturity of AV Fistula

Authors

**Dr Talluri Bhavishya<sup>1</sup>, Dr Ramesh Kumar Rudrappa<sup>2</sup>**

<sup>1</sup>Post Graduate, <sup>2</sup>Professor and Head of Department

<sup>1,2</sup>Department of Radio-diagnosis, Sri Manakula Vinayagar Medical College and Hospital, Madagadipet, Kalitheerthalkuppam, Puducherry-605107, India

Corresponding Author

**Dr T.Bhavishya**

Department of Radio-diagnosis, Sri Manakula Vinayagar Medical College and Hospital, Madagadipet, Kalitheerthalkuppam, Puducherry-605107

Email: [talluribhavishya@gmail.com](mailto:talluribhavishya@gmail.com), Contact no.9626598645

### ABSTRACT

*Vascular access is a hemo-dialysis patient's lifeline. Two types of permanent vascular access are designed which include the arterio-venous fistula and the arterio-venous graft. After surgical creation, arterio-venous fistulas typically require several months of maturation for the draining vein to dilate and the arterio-venous blood flow to increase. The criteria for AV fistula maturation is vein diameter of 4 mm and access blood flow volume of 500 ml/min by using Doppler. Here we assess the intima-media thickness of the vein in determining maturity of AV fistula.*

**Purpose-** *To determine cannulation readiness of AV fistula by determining vein intima-media thickness.*

**Materials and methods-** *Institutional review board approval and informed consent were obtained for this study. The study is a cross-sectional study at our hospital tertiary health care set up.*

**Statistical Analysis –** *A Chi-square test is used to find an association between variables (gender, diabetic and hypertensive status).*

**Results and Conclusion-** *The conclusions drawn are those cases with intima-media thickness  $\leq 0.20$  mm are not matured, while those cases with intima-media thickness  $\geq 0.26$  mm were matured and those cases with intima-media thickness between 0.21-0.25 mm were matured only by vein diameter.*

**KEYWORDS-** *Intima-media thickness, Vein, maturity, arteriovenous fistula.*

### INTRODUCTION

A vascular access lets large amounts of blood flow continuously during hemodialysis treatments to filter as much blood as possible per treatment<sup>(1)</sup>. A vascular access makes life-saving hemodialysis treatments possible. Dialysis is a life-saving process whereby removing wastes, salts and excess fluid from the blood and is used

primarily as an artificial replacement for lost kidney function in people with renal failure. Hemo-dialysis is a treatment for kidney failure that uses a machine to send the patient's blood through a filter, called a dialyzer, outside the body. The kidney failure and the eventual process of dialysis is a costly affair with significant risks of morbidity and mortality.

The dialysis outcome quality initiative guidelines tell that creation of primary arterio-venous fistula is possible in only 50% of the patients <sup>(2,3)</sup>. The matured arterio-venous fistula outperforms arterio-venous graft in having higher patency rates, freedom from infection and low maintenance costs <sup>(4)</sup>. To increase the use of native arterio-venous fistulas, for early detection of access dysfunction and subsequently needed intervention and for reducing the rate of access failure periodic and early monitoring is required <sup>(5,6)</sup>. Duplex ultrasound is considered superior as it provides information both on the morphology and the function of vascular access. In addition, it offers an advantage of being non-invasive, bedside procedure with less cost and no need of radio-contrast<sup>(6)</sup>. Hence ability to predict whether arterio-venous fistula is going to mature eventually is important. So, I intend to study the role of ultrasound in evaluating the maturity of arterio-venous fistulas using vein intima-media thickness contrary to the already being used maturation criteria (vein diameter and access blood flow volume).

## OBJECTIVES

The study is to evaluate arterio-venous fistula maturity using ultrasound by measuring vein intima-media thickness for hemo-dialysis patients within 4 months of placement of arterio-venous fistula at our institution.

## MATERIALS AND METHODS

**INCLUSION CRITERIA:** All patients aged about 15-80 years within 4 months placement of arterio-venous fistulas for hemo-dialysis are included in our study. The patients are taken up for a period of 18 months.

**EXCLUSION CRITERIA:** All patients post-placement of arterio-venous fistula with complications such as infection, stenosis, thrombosis, steal phenomenon, aneurysm and pseudo-aneurysm formation are excluded from our study.

**SAMPLING:** All patients coming for hemo-dialysis within 4 months of placement of vascular access.

**STATISTICAL ANALYSIS:** Frequencies and percentages are calculated. A Chi-square test is used to find an association between variables (gender, diabetic and hypertensive status). Mean and standard deviation are calculated for vein intima media thickness

Independent t test are done to compare mean and standard deviation between groups. Data will be entered and analyzed using Epi info version 7 software. p value < than 0.05 will be considered to be statistically significant.

Vein intima-media thickness was measured using Philips HD 11 ultrasound machine with a linear probe of frequency range 7-12 Mhz to assess the maturity of arteriovenous fistula.

## ETHICAL CONSIDERATIONS

The Ethical approval was obtained from the Institute Ethics committee. All the ethical principles are adhered in the study.

**PROCEDURE:** The feeding artery, anastomoses and the entire draining vein should be scanned, and the minimum diameter should be measured. The depth of the anterior wall of the AVF from the skin surface is also measured. The AVF feeding artery, anastomosis, and draining vein are analyzed, using spectral and color Doppler. The depth of the anterior wall of the draining vein from the skin surface is measured in the forearm for a forearm AVF and in the upper arm for an upper arm AVF. If the depth of the vein is greater than 0.5 cm, it will be too deep for easy access with a 15- gauge needle.

Blood flow is measured in the AVF in ml/min, using the volume flow measurement function of the Duplex instrument. If the blood flow equals or exceeds 500 mL/min, the likelihood of fistula adequacy is near twice as great as with lower flow rates.

Vein diameter of minimum 4 mm and blood flow velocity of minimum 500 ml/min are considered sonological criteria for the maturity of arterio-venous fistulas. Vein intima-media thickness is taken as maturation criteria and

correlated with already established criteria of vein diameter and access blood flow volume. The combination of the echogenic line interface and hypoechoic band represented the intima-media thickness. The machine used for imaging is PHILIPS HD 11XE, linear transducer probe with a frequency range of 7 megahertz to 12 megahertz.

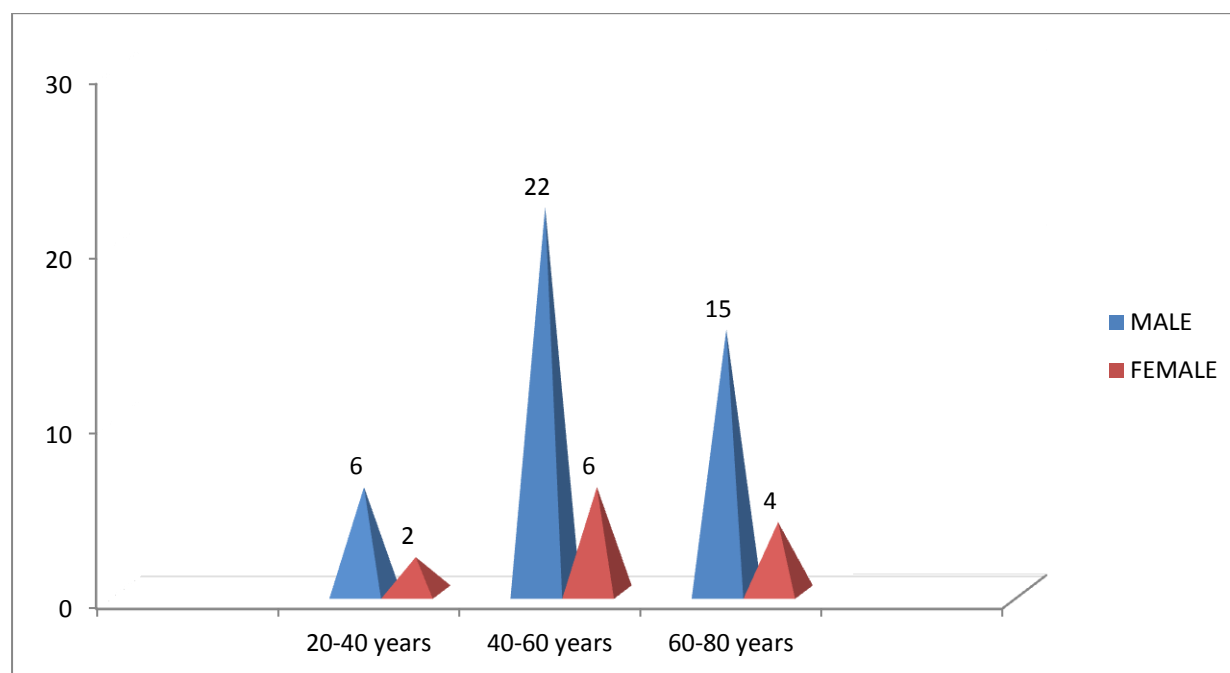
## RESULTS

Of the total 55 cases done, there was good correlation of the number of matured (46) and immatured (9) cases using intima-media thickness and access blood volume criteria (Table 2). 46 cases were matured by both intima-media thickness and vein diameter. 9 immatured cases were noted of which 6 were matured by vein diameter but not by intima-media thickness and 3 were not matured by both intima-media thickness and vein diameter (Table 3). The intima-media thickness were categorized into three subdivisions based on their maturation status and there was good correlation between access blood flow volume and intima-media thickness (Table 4). With Intima-media thickness of  $\geq 0.26$  mm, 46 cases were matured by both access blood flow volume and intima-media thickness. With Intima-

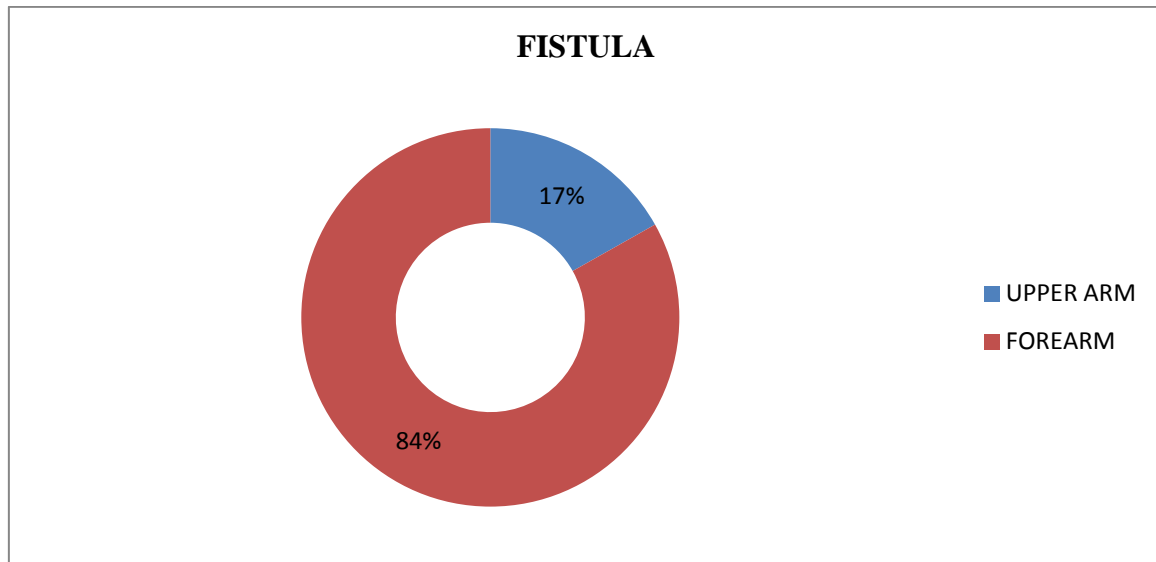
media thickness  $\leq 0.25$  mm, 9 cases were not matured by both access blood flow volume and intima-media thickness. With Intima-media thickness of  $\leq 0.20$  mm, 3 cases were not matured by both vein diameter and intima-media thickness. With Intima-media thickness  $\geq 0.21$  mm, 52 cases were matured by both vein diameter and intima-media thickness (Table 5). The conclusions that were drawn are those cases with intima-media thickness  $\leq 0.20$  mm are not matured, while those cases  $\geq 0.26$  mm were matured and those cases with intima-media thickness between 0.21-0.25 mm were matured only by vein diameter.

Of the 55 cases, 84% of the vascular access created were of radiocephalic fistula while 13% were contributed by brachiocephalic fistula and remaining 4% by brachio basilic transposition. More cases of radiocephalic fistula created could relate to the low incidence of complications associated with it, patients pre-placement examination status of the vessels and depends on the surgeon's choice and expertise in vascular surgeries.

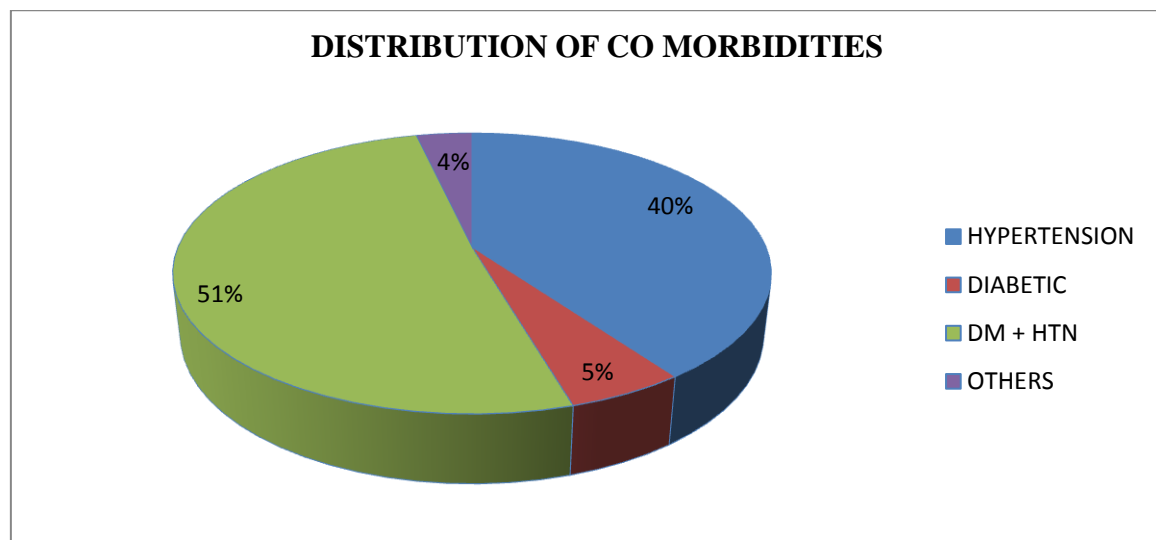
The mean intima media thickness obtained was 0.28 mm with standard deviation of 0.04 mm (TABLE 1)



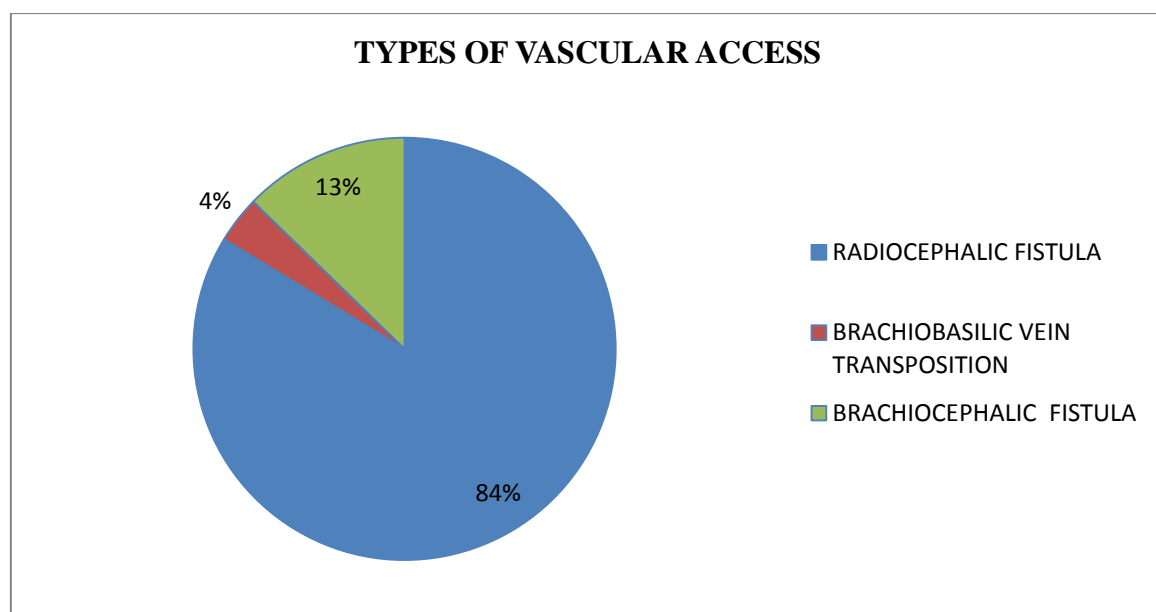
**Figure 1-** Distribution of Study Population According to Sex and Age



**Figure 2-**Majority of the Fistulas Created Are in the Forearm.



**Figure 3-** Distribution of Co Morbidities



**Figure 4-** Types Of Vascular Access

**Table 1-**Calculation of Mean,S standard Deviation And 95% CI

Sl no.	Parameter	Mean	Standard deviation	95% confidence interval
1	Age	51.22	12.116	47.94-54.49
2	Vein intima media thickness	0.28	0.04	0.19-0.37

The mean, standard deviation and 95% confidence interval was calculated for age & vein intima-media thickness. The mean age of the patient in the study is (51.2 +/- 12.1) with a standard deviation of (12.1) and 95% confidence interval of (47.94-54.49). The mean

vein intima-media thickness is (0.28 mm) with a standard deviation of (0.04) and 95% confidence interval of (0.19-0.37). The confidence interval achieved assumes significance as all the values are placed on same side of zero.

**Table 2-**Comparison of Intima Media Thickness and Access Blood Flow Volume

Sl. No	Access blood flow volume	Intima-media thickness				Total & %	Chi square value, degree of freedom	p value
		Matured		Not matured				
		N	%	N	%			
1	Matured	46	100	0	0	46(83.6)	55, 1	0.001
2	Not matured	0	0	9	100	9(16.4)		
Total & %		46	83.6	9	16.4	55(100)		

The number of matured and immatured cases are same on intima-media thickness and access blood

volume criteria. The p value achieved is significant (0.001)

**Table 3-**Comparison of Intima-Media Thickness and Vein Diameter

Sl. No	Vein diameter	Intima-media thickness				Total & %	Chi square value, degree of freedom	p value
		Matured		Not matured				
		N	%	N	%			
1	Matured	46	100	6	66.7	52(94.5)	16.2, 1	0.001
2	Not matured	0	0	3	33.3	3(5.5)		
Total & %		46	83.6	9	16.4	55(100)		

All the 46 cases are matured by both intima-media thickness and vein diameter, while of the 9 immatured cases, 6 were matured by vein diameter but not by intima-media thickness and 3

were not matured by both intima-media thickness and vein diameter. The p value achieved is significant (0.001)

**Table 4-**Comparison of Intima-Media Thickness Criteria and Access Flow Volume

Sl. no	Intima media thickness criteria	Access blood flow volume				Chi square value, degree of freedom	p value
		Matured		Not matured			
		N	%	N	%		
1	$\leq 0.20\text{mm}$	0	0	4	100	55, 2	0.001
2	0.21-0.25mm	0	0	5	100		
3	$\geq 0.26\text{mm}$	46	100	0	0		
Total		46	83.6	9	16.4		

The intima media thickness were categorized into three subdivisions based on their maturation status. Of 55 cases, 4 cases were showing IMT of  $\leq 0.20\text{mm}$  and are not matured by access blood flow volume. 5 cases were showing IMT of 0.21-

0.25mm and are not matured by access blood flow volume. All cases above IMT of  $\geq 0.26\text{mm}$  were matured by access blood flow volume too. The p value achieved is significant (0.001)

**Table 5-**Comparison of Intima-Media Thickness Criteria and Vein Diameter

Sl. no	Intima media thickness	Vein diameter				Chi square value, degree of freedom	p value
		Matured		Not matured			
		N	%	N	%		
1	</=0.20mm	0	0	3	100	40.4, 2	0.001
2	0.21-0.25mm	6	100	0	0		
3	>/=0.26mm	46	100	0	0		
Total		52	94.5	3	5.5		

The intima-media thickness were categorized into three subdivisions based on their maturation status. Of 55 cases, 3 cases were showing IMT of  $\leq 0.20\text{mm}$  and are not matured by vein diameter. 6 cases were showing IMT of 0.21-0.25mm and

are found matured by vein diameter. and intima-media thickness. All cases above IMT of  $\geq 0.26\text{mm}$  were matured by vein diameter too. The p value achieved is significant (0.001)

**Table 6-**Calculation Of Odd's Ratio With Risk Factors

Sl no.	Risk factors	Category	Odds ratio	95% CI	p value
1	Age	20-45	1		0.310
		46-55	0.87	0.180-4.176	0.85
		$\geq 56$	2.36	0.558-10.017	0.28
2	Gender	Male	1		
		Female	1.118	0.255-4.8	0.8
3	Hypertension	Yes	1.714	0.17-16.6	0.64
		No	1		0.21
4	Diabetes mellitus	Yes	1.42	0.43-4.7	0.55
		No	1		0.02
5	Number of co-morbidities	One	1		0.03
		Two	1.25	0.35-4.3	0.72
		Three	4.8		1
6	Type of fistula	Brachio basilic			0.99
		Brachio cephalic	3.77	0.73-19.3	0.11
		Radio cephalic	1		0.002

**AGE-** Odd's ratio for patients aged more than 55 years (2.36) have relative increased risk for delaying the maturity of fistula which is associated high confidence interval. This could probably be related to the age related changes in the vasculature and associated co-morbidities with increased age.(TABLE 6)

**GENDER-** Females are associated with a high Odd's ratio of more than 1 indicating higher chance of altering the maturity of AV fistula and with high confidence interval it increases precision of obtained Odd's ratio.

**HYPERTENSION-** Patients with hypertension are having a Odd's ratio of 1.7 suggesting exposure is associated with higher chance of causing immaturity of AV fistula. There is associated high confidence interval.

**DIABETES MELLITUS-** Patients with diabetes mellitus are having a Odd's ratio of 1.4 suggesting exposure is associated with higher chance of causing immaturity of AV fistula. There is associated high confidence interval.

**NUMBER OF CO-MORBIDITIES-** With increase in the number of co-morbidities there is an increase in Odd's ratio. Patients associated with three co-morbidities have a high Odd's ratio(4.8).

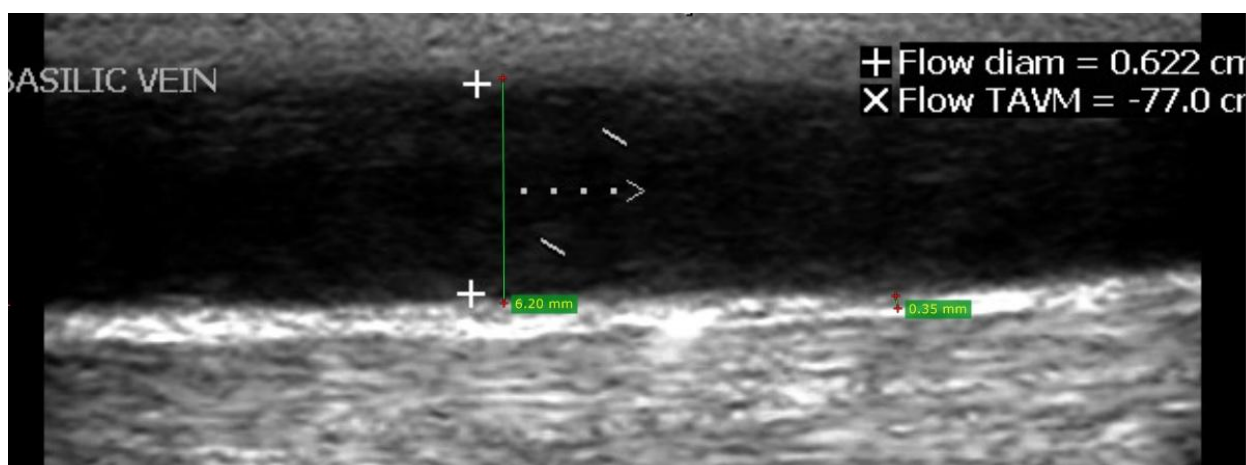
**TYPE OF FISTULA-** Patients with brachiocephalic fistula (3.7) have high Odd's ratio as compared to radiocephalic fistula(1) suggesting exposure is prone for causing higher chance of immaturity of AV fistula.



## CASE OBSERVATIONS



**Figure 5-**US grayscale image in longitudinal plane demonstrating the intima-media thickness as 0.21mm



**Figure 6-**US grayscale image in longitudinal plane demonstrating intima-media thickness as 0.35mm.

## DISCUSSION

In our study, 52 cases(94.6%) were matured and 3 cases (5.4%) were not matured. All the immature cases, developed post procedural complications in the form of thrombosis at the anastomotic site or in the cephalic vein.

Anatomic variation in the form of high origin of radial artery was noted in one case. Few cases showed the bulk of the fistulous flow being drained into basilic vein through the median cubital vein from the cephalic vein and few cases showed communication between superficial veins and the venae comitantes of the deep arteries through which the fistulous flow goes at the level of the elbow.

Venous intima media thickness can be used to assess maturity of AV fistula along with vein diameter and access blood flow volume. Increase in intima-media thickness can increase the probability of maturity of AV fistula. Venous intima-media thickness can be also correlated with

the histological examination. The increase in venous intima-media thickness is due to smooth muscle cell proliferation and neointimal hyperplasia.

Compared to the study done by Arash jaberi et al, we did not use very high frequency probes and hoop stress to assess maturity. The minimum intima-media thickness obtained to characterize a fistula as matured is  $\geq 0.21$ mm in comparison to 0.16mm obtained by Arashjaberi et al (12). The probable reason could relate to the high frequency probes that were employed.

## CONCLUSION

Our findings indicate that venous wall intima-media thickness using US can be used to predict cannulation readiness to maximize successful cannulation and avert AVF damage by premature cannulation. These findings require further study and validation in multicenter prospective studies. Vein intima-media thickness can be used to assess

maturity and to know the temporal changes in vein since the creation of fistula and can be complementary to other US maturation criteria (vein diameter & access blood flow volume).

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