



A Statistical Analysis-Usefulness of Resistive Index and Vascularity patterns to differentiate benign from malignant breast lesions using Color Doppler Ultrasound

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Abstract

Objectives: To establish the usefulness of Resistive Index and vascularity patterns using Color Doppler Ultrasound (CDUS) in differentiating benign from malignant breast lesions and to correlate the imaging findings with pathologic results.

Results: Significantly increased values of $RI > 0.73$, Peak systolic velocity $>25\text{cm/sec}$ along with the presence of more penetrating vessels which are radially arranged and show chaotic vascularity are characteristic features of malignant breast lesion. When RI is around $0.66-0.73$, Peak systolic velocity $<25\text{cm/sec}$ along with the vascularity along the tumor margins in a peripheral net pattern, they are usually features of benign lesions. In this way we can differentiate benign from malignant breast pathologies and also categorise indeterminate lesions into either of them.

Conclusion: Color Doppler sonography is an ideal imaging technique that can be used in conjunction with basic imaging modalities such as mammography and grey scale imaging ultrasonography, as a non invasive method for confirmatory diagnosis of breast lesions. Some of the variables have been statistically analysed to establish its unique role in better evaluation of breast cancers. It's based on the fact that most malignant lesions show more neovascularisation than benign lesions when compared to the normal breast parenchyma.

Keywords: Color Doppler sonography, Resistive Index (RI), Peak systolic velocity (PSV).

Introduction

Breast cancer is the leading cause of death among women accounting for 14% of cancer related deaths worldwide. Amidst increasing awareness and sensitisation, trend of early detection of malignancies through various imaging modalities have undergone a tremendous upgradations.

For long mammography has remained unchallenged as the basic screening method for

breast cancer. There are certain limitations of mammography in young women, pregnancy because of radiation hazards, women who are obese and have dense breasts, wherein the detection rate through mammography declines to 38%. Routine imaging with ultrasound alongside mammography can improvise the diagnostic accuracy to 75% whereas the sensitivity of only mammography is (50%)^[1]. Even small breast

lesions which go unnoticed in mammography films can be identified by ultrasound imaging by grey scale [2]. Since there are challenges in diagnosing benign and malignant lesions of the breast and the term indeterminate is more often used, a single imaging modality may not be confirmatory. This is where Color Doppler Ultrasonogram helps us to characterise benign and malignant breast lesions based on a different perspective. It defines how benign and malignant lesions differ the morphology, distribution of vessels and the flow impedance^[3,4].

Even though a constellation of other imaging techniques and principles such as sonoelastography, 3D Doppler, tissue harmonics, tomosynthesis, MRI have become available, mammography still remains the initial imaging investigation to assess breast lesions^[5,6]. There is still more room for improvisations when vascularity and flow related parameters are explored and taken into consideration as a part of the routine imaging for better diagnosis^[7].

Materials and Method

For our study 40 patients who were willing to be subjected for the imaging investigations were enrolled. On the basis of the histopathology reports two groups were formed comprising 20 benign cases and 20 malignant cases. The study population were of the age group of 20 years to 60 years. The study was approved by the Department of Radiology, Rajah Muthiah Medical College and conducted during the period of July 2017 to Sep 2018. Informed written consent was obtained from all patients.

Inclusion Criteria

Inclusion criteria for the sample was any patient with solid space occupying or palpable breast lesions in women of the age group 20-60 years were identified clinically –subjected to ultrasound, mammography and subsequently FNAC.

Exclusion Criteria

Pregnancy

Patients with previous operative history for a breast cancer

Cases with inconclusive cytology reports due to inadequate tissue sampling

Patients who did not turn up with their FNAC reports

Patients who could not be tracked or could not be contacted further

Positioning and Technique

The patient was positioned comfortably in supine position, slightly rotated away from the side of interest so that the breast parenchyma is uniformly spread over the anterior chest wall. The other arm was positioned behind the head. A systematic approach was followed while using the transducer in a radial fashion in the clockwise direction. Axial as well as sagittal images were acquired. After documenting the morphologic characteristics on grey scale sonography, color Doppler was done using LN5-12 linear transducer. An adequate time of 10 to 20 minutes were taken to perform the scan depending on the lesion.

Results

Table -1: Doppler Criteria - Number of blood vessels

No. of Vessels	Benign	Malignant
0	30	5
1	50	0
2	10	20
3	5	10
>4	5	65

In our study group of the 40 cases, 20 benign cases and 20 malignant cases were enrolled. 14 (70%) of the benign cases showed vascularity of which 13(65%) had less than 4 vessels. Whereas 13(65 %) of the malignant lesions showed more than 4 vessels. Thereby malignant lesions showed more feeding vessels when compared to the benign lesions^[8].

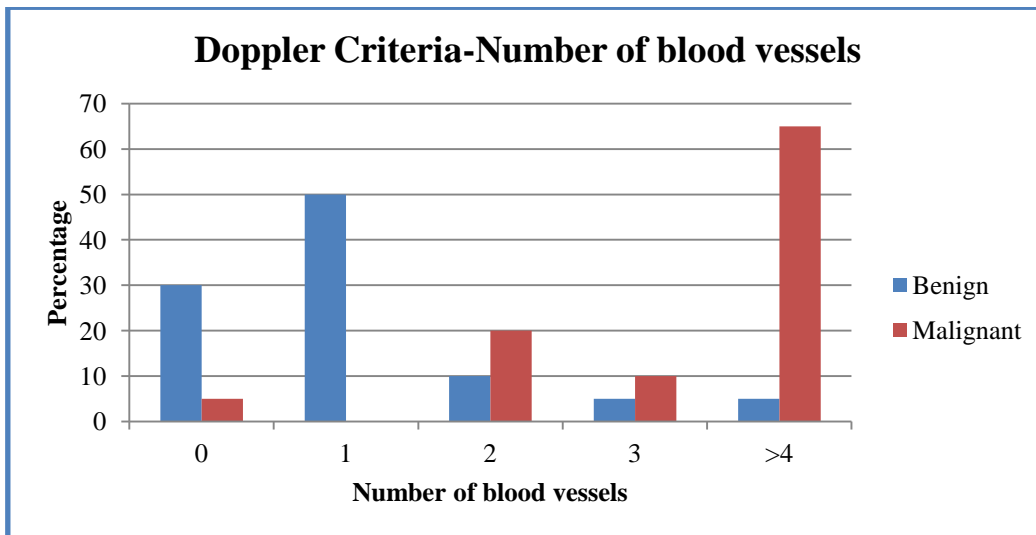


Table - 2: Doppler Vascularity Pattern

Morphology of vessels	Number of vessels
Smooth Vessels	9
Tortuous Vessels	4
Chaotic Vascularity	1
Absence of Vascularity	6

Of the 14 (70%) benign lesions which showed vascularity, 9(45%) showed smooth vessels, only 4 (20%) showed tortuous vessels and chaotic vascularity was demonstrable in 5 % of the cases. Most benign lesions have less metabolic demands, require less neovascularization and usually do not distort the microvasculature^[9].

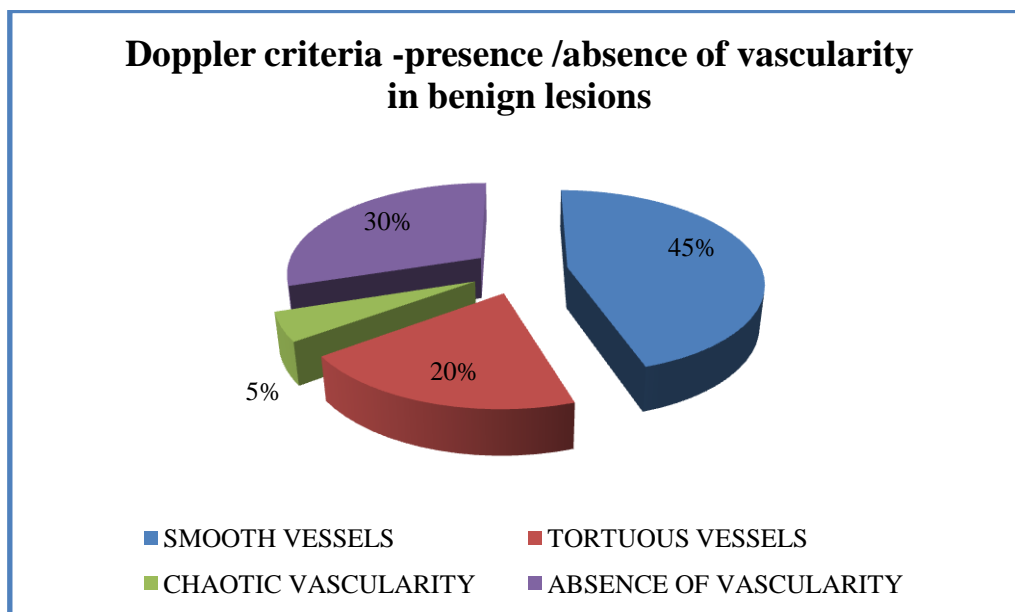


Table -3: Doppler criteria-Presence/Absence of vascularity in malignant lesions

Morphology and Distribution of vessels	Number of vessels
Smooth vessels	5
Absence of vascularity	2
Tortuous vessels	11
Chaotic vascularity	2

Of the 18 (90%) malignant lesions which showed vascularity, 11(55%) showed tortuous vessels, only 5(25%) showed smooth vessels and chaotic vascularity was seen in 10 % of the cases. Most malignancies have extensive neovascularization as they grow and proliferate^[10]. Penetrating vessels enter in a perpendicular fashion into the core of the lesion without traversing the capsule giving a spoke wheel pattern^[11].

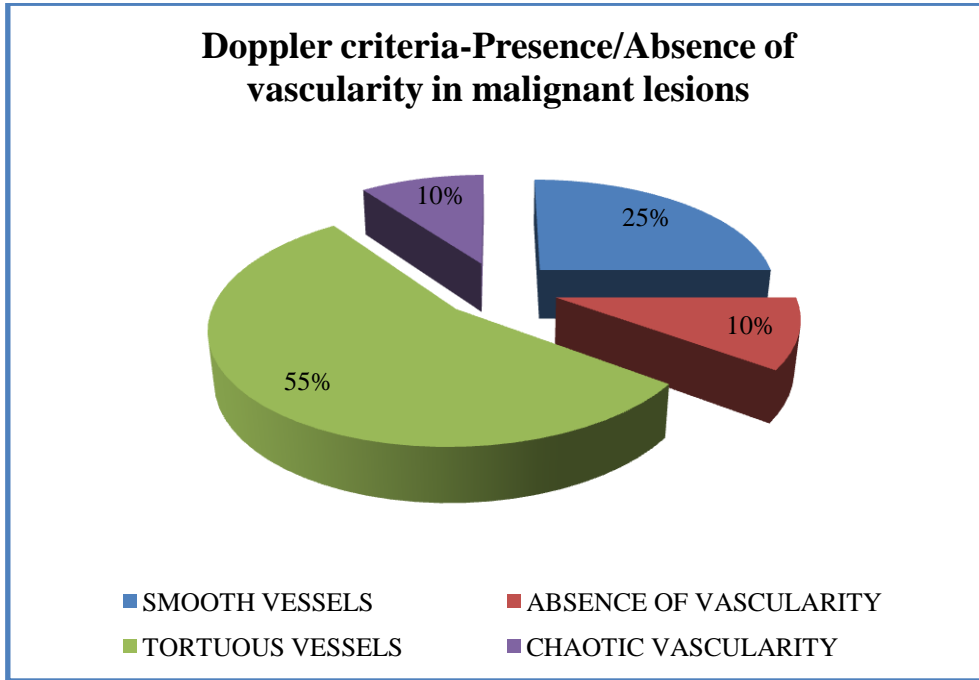


Table- 4: Doppler Waveform

Type of Waveform	Benign	Malignant
Low Impedance	68	4
High impedance	5	64
Turbulent	11	25
Venous	16	7

It was demonstrated in this study that there was significantly lower flow impedance in 68% of the benign lesions and high impedance flow in 64% of the malignant lesions. The core of the lesion showed vessels with high peak systolic velocities

and high resistive index whereas the periphery of the lesion showed low velocity flow with low resistive index. The venous pattern was seen in 16% of benign lesions and 7 % of malignant lesions because of arterio-venous shunts^[10].

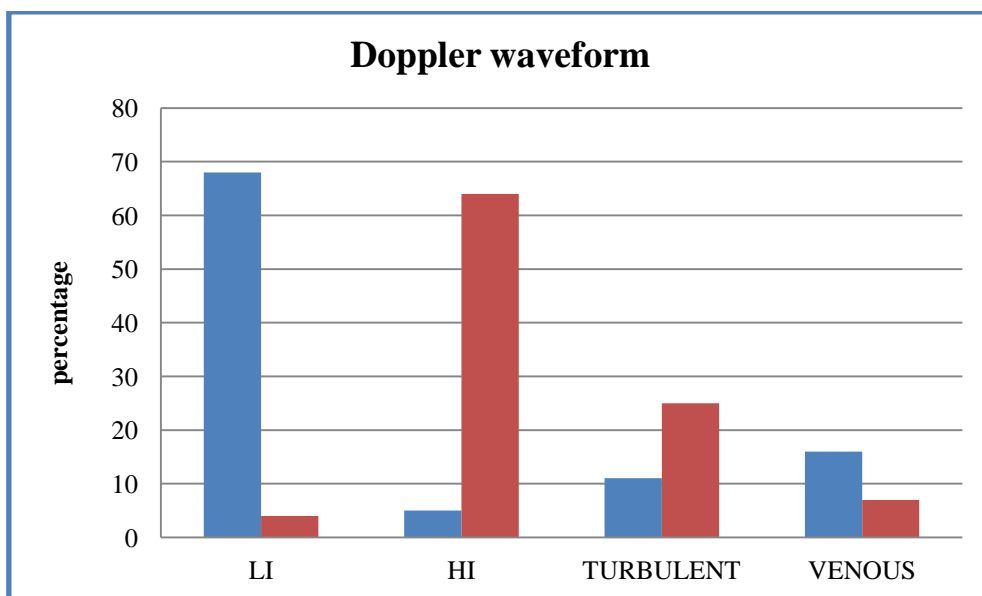


Table - 5: Doppler Vascularity Pattern

	Central	Peripheral	Mixed	Capsular	No Vascularity
Benign	3	9	2	13	6
Malignant	11	2	5	4	2

In our study it was observed that 13 (65%) benign lesions had trans-capsular vessels while only 4 (20%) malignant cases showed capsular vessels. As already discussed 9 (45%) of the benign

lesions had predominantly peripheral net pattern of vessels but most malignant lesions in our study about 11 cases (55%) showed predominantly central vascularity^[12].

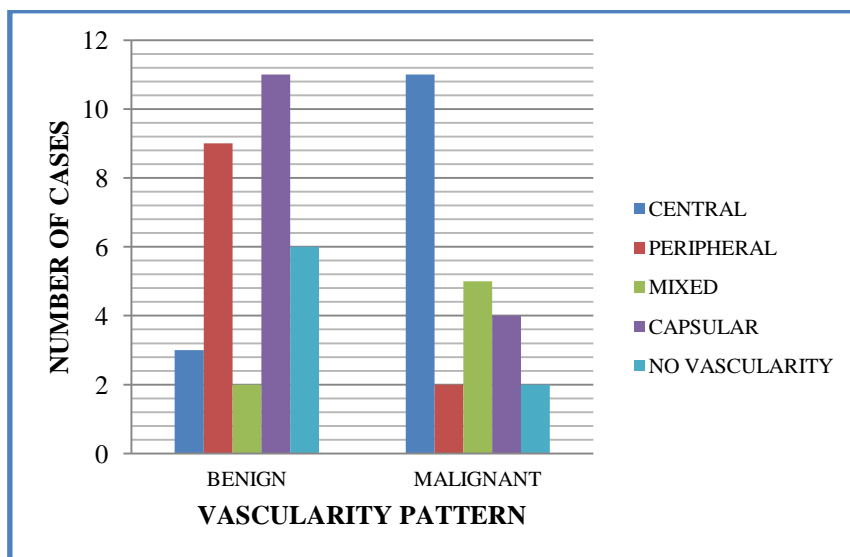
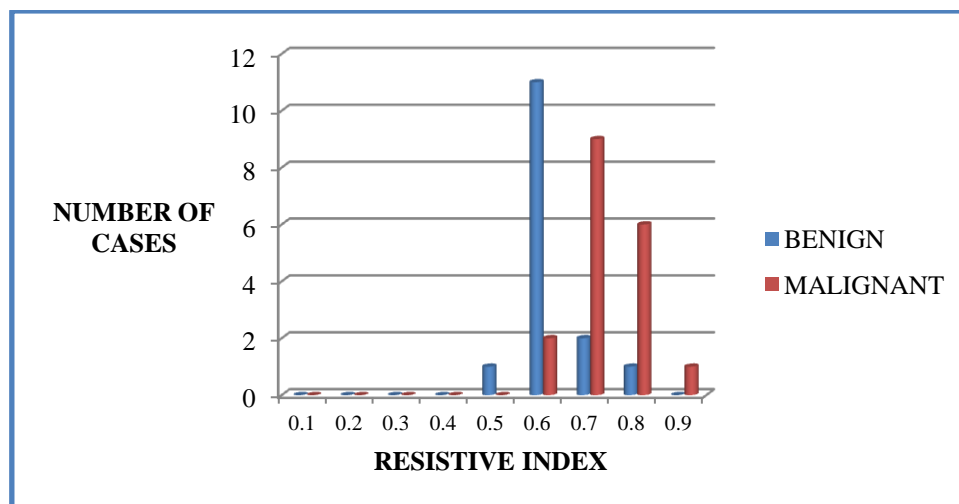


Table : Doppler - Resistive Index

Resistive Index	Benign	Malignant
0.1	0	0
0.2	0	0
0.3	0	0
0.4	0	0
0.5	1	0
0.6	11	2
0.7	2	9
0.8	1	6
0.9	0	1

In our study sample, benign lesions showed higher RI values in 12 (60%) of the cases of mean 0.66 with a SD of 0.062. Malignant lesions showed higher RI values in 16 (80%) of the cases of mean 0.73 with a SD of 0.083.



In our study sample, majority of the benign lesions showed relatively lower PSV values in 12 (60%) of the cases of mean of 22. Malignant

lesions showed higher PSV values in 16 (80%) of the cases of mean value of 0.26.

Table : Doppler - Resistive Index

Patients	Peak systolic velocity in (cm / sec)	
	Benign	Malignant
1	19	26
2	21	28
3	26	NV
4	NV	25
5	18	22
6	30	28
8	NV	28
9	24	25
10	25	30
11	21	NV
12	21	24
13	NV	28
14	28	25
15	NV	30
16	18	20
17	22	26
18	NV	25
19	NV	28
20	26	22

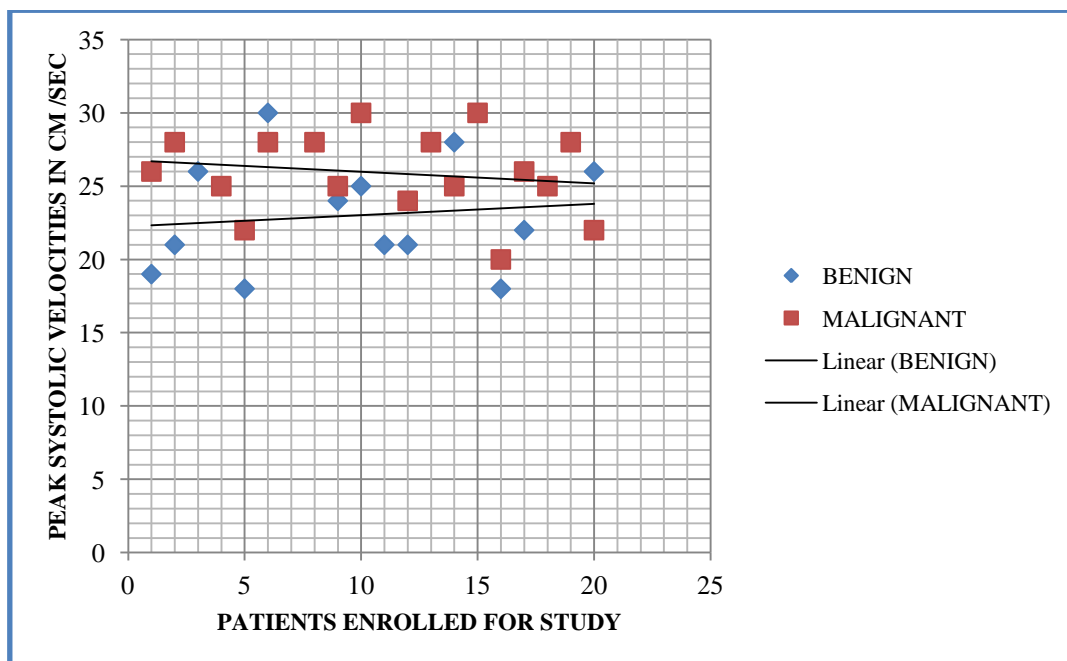
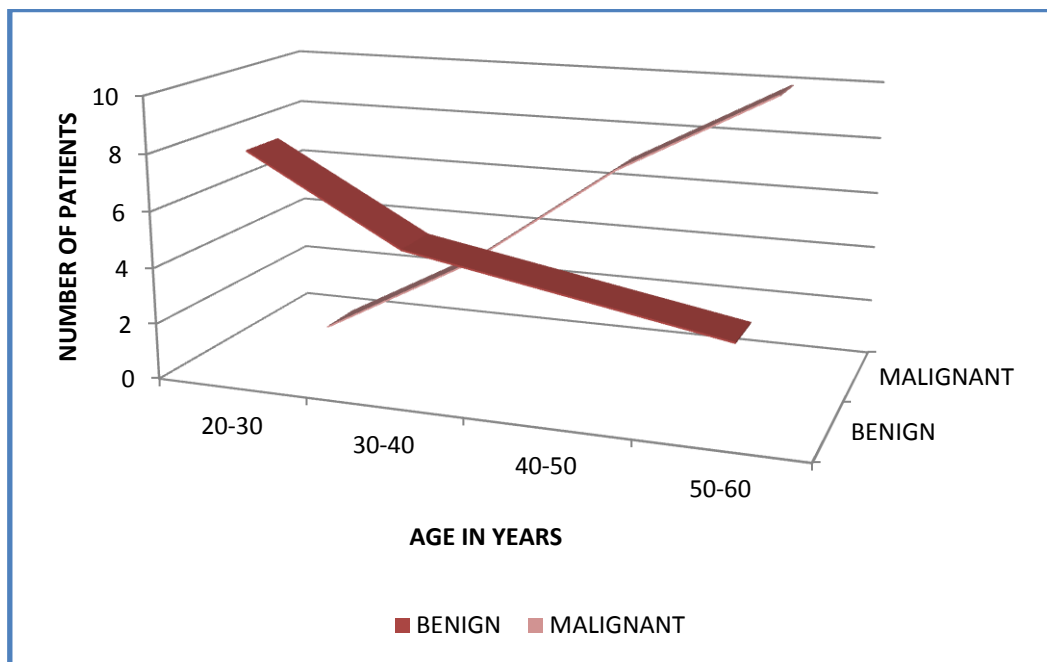


Table: Age in Years

Discussion

Women in our study sample were subjected to clinical examination, digital mammography, ultrasound examination, CDUS and finally the imaging findings were correlated with the histopathology reports. Some of the essential Doppler criteria taken into consideration were 1. Whether vascularity is present /absent ^[13] 2. The morphology of vessels (smooth with regular branching / irregular or tortuous /chaotic) 3. distribution of vessels (central /peripheral, mixed, capsular) –whether the penetrating arteries are entering perpendicular to the mass, without crossing the capsular region or entering through the capsule ^[14] 4. Type of Doppler waveform (low impedance pulsatility, high impedance pulsatility, turbulent or continuous venous flow) 5. Number of feeding vessels within the lesion (1-2 arteries were referred to as hypovascular lesions, >4 arteries were identified as hypervascular lesions)^[15] 6. Spectral analysis of the arteries using Peak Systolic Velocity (PSV) 7. Resistive Index (RI). Images were taken in various planes during real time imaging and stored in JPEG format.

Conclusion

Basically Color Doppler study is a safe, non-invasive modality and radiation free when

compared to mammography for evaluation of palpable breast masses. Thus ultrasound along with Color Doppler Ultrasound is recommended as the prime screening tool for breast lesions in pregnant women, young women with high risk for breast cancer and those with dense breasts on mammogram. Indeterminate lesions with higher RI values, PSV values along with hyper vascularity favour the diagnosis of malignancy in cases of diagnostic dilemmas while in cases with relatively lower RI values, low impedance flow with minimal vascularity we can be reassured of the benignity of the lesion.

Still more studies with bigger study population and taking into account some more Doppler parameters using multivariate logistic regression are essential to give a better insight.

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