ORIGINAL RESEARCH PAPER
Volume - 12 | Issue - 10 | October - 2023 | PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr
INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

CORRELATION OF PEAK SYSTOLIC VELOCITY ON DOPPLER WITH DEGREE OF STENOSIS ON CAROTID CT - ANGIOGRAPHY IN CAROTID STENOSIS

Radiology

Shreyosi Santra PG Radiology, RML, Delhi.
Shishir Chumber Research Associate Neurology, RML, Delhi.
Kavita Vani* Consultant Radiology, RML, Delhi. *Corresponding Author

ABSTRACT

Carotid artery stenosis is a risk factor for cerebrovascular disease. Carotid plaque, resulting due to atherosclerosis in carotid arteries causes carotid stenosis. Other causes of carotid stenosis include thrombosis, and non-atheromatous vascular diseases like fibromuscular dysplasia, dissection, and vasculitis. For the initial work-up of carotid stenosis Doppler ultrasound and carotid angiography are used. Appropriate management based on accurate and timely early characterization of stenosis and causative plaque can prevent stroke and its complication like paresis. The study revealed a strong correlation (r = 0.76) between peak systolic velocity measured on Doppler with stenosis measured on carotid angiography. Doppler ultrasound with its velocity parameter like peak-systolic velocity can predict stenosis degree with high sensitivity, specificity, and accuracy.

KEYWORDS

INTRODUCTION

Carotid artery stenosis is a risk factor for cerebrovascular disease. Carotid plaque, resulting due to atherosclerosis in carotid arteries, causes carotid stenosis.

For the initial work-up of carotid stenosis, Doppler ultrasound, and Carotid CT- angiography are used. It can estimate the degree of stenosis, and velocity parameters such as peak systolic velocity (PSV), end-diastolic velocity (EDV), ICA/ CCA velocity ratio, and IMT thickness.

Grading of the severity of carotid stenosis on Doppler ultrasound is based on the Society of Radiologists in Ultrasound (SRU) criteria which use peak systolic velocity (PSV) and luminal stenosis by plaque as primary parameters. PSV_{ICA} / PSV_{CCA} ratio and ICA-EDV are used as secondary parameters.[2]

Stenosis Grading -

The stenosis calculation on both modalities is done either by NASCET (North American Symptomatic Carotid Endarterectomy Trial) method or the ECST (European surgery carotid trials) method as diameter or area stenosis.

More than 70% of stenosis in asymptomatic patients and more than 50% in symptomatic patients is considered significant stenosis.[5] The measurements are either done manually or by semi-automated method. Twenty-two consecutive adult patients referred for CT -angiogram (CTA) of the brain and neck, for any reason such as subarachnoid hemorrhage or history of stroke were taken up for the Doppler study. The degree of stenosis in the extracranial carotid arterial system was calculated using the NASCET method (diameter) on CT- brain and neck angiography. Carotid Doppler was then performed, and PSV was measured at the site of stenosis. The PSV and degree of stenosis on CTA were analyzed to find the correlation between them, if any. Informed consent of the patient was taken.

ROC curve was prepared using PSV to predict severe stenosis. Based on the ROC curve, the cut-off value was calculated. The sensitivity, specificity, PPV (positive predictive value), and NPV (negative predictive value) of PSV were calculated to predict stenosis.

The correlation of PSV and the grade of stenosis on CTA was evaluated using a linear correlation. 'P' value less than 0.05 was considered statistically significant.

Degree of stenosis on CTA-

The stenosis calculated on carotid CTA using the NASCET method ranged from 30% to 100%. Total occlusion followed by near occlusion/ stenosis was the most common stenosis severity found. Severe stenosis (> 70%) was seen in twenty-two vessel segments (57.8%). Eight vessel segments (21 %) each showed mild (< 50%) and moderate stenosis (> 50%).

PSV On Doppler -

PSVs calculated on Doppler ultrasound showed an increasing trend till 80% stenosis, which was variable in near occlusion cases and zero in total occlusion. The range of PSVs found was 22 cm/sec (Near occlusion - 95% stenosis) to 280 cm/ sec (71% stenosis).

PSVs in near occlusion were variable and unpredictable ranging from as low as 22 cm/ sec to as high as 147 cm/sec. All cases of total occlusion showed no flow or spectral waveform on Doppler ultrasound.

A few patients of carotid stenosis with no plaque on Doppler were nearly occluded and showed severely attenuated caliber, that is, concentric symmetrical wall thickening on CTA.

On CTA, atherosclerotic plaques were classified as fibrofatty, calcified, and mixed. The most common plaque among them was fibrofatty plaque followed by mixed plaque. The least common type was a calcified plaque.

Comparison and Correlation-

The association of the degree of stenosis measured on CTA with PSV on Doppler was found to have a statistically significant P value < 0.001 using the Kruskal Wallis H test.

Using the Spearman correlation coefficient, a strong correlation was found between PSV on Doppler and degree of stenosis on CTA. The linear, quadratic, and cubic correlation between these parameters were 0.76, 0.66, and 0.71 respectively. Near occlusion and total occlusion were excluded while calculating correlation because of variable and zero PSV respectively.

The diagnostic accuracy of PSV for predicting moderate and severe stenosis was analyzed using ROC curves. The area under the curve for moderate and severe stenosis was 0.96 and 0.93 respectively. The cut-off PSV values found were 98.5 cm/sec and 153.5 cm/sec for > 50% and >70% stenosis respectively.

Sensitivity and NPV to predict stenosis by these PSV cut off values were higher as compared to standard PSVs- 125cm/sec (> 50%) and 230 cm/sec (> 70%). On the contrary, the specificity and PPV of the PSV cut-off 153.5 cm/sec to predict severe stenosis was less than the PSV cut-off 230 cm /sec. The specificity and PPV of the PSV cut-off 98.5 cm/sec to predict moderate stenosis was the same as the PSV cut-off 125 cm/sec. The PSV cut-off value - 98.5 cm/sec was more accurate to predict moderate stenosis than the standard PSV cut-off value - 125cm/sec with a diagnostic accuracy of each being 90% and 80% respectively. In severe stenosis, the prediction by standard PSV cut-off of 230 cm/sec showed an accuracy of 90% as compared to 85% accuracy of PSV cut-off 153.5 cm/sec.

CONCLUSION -

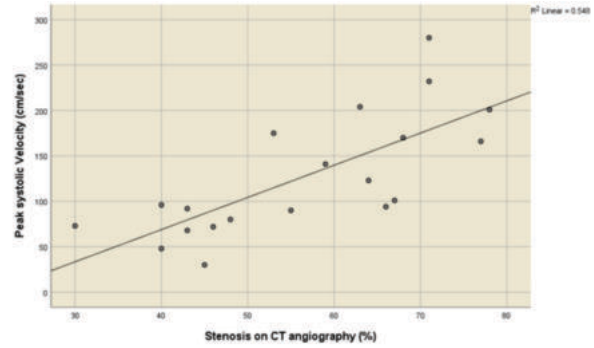
Atherosclerosis is the most widely prevalent etiology responsible for carotid stenosis. Doppler-ultrasound and Carotid angiography are rapid and reliable modalities to diagnose carotid stenosis. The

management of carotid stenosis relies highly on the severity of the disease as predicted by the grading of stenosis.

The study revealed a strong correlation (r = 0.76) between PSV measured on Doppler with stenosis measured on carotid angiography. Doppler ultrasound with its velocity parameter like PSV can predict the degree of stenosis with high sensitivity, specificity, and accuracy.

Thus, Doppler ultrasound, being a non-invasive, radiation-free modality, is an excellent screening tool to identify carotid stenosis and to predict its severity. CTA can then be performed before any surgical intervention to delineate the anatomy of the intra and extracranial carotid arterial system in a detailed manner.

Table 1: Scatterplot Showing The Correlation Between PSV And % Stenosis After Excluding Near & Total Occlusion



(a) > 70% Stenosis **(b) > 50% Stenosis**

Table 2 - ROC curve using PSV predict stenosis (a) > 70 % stenosis (severe) and (b) > 50% stenosis (moderate)

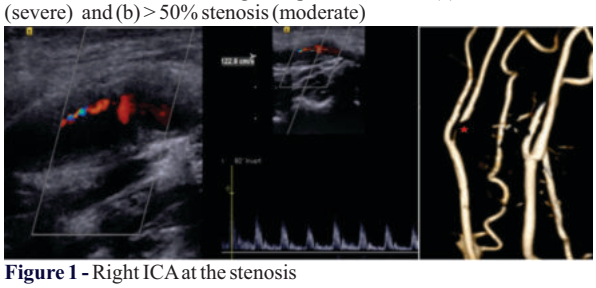


Figure 1 - Right ICA at the stenosis

(a) Doppler shows predominantly echogenic plaque with thickened IMT causing stenosis. A lack of color flow is seen on the color Doppler at the stenosis site.
(b) Pulsed-wave Doppler shows a PSV of 122.8 cm/sec at the stenosis site
(c) CT carotid angiography showing stenosis of Right ICA – 64% (NASCET) VRT(Volume reconstruction technique) showing stenosis in right ICA (red arrow)
(d) ABBREVIATIONS-
(e) CCA - Common carotid artery
(f) CT - Computed Tomography
(g) CTA - Computed Tomography angiography
(h) ECST - European carotid surgery trial
(i) EDV - End diastolic velocity
(j) Fig - Figure
(k) ICA - Internal carotid artery
(l) IMT - Intima media thickness
(m) NASCET - North American Symptomatic Carotid endarterectomy
(n) PSV - Peak systolic velocity
(o) ROC - Receiver operating curve
(p) SD - Standard Deviation
(q) SRU - Society of Radiologist in ultrasound

REFERENCES -

1) Zarins CK, Giddens DP, Bharadvaj BK, Sottiurai VS, Mabon RF, Glagov S. Carotid bifurcation atherosclerosis. Quantitative correlation of plaque localization with flow velocity profiles and wall shear stress. Circulation research. 1983;53(4):502-14. Doi : 10.1161/01.RES.53.4.502
2) Grant EG, Benson CB, Moneta GL, Alexandrov AV, Baker JD, Bluth EI et.al. Carotid artery stenosis: gray-scale and Doppler US diagnosis--Society of Radiologists in Ultrasound Consensus Conference. Radiology. 2003;229(2):340-6. Doi : 10.1148/radiol.2292030516
3) Hunink MG, Polak JF, Barlan MM, O'Leary DH. Detection and quantification of carotid artery stenosis: efficacy of various Doppler velocity parameters. AJR Am J Roentgenol. 1993;160(3):619-25. Doi : 10.2214/ajr.160.3.8430567
4) Robinson ML, Sacks D, Perlmutter GS, Marinelli DL. Diagnostic criteria for carotid duplex sonography. American Journal of Roentgenology. 1988;151(5):1045-9. Doi : 10.2214/ajr.151.5.1045
5) Stefanini M, Gaspari E, Boi L, Del Giudice C, Mastrangeli R, Nucera F et.al. Correlation between US-PSV and 64 row MDCTA advanced vessel analysis in quantification of 50%-70% carotid artery stenosis. Int J Vas med. 2012;2012(1) Doi : 10.1155/2012/928638
6) Lowe GD. Venous and arterial thrombosis: epidemiology and risk factors at various ages. Maturitas.2004;47(4):259-263 Doi : 10.1016/j.maturitas.2003.12.009
7) Touboul PJ, Hennerici MG, Meairs S, Adams H, Amarenco P, Desvarieux M, Ebrahim S, Fatar M, Hernandez RH, Kownator S, Prati P. Mannheim intima-media thickness consensus. Cerebrovascular diseases. 2004;18(4):346-9. Doi : 10.1159/000081812
8) Geroulakos G, Ramaswami G, Nicolaides A, James K, Labropoulos N, Belcaro G et.al. Characterization of symptomatic and asymptomatic carotid plaques using high-resolution real-time ultrasonography. Br J Surg. 1993;80(10):1274-7. Doi : 10.1002/bjs.1800801016
9) Baradaran H, Gupta A. Carotid vessel wall imaging on CTA. American Journal of Neuroradiology. 2020 Mar 1;41(3):380-6. Doi: 10.3174/ajnr.A6403
10) Bosiers M, Peeters P, Deloose K, Verbist J, Sprouse RL 2nd. Selection of treatment for patients with carotid artery disease: medication, carotid endarterectomy, or carotid artery stenting. Vascular. 2005;13(2):92-7. Doi: 10.1258/rsmvasc.13.2.92