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Carotid Artery Disease Spectrum on Carotid Doppler Sonography: An Experience at Tertiary Cardiac Care Center

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ABSTRACT

Objective: To assess the carotid artery disease spectrum in patients with coronary artery stenosis who underwent Carotid Doppler studies.

Study Design: Analytical Cross-sectional study.

Place and Duration of Study: Radiology department, AFIC/NIHD, Rawalpindi Pakistan from Jan 2018 to Jul 2019.

Methodology: Doppler ultrasound study of both carotid arteries was done in consecutive patients. All participants regardless of age and gender underwent carotid doppler assessment for the site of carotid plaque and percentage of stenosis. Data was grouped into two categories based upon Carotid Doppler outcomes such as; insignificant findings and significant findings. Insignificant findings comprised of no plaque or insignificant plaque with intima-media thickness (≤1.1mm), peak systolic velocity (<125cm/s), end-diastolic velocity (<40cm/s) and <50% narrowing of carotid arteries. Findings in which intima-media thickness was >1.1mm, peak systolic velocity (>125cm/s), end-diastolic velocity (>40cm/s) and >50% carotid stenosis were represented as significant Doppler outcomes. Pearson Chi-square test was applied by using SPSS-26:00.

Results: Total n=654 patients were included. Normal carotid doppler outcome was seen in 290(43.4%) patients, while 350(53.5%) had insignificant findings and 20(3.1%) had significant findings. The commonest lesion found was the atherosclerotic plaque and most frequently present in the left carotid system 392(60.0%) while most common site of plaque presence was at carotid bifurcation 218(33.3%). Significant association of plaque site and plaque type with carotid doppler outcomes was found (p<0.001).

Conclusion: Carotid artery disease is common on routine ultrasonic assessment. Carotid bifurcation was the most common site of plaque while the left internal carotid artery was the commonest site of both critical and significant stenosis.

Keywords: Carotid artery doppler, Carotid artery stenosis, Doppler ultrasound.

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INTRODUCTION

It is estimated that Cardiovascular Disease (CVD) will overtake infectious illnesses as the world's largest cause of death and disability by 2050.[1] Carotid artery disease is found in 3.5-52% of Coronary Artery Bypass Graft (CABG) patients, depending on the study.[2,3] Carotid artery disease is a key risk factor for stroke, which is a leading cause of worldwide disability. The likelihood of this happening rises as the degree of carotid artery stenosis does. Patients receiving surgical bypass for ischemic heart disease typically have severe Carotid Artery Stenosis (CAS).[4]

Carotid Ultrasonography (CUS) has surpassed other methods of carotid scanning because of its reliability as a noninvasive, low-cost, and sensitive diagnostic technique for detecting plaque & asymptomatic carotid artery stenosis. It can assess the extent of atherosclerotic arterial disease and structural changes in the carotid artery. Patients undergoing open-heart surgery can reduce their risk of stroke by having their CAS detected early with screening CUS.[5] Sonography of the extra-cranial carotids can be used to assess their atheromatous condition in a generally safe, practical, and cost-effective manner. Numerous researches have shown that sonography is better than other methods for grading carotid stenosis, with some studies demonstrating that the test is at least 90% accurate.[6,7]

Carotid Doppler ultrasonography, often known as ultrasound imaging, is a common technique for produ-cing diagnostic images of blood vessels without causing any discomfort to the patient. Traditional ultrasonic imaging makes use of a highfrequency transducer. However, Doppler ultrasound can determine the rate and course of blood flow within an artery. Carotid Doppler combines traditional

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ultrasound with Doppler ultrasound to evaluate blood flow in the carotid arteries, as well as the speed and direction of blood flow in the arteries, the vessel's diameter, and the extent to which it is obstructed.[8] Carotid Intima-Media Thickness (CIMT) has become a routine imaging diagnostic for atherosclerosis, proving to be not only accurate but also reliable, cost-effective and reprodu-cible. Eventually, Doppler ultrasonography was deve-loped, which has since supplanted all earlier imaging modalities as the primary and most common method of identifying carotid artery disease in the world.[6]

For patients anticipating CABG surgery, carotid doppler sonography is most commonly used as part of the normal pre-operative workup for evaluation and fitness prior to surgery.[7] One of the leading causes of perioperative strokes in patients who have CABG surgery is the presence of concurrent carotid artery disease and substantial carotid arterial stenosis.[9]

Massively increased disease burden over the few years needed recent study for record of estimation of the current disease burden. Therefore, the main objective of existing study was to assess the carotid artery disease burden in the tertiary careteaching institute, in patients referred to radiologists by various specialties (Medicine, Emergency Department and Surgery) for evaluation.

METHODOLOGY

This Analytical Cross-Sectional study was carried out at a Armed Forces Institute of Cardiology/ National Institute of Heart Disease Rawalpindi. Non-probability consecutive sampling technique was used to recruit patients from radiology department during Jan 2018 to July 2019. Formal ethical approval was obtained from Institutional Ethical Review Board (IERB Ltr#: 9/2/R&D/2023/273).

Sample size was calculated by using WHO sample size calculator and by taking prevalence of carotid artery disease 52% in CABG patients.[2,3] The calculated sample size was n=384 but we recruited all the patients who underwent carotid doppler assess-ment during the study period i.e. n=654.

Inclusion Criteria: Pre-operative CABG patients regardless of age and gender who underwent carotid doppler assessment for detecting the site of carotid plaque and percentage of stenosis by radiology depart-ment, patients referred from cardiology OPD for symptomatic evaluation of syncope and TIA, were included in the study.

Exclusion Criteria: Patients with history of any surgery were excluded from the study.

The patients selected for this study were pre-operative patients, who were on the waiting list for CABG after being diagnosed to have severe coronary artery disease. Participants underwent carotid doppler assessment for the site of carotid plaque and percen-tage of stenosis. Carotid artery findings and other patient parameters like age, gender, were documented from patients' case files. All these patients were evaluated with carotid doppler studies which was performed with the patient in supine position and head tilted to the opposite side and extended slightly. The carotid doppler studies were performed by using ultrasound probe of high resolution (7.5MHz) on Toshiba Aplio 500. Common carotid arteries, internal carotid arteries and external carotid arteries of both sides (left and right) were studied. Gray scale imaging and color doppler techniques were used to evaluate for intimal thickness, plaque, degree of carotid arteries stenosis (evaluated with percentage stenosis & velocity criteria), presence and site of atherosclerotic plaques. Data was grouped into two categories based upon Carotid Doppler outcomes such as; insignificant findings and significant findings. Insignificant findings comprised of no plaque or insignificant plaque with intima-media thickness (≤1.1mm), peak systolic velocity (<125cm/s), end-diastolic velocity (<40cm/s) and <50% narrowing of carotid arteries. Findings in which intima-media thickness was >1.1mm, peak systolic velocity (>125cm/s), end-diastolic velocity (>40cm/s) and >50% carotid stenosis were represented as significant Doppler outcomes.

Data was analyzed using Statistical Package for the social sciences (SPSS) version 26:00. In descriptive statistics, numerical variables like age were presented as mean & standard deviation. Qualitative variables were presented as frequencies and percentages. Chi-square test was applied to find association by consi-dering level of significance ≤0.05.

RESULTS

A total of Six hundred and fifty four (n=654) participants were included in the study; among these 522(79.8%) patients were males and 132(20.2%) were females. Mean age was 57.38±11.77 years range from 16 to 89 years. The commonest lesion found was the atherosclerotic plaque which was observed in Right carotid system, left carotid system and carotid bifurcation of [44(6.7%) & 392(60.0%) and 218(33.3%)] patients respectively. Plaque characteristics revealed

higher percentage of hyperechogenic 8(40.0%), and calcific plaques 6(30.0%) and low echogenic and moderate or heterogeneous plaques were less prevalent [3(15.0%) and 3(15.0%) respectively] in patients of significant Carotid Doppler Outcomes (Table-I).

Normal Carotid Doppler outcomes were seen in 284(43.4%) patients, while 350(53.5%) had insignificant findings, 20(3.1%) had significant findings shown in Figure.

Peak systolic velocity ratio showed significant Doppler outcomes in 20(3.06%) study participants and were more prevalent in males, 17(85.0%). Calcified and bilateral plaque were most prevalent (11(55%) out of 20; 15(75.0%) out of 20) with significant Carotid Doppler outcomes (p<0.01) as shown in Table-II.

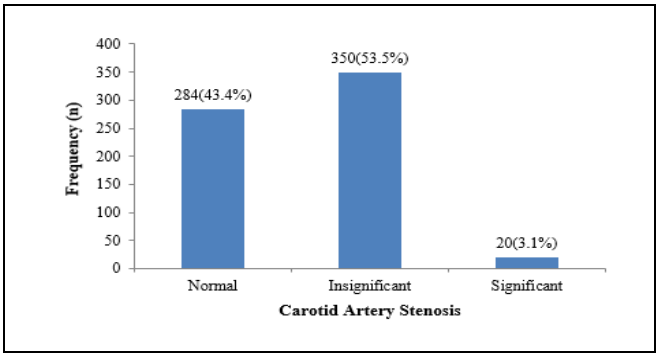

Figure: Carotid Doppler Findings in Study Sample (n=654)

Table-I: Frequency distribution of Atherosclerotic Plaque (n=654)

Parameters	values
Age (years) (Mean±SD)	57.38±11.77
Gender	
Male	522(79.8%)
Female	132(20.2%)
Right carotid system	44(6.7%)
Left carotid system	392(60.0%)
Carotid Bifurcation	218 (33.3%)
Plaque Characteristics of Significant Carotid Doppler Outcomes (n=20)	
Hyper-echogenic	8(40.0%)
Calcific	6(30.0%)
Low Echogenic	3(15.0%)
Moderate or Heterogeneous	3(15.0%)

DISCUSSION

Carotid artery atherosclerosis can be evaluated using doppler ultrasonography. This device's two-dimensional grey scale can be used to measure the intima-media thickness, which is an incredible biomarker for atherosclerosis and can assist in plaque characterization.[10] In our study, plaque characteristics showed 8(40.0%) hyper-echogenic, 6(30.0%) calcific, 3 (15.0%) low echogenic and 3(15.0%) moderate or heterogeneous plaques. Total occlusion was observed in 7(1.1%) patients. Plaque site and plaque type were significantly associated with of Carotid Doppler outcomes (p<0.001).

Table-II: Comparison of Carotid Doppler Outcomes with other Variables (n=654)

Study Variables		Carotid Doppler Outcome		p-value
		Normal+Insignificant Findings (n=634) Frequency(%)	Significant Findings (n=20) Frequency(%)	
Gender	Male	505(79.7%)	17(85.0%)	0.77
	Female	129(20.3%)	3(15.0%)	
Plaque Type	Smooth	142(22.4%)	3(15.0%)	<0.001
	Calcified	123(19.4%)	11(55.0%)	
	Mixed	75(11.8%)	6(30.0%)	
	Nil	293(46.3%)	-	
Site of Plaque	Right	87(13.8%)	2(10.0%)	<0.001
	Left	90(14.2%)	3(15.0%)	
	Bilateral	159(25.2%)	15(75.0%)	
	Nil	296(46.8%)	-	

Plaque morphology influences stroke risk and is also known as a powerful predictor of future embolic events.[11] Carotid artery stenosis has been detected using color doppler and pulse doppler ultrasono-graphy.[12] Unique physical features distinguish Doppler ultrasound from other methods. It is possible to have a relative position between a patient and an examiner when doing carotid ultrasonography. When the exami-ner sits with his or her back to the patient, he or she uses two hands to do ultrasonography in the overhead position.[13,14] Right carotid artery and left carotid artery should be examined with the examiner's hands in this position. Because the examiner can utilise both hands in this posture, there are a variety of placements for the ultrasonography probe to be placed.[15] Widening the sonic window allows for a better view of the carotid artery, especially from the postero-lateral projection.[16,17]

In Pakistan, however, very few studies have examined the frequency of CAD in patients under-going CABG. Our results showed that normal carotid doppler outcome was 284(43.4%) although 350(53.5%) had insignificant findings, 20(3.1%) had significant findings. The same institute conducted a study in Decem-ber 2014, although the comparatively low disease burden and small sample size limit the study's appli-cability to a larger population at risk.[18] According to the study done by Cirilo *et al.*, 71.6% of

participants had normal carotid arteries without signs of atheromatous alterations. The remaining 28.4% had atherosclerotic disease, with mild and moderate stenosis affecting 18.5% and 5.5%, respectively. In comparison, just 1.1% of people had total occlusion, while 3.4% had significant stenosis.[19] Likewise, the data of our study showed the same findings i.e. total occlusion was seen in 7(1.1%) patients.

It was found that 22.2% of the cases had smooth plaques, and 20.4% were calcified plaques. Carotid arteries were normal in 43.8% of individuals. According to Cirilo *et al*.[19] non-obstructive carotid artery disease affects 61.6% of the population, compared to 10.2% of those with critical stenosis. On the other hand, Rath *et al*.[20] found that 66.3% of patients had non-obstructive carotid artery disease, whereas 5.3% had substantial carotid artery disease and 3.7% had critical carotid artery disease. Plaque formation was most common in the internal and external carotid arteries in our study. According to Kallikazaros *et al*.[21] the carotid bulb is the most common location of plaque formation, followed by ICC and ECC, however this is contrary to their findings. There was a significant association of Carotid Doppler findings with age, plaque and stenosis however, there was no discernible difference between the gender with regard to these. Current study's result agrees with prior research findings as well.[4]

Doppler ultrasound examination is an effective screening method since it does not expose patients to radiation. Follow-up CT carotid angiography can provide objective confirmation for patients with severe carotid artery disease on Doppler ultrasound testing. Doppler ultrasound investigation of carotid artery disease has the potential to be as effective as CT carotid angiography, but future research is needed to make that determination.[4,21]

LIMITATIONS OF STUDY

This study has few limitations, first it was a cross sectional study, comparative studies are a need of time. Secondly, it was conducted in a single center, multi centered studies with larger sample size are required.

CONCLUSION

Carotid Doppler's importance in detecting the location of atherosclerotic plaque and assessing stenosis is well-established and supported. Future study using this technique should be conducted to determine the prognosis of individuals with one or more risk factors for cerebrovascular illness, regardless of whether they are currently symptomatic.

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Conflict of Interest: None

Authors' Contribution

Following authors have made substantial contributions to the manuscript:

ND & AHS: Study design, drafting the manuscript, Study concept, approval of the final version to be published.

SK & TMB: Critical review, Data acquisition, Data analysis, Drafting the manuscript, approval of the final version to be published.

JK: Study design, Critical review, Approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved

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