ORIGINAL ARTICLE

Exploring Diagnostic Echoes Doppler Ultrasound Performance in Plaque Detection against CT as Gold Standard

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ABSTRACT

Background: Cerebrovascular stroke is the third leading cause of death globally and is often associated with carotid artery stenosis, particularly in older adults. While ultrasonography is a widely used and non-invasive diagnostic tool, its limitations include operator dependency, potential for misinterpretation, and reduced sensitivity in detecting subtle plaque characteristics compared to computed tomography. Further research is needed to enhance its diagnostic accuracy and standardization.

Objective: To evaluate the diagnostic performance of carotid Doppler ultrasound against CT gold standard.

Methodology: A retrospective descriptive study was carried out at the Radiology Department of Shifa International Hospital, involving 100 participants categorized into 50 with calcified plaques and 50 with non-calcified plaques. Participants underwent a doppler carotid ultrasound followed by a CT carotid angiogram using non-probability convenient sampling. Data was collected on structured forms and analyzed using IBM SPSS version 23.

Results: In a sample of 100 participants, 96 were elderly and 4 were younger adults with a gender distribution of 68 males and 32 females.

Ultrasonography (USG) Doppler performed exceptionally well in terms of diagnosis. 88% sensitivity, 84% specificity, 84.6% positive predictive value, 87.5% negative predictive value, and 86% diagnostic accuracy were attained for noncalcified plaques. USG Doppler showed enhanced performance for calcified plaques, with 94% diagnostic accuracy, 92% sensitivity, 96% specificity, 95.8% positive predictive value, and 92.3% negative predictive value.

Conclusion: Our study highlights the high sensitivity, specificity, and predictive values of Doppler ultrasound for assessing non-cified and calcified plaques, emphasizing its utility as a valuable diagnostic tool in atherosclerosis management.

Keywords: *Plaque detection, doppler ultrasound, atherosclerotic plaques.*

INTRODUCTION

Atherosclerosis is the most common cause of carotid artery stenosis [1]. Cerebrovascular stroke ranks as the third most common cause of mortality globally and is a significant contributor to severe and enduring disabilities in the adult population. Carotid artery stenosis is recognized as a primary etiology of ischemic stroke, with its incidence increasing notably with age progression [2]. Future ischaemic cerebrovascular events can be considerably decreased by early detection and effective treatment of carotid atherosclerosis. The treatment options depend upon the degree of stenosis with medical treatment or frequent follow-up exams are typically used to treat patients with carotid stenosis that is less than 50% [3].

Various invasive and non-invasive techniques are employed to detect arterial plaque accumulation, with ultrasound imaging serving as the first-line diagnostic modality and is widely used in Pakistan [4].

Ultrasonography stands out among neuroimaging modalities for its non-invasive nature, safety, cost-effectiveness, and efficiency, making it a convenient bedside tool with rapid examination capabilities [5, 6]. In addition to evaluating anatomical alterations in the carotid artery, it can determine the degree of atherosclerotic vascular disease.

Given that it doesn't expose patients to radiation, Doppler ultrasound screening is a useful screening technique and its diagnostic accuracy in plaque detection against gold standard computed tomography remains an essential research focus [7].

MATERIALS AND METHODS

A retrospective descriptive study was conducted at the Radiology Department, Shifa International Hospital. 100 participants who presented to our department between 2020 to 2023 for carotid doppler ultrasound followed by CT carotid angiography were included. 50 patients had calcified plaques and 50 with non-calcified carotid arterial plaques. The patients who had a history of stroke or sudden neurological deficit among our study population were included in our study while excluding those with normal/negative studies. A nonprobability convenient sampling technique was applied. Data was collected on structured proforma and was analyzed using IBM SPSS version 23. Frequencies

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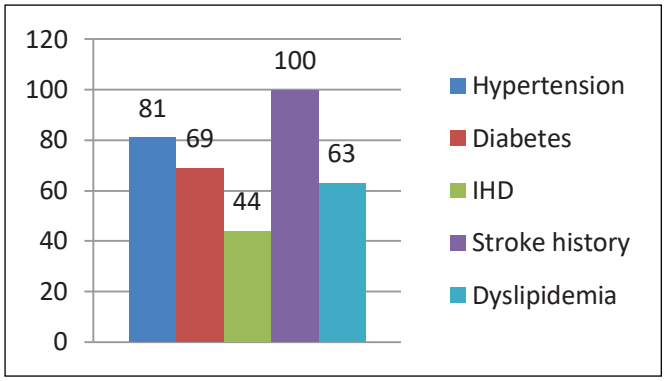
and percentages were computed for categorical variables. Diagnostic accuracy parameters including sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and overall diagnostic accuracy were computed.

RESULTS

Among the study population of 100, 96 patients were elderly, and 4 were young patients with a gender distribution of 68 males and 32 females.

Our population exhibited a frequency of various comorbidities, including stroke (100%), hypertension (81%), diabetes (69%), dyslipidemia (63%), and ischemic heart disease (44%) (**Fig. 1**).

Fig. (1): Bar chart showing the distribution of different co-morbidities including stroke, hypertension, diabetes, dyslipidemia, and ischemic heart disease among our population.



Doppler ultrasonography (USG) was utilized as a diagnostic modality to evaluate vascular diseases and showed encouraging performance in identifying non-calcified plaques. According to the performance metrics, there was an 86% overall diagnostic accuracy for non-calcified plaque detection, with a sensitivity of 88%, specificity of 84%, positive predictive value of 84.6%, negative predictive value of 87.5%, and overall diagnostic accuracy of 86% (**Fig. 2**).

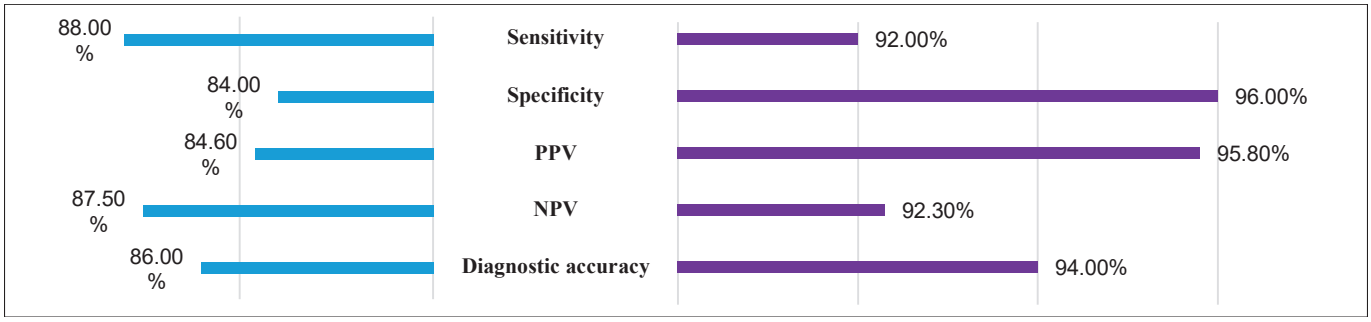
Conversely, the diagnostic assessment of calcified plaques by the use of USG Doppler demonstrated improved performance characteristics, registering 94% diagnostic accuracy, 92% sensitivity, 96% specificity, 95.8% positive predictive value, and 92.3% negative predictive value (**Fig. 2**).

These findings underscore the potential of USG Doppler as a reliable imaging modality for the assessment of vascular plaques, with particularly high accuracy rates observed for calcified plaques in this diverse patient population. The implications of these results advocate for the integration of USG Doppler in routine clinical practice for detecting vascular abnormalities, particularly in elderly patients with prevalent comorbid conditions.

DISCUSSION

A stroke, also known as a cerebrovascular accident, is caused by an abrupt stoppage of blood supply to the central nervous system, resulting in the rapid development of a "focal neurological deficit" (FND) that lasts longer than twenty-four hours. It is a significant contributor to both disability and death. 87% of strokes are ischemic, 10% are caused by intracerebral hemorrhage, and 3% are caused by aneurysmal subarachnoid hemorrhage, according to the etiology [8]. Atherosclerosis is the most frequent cause of ischemic stroke, leading to thrombosis and subsequent artery constriction or occlusion [9]. The bursting of these damaged arteries leads to hemorrhagic stroke [10]. Various neuroimaging techniques, each with pros and cons of their own, are helpful for imaging stroke patients. These include computed tomography (CT), magnetic resonance angiography, and ultrasound testing. With outstanding accuracy equivalent to angiography, Doppler ultrasonography is the most often used modality for the diagnosis of carotid artery stenosis [11]. Carotid ultrasonography is a commonly used screening tool for stroke patients. When compared to alternative neuroimaging techniques, ultrasonography is a quick, safe, affordable, and non-invasive bedside tool. It is commonly used to measure the blood flow velocity in the carotid arteries during a cardiac cycle [12, 13]. A significant cause of stroke and transient ischemic episodes is internal carotid artery stenosis.

Fig. (2): Shows comparison of sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy for calcified *versus* non-calcified plaques detected by ultrasound doppler against CT as gold standard.



Patients who had a lumen constriction of ≥70% in their internal carotid arteries showed significant improvement with endarterectomy. Nonetheless, the time and choice of patients have a significant impact on its efficacy.

As demonstrated by the NASCET study, the use of ultrasonography as a diagnostic tool for stenosis and its percentage has already been assessed. The 1993 study assessed the sensitivity, specificity, and predictive values for identifying 70% to 99% of stenosis using Doppler ultrasonography. Achieving an overall accuracy of 88% for the identification of stenosis from 70% to 99%, as well as sensitivity (91%), specificity (87%), positive predictive value (76%), negative predictive value (96%) and negative predictive value (96%) [14-16]. Our study is consistent with other published research, which has demonstrated that ultrasound is more sensitive and accurate than color Doppler in detecting plaque instability [17-19]. For example, Ten *et al*.'s study found that ultrasound had an 88% sensitivity and a 72% specificity in detecting plaque [20]. Overall, the use of Ultrasonography Doppler may represent a pragmatic approach in both the diagnosis and management of patients with significant cardiovascular risk profiles.

LIMITATIONS

Our study has certain limitations including its retrospective design, which may introduce selection bias as well as the operator dependency of Doppler ultrasound, potentially affecting result consistency. The non-probability sampling method and the single-center approach limit the generalizability of findings.

CONCLUSION

Our study demonstrates commendable sensitivity, specificity, and predictive values of doppler ultrasound for both non-calcified and calcified plaques. These findings underscore the utility of USG Doppler as a valuable diagnostic tool in the assessment of atherosclerotic plaques, offering promise for enhanced clinical management and risk stratification in a population with cost-effectiveness and reduced radiation exposure in varying cardiovascular risk factors and disease states.

FUTURE RESEACH DIRECTIONS

Future research should focus on enhancing the diagnostic accuracy of Doppler ultrasound through advanced imaging techniques and standardized protocols to minimize operator dependency. Furthermore, prospective studies evaluating long-term outcomes associated with Doppler ultrasound findings in diverse populations will be essential to validate its efficacy in various clinical scenarios.

DISCLOSURE

The part of this study was presented in Radiological Society of Pakistan 39th Annual Radiology Conference (2023) and previously published as abstract in the abstract book of PJR/RSP 2023 and available at: http://www.pakjr.com/ojs/index.php/PJR/article/view/1716

ETHICS APPROVAL

This study was approved by the institutional review board of the Shifa International Hospital, Islamabad, Pakistan (IRB# 0456-23). All procedures performed in studies involving human participants were following the ethical standards of the institutional and/ or national research committee and the Helsinki Declaration.

CONSENT FOR PUBLICATION

Not applicable.

AVAILABILITY OF DATA

From RIS Data Base (Radiology Data).

FUNDING

None.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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Declared none.

AUTHORS' CONTRIBUTION

Amna Mehboob: Idea, data collection and write up

Khurram Khaliq Bhinder: Write up and critical analysis

Kiran Ali Mian: Critical analysis

Qindeel Fatima: Data collection

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