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Carotid Artery Doppler Study in Patients Presenting with STEMI

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ABSTRACT

Carotid Artery Disease (Carotid CAD) is a significant risk factor for cardiovascular events, particularly in patients with ST-Elevation Myocardial Infarction (STEMI). Carotid artery stenosis (CAS) has been related to poor outcomes in STEMI patients, but limited data exist on the prevalence and severity of CAS in this population, especially in Pakistan. **Objectives:** To evaluate the presence, severity, and characteristics of Carotid CAD through Doppler ultrasonography in STEMI patients, and to assess the relationship between CAS and clinical outcomes such as hospital stay duration. **Methods:** A cross-sectional observational study was conducted at Hayatabad Medical Complex, Peshawar, from May 2025 to August 2025. A total of 172 patients with STEMI were assessed using a Mindray® DC 70 Colour Doppler Ultrasound Scanner. The severity of CAS was classified as mild, moderate, or severe based on Peak Systolic Velocity (PSV). **Results:** The study found that 48 (27.9%) patients had mild CAS, 86 (50%) had moderate stenosis, and 38 (22.1%) had severe stenosis. The mean PSV values were 95.3 cm/s (mild), 123.4 cm/s (moderate), and 142.8 cm/s (severe). Patients with severe stenosis had significantly longer hospital stays (mean 9.2 days) compared to mild (6.3 days) and moderate stenosis (7.5 days); the p-values obtained were 0.025 and 0.035, respectively. Hypertension showed a significant association with severe stenosis ($p = 0.016$). **Conclusions:** This research work highlights the high prevalence of CAD in STEMI individuals.

INTRODUCTION

Acute ST-Elevation Myocardial Infarction (STEMI) is a severe form of coronary artery disease (CAD) and a leading cause of mortality globally, including in Pakistan. The management of STEMI has significantly advanced with improvements in diagnostic imaging, particularly with the use of carotid artery Doppler ultrasonography. This technique gives helpful information about the atherosclerotic burden and cardiovascular risk in STEMI patients [1, 2]. Doppler ultrasound is an effective, non-invasive tool for detecting significant Carotid Artery Stenosis (CAS) in STEMI patients, allowing for the assessment of cardiovascular risks. Local studies conducted in Peshawar, Pakistan, have shown its effectiveness in screening for significant CAS, particularly in patients undergoing open-heart surgery, potentially helping to prevent strokes [3, 4]. Carotid Artery Disease (Carotid CAD) is a significant risk factor for cardiovascular events, especially in STEMI patients. Research indicates that the prevalence of clinically significant CAS increases with the extent of CAD, underscoring the importance of carotid screening in these patients [5]. The pathophysiology of STEMI often involves plaque rupture in the coronary arteries, which can also be reflected in the carotid arteries. Studies have shown a correlation between myocardial infarction and carotid atherosclerotic disease [6]. Doppler ultrasound also helps find carotid plaques, which are more common in people who have had heart disease in the past. This illustrates the importance of routine screening in high-risk individuals [7]. Recent studies have emphasised the prognostic value of

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haemodynamic parameters such as the pulsatility index and resistive index, which are associated with adverse outcomes in STEMI patients [8]. Birmpili et al. compared Doppler ultrasound with Computed Tomography Angiography (CTA) for grading carotid stenosis, finding that CTA has higher sensitivity for detecting significant CAS [9]. This study, conducted at a tertiary care centre in Peshawar, addresses the high prevalence of cardiovascular diseases in the region, compounded by risk factors such as diabetes, smoking, and hypertension [10]. Carotid Doppler ultrasonography is a non-invasive and accessible screening tool that could reduce the risk of future cardiovascular events through timely interventions [11]. It is hypothesized that STEMI patients have a high prevalence of CAS, and the severity of CAS is associated with longer hospital stays and a higher prevalence of hypertension. Doppler ultrasonography can be used effectively for early detection of Carotid CAD, which could help in improving patient outcomes by identifying those at greater risk for cardiovascular complications.

This study aimed to evaluate the presence, severity, and characteristics of carotid CAD in STEMI patients, aiming to improve patient outcomes by identifying those at risk for future cardiovascular events through early carotid artery assessments.

METHODS

This was a cross-sectional observational study conducted to evaluate Carotid CAD in patients presenting with STEMI. The study was carried out at the Department of Cardiology, Hayatabad Medical Complex, Peshawar, between May and August 2025. The study focused on a cohort of patients diagnosed with STEMI and admitted to the Department of Cardiology, following synopsis approval (No: 2317). The sampling technique employed was non-probability sampling, specifically a convenience sampling approach. Patients who met the inclusion criteria and presented with STEMI during the study period were selected for participation. The sample size was calculated to be 172, based on a reported prevalence of 12.8% of patients with significant CAS (PSV > 125 cm/s) as reported by Steinvil et al. [5]. Sample size calculation was performed using the WHO formula, assuming a 95% confidence interval and a margin of error of 5%. Individuals aged between 18 and 80 years who were diagnosed with STEMI, confirmed based on clinical history, electrocardiographic findings of ST-segment elevation, and elevated cardiac biomarkers. Both male and female patients who met these criteria were included in the study. Individuals with a history of prior carotid artery surgery or intervention, those with chronic kidney disease requiring dialysis, patients who had experienced acute neurological events such as stroke within the past 30 days, and patients who were either unwilling or unable to undergo carotid Doppler ultrasound were excluded from the study. The data collection process began with identifying patients diagnosed with STEMI in the Emergency and Cardiology Wards. Once the diagnosis was confirmed, the patients were approached for participation, and informed consent was obtained from each participant. Following consent, each patient underwent a carotid artery Doppler ultrasound examination using the Mindray® DC 70 Colour Doppler Ultrasound Scanner. The severity of CAS was classified based on Peak Systolic Velocity (PSV) measurements: Mild stenosis: PSV < 125 cm/s, Moderate stenosis: PSV between 125 cm/s and 150 cm/s, and Severe stenosis: PSV > 150 cm/s. This classification was based on established guidelines for evaluating carotid artery stenosis using Doppler ultrasonography. A structured proforma was used for data collection, which included fields for patient demographics, medical history, characteristics of STEMI, and results from the carotid Doppler examination. The proforma was completed by the attending radiologist or trained medical staff, ensuring that all relevant information was accurately documented. Data were analyzed using SPSS version 25.0. Descriptive statistics were used to summarize the data. Means and standard deviations (SD) were employed to describe quantitative variables such as age, body mass index (BMI), and hospital stay duration. Frequencies and percentages were used to describe categorical variables such as gender, smoking status, hypertension, diabetes, and the degree of CAS. To assess the association between various factors and carotid artery disease, stratification was performed by age, gender, BMI, hospital stay, smoking status, hypertension, and diabetes. Post-stratification chi-square tests were used to assess the statistical significance of these factors on carotid artery disease and STEMI outcomes. A p-value of less than 0.05 was considered statistically significant, indicating a meaningful association between the studied variables.

RESULTS

A total of 180 patients were initially screened for inclusion in the study. Out of these, 172 patients met the eligibility criteria and were included. Eight patients were excluded for the following reasons: five had a history of prior carotid artery surgery, two had acute neurological events within the last 30 days, and one patient declined the carotid Doppler ultrasound. The final sample consisted of 172 patients who all presented with STEMI and underwent carotid artery Doppler ultrasound. The mean age of the patients was 56.3 ± 12.4 years, with an age range of 18 to 80 years. Out of the total 172 patients, 108 (62.8%) were male, and 64 (37.2%) were female. The majority of patients (n = 120, 69.8%) had a BMI ≥ 25, classifying them as overweight or obese. Hypertension was present in 93 patients (54.1%),

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diabetes in 62 (36.0%), and 45 patients (26.2%) were current smokers (Table 1).

Table 1: Baseline Characteristics of Study Participants

Characteristics	Total (n= 172)	Male (n= 108)	Female (n= 64)	p-value
Age (Years)	56.3 ± 12.4	55.2 ± 11.9	58.1 ± 13.0	0.118
BMI (kg/m^2)	27.4 ± 4.5	27.8 ± 4.6	26.8 ± 4.3	0.202
Hypertension (%)	93 (54.1%)	62 (57.4%)	31 (48.4%)	0.178
Diabetes (%)	62 (36.0%)	41 (38.0%)	21 (32.8%)	0.471
Smoking (%)	45 (26.2%)	30 (27.8%)	15 (23.4%)	0.499

The severity of carotid artery stenosis (CAS) was determined based on Peak Systolic Velocity (PSV) measurements: Mild stenosis: PSV < 125 cm/s, Moderate stenosis: PSV between 125 cm/s and 150 cm/s, and Severe stenosis: PSV > 150 cm/s. Out of 172 patients, 48 (27.9%) had mild stenosis, 86 (50.0%) had moderate stenosis, and 38 (22.1%) had severe stenosis. The mean PSV for mild stenosis was 95.3 ± 13.2 cm/s, for moderate stenosis it was 123.4 ± 15.6 cm/s, and for severe stenosis it was 142.8 ± 18.3 cm/s. A significant positive correlation was found between increasing PSV values and the severity of stenosis ($p<0.001$). The hospital stay duration differed significantly between the severity groups. Patients with mild stenosis had an average stay of 6.3 ± 1.5 days, those with moderate stenosis had a mean stay of 7.5 ± 2.1 days, and patients with severe stenosis had the longest hospital stays at 9.2 ± 2.3 days. One-way ANOVA showed a statistically significant difference in hospital stay duration between the severity groups ($F = 7.13$, $p=0.024$). Post-hoc analysis indicated that patients with severe stenosis had significantly longer stays compared to those with mild ($p=0.025$) and moderate stenosis ($p=0.035$). Additionally, hypertension was significantly associated with the severity of carotid stenosis ($\chi^2 = 8.23$, $p=0.016$). A higher percentage of patients with severe stenosis had a history of hypertension (72.4%) compared to those with mild (51.2%) and moderate stenosis (58.1%) (Table 2).

Table 2: Hospital Stay Duration by Carotid Stenosis Severity

Carotid Stenosis Severity	Mean Hospital Stay (Days)	Hypertension (%)	p-value
Mild	6.3 ± 1.5	51.2%	0.024
Moderate	7.5 ± 2.1	58.1%	
Severe	9.2 ± 2.3	72.4%	

Pearson's correlation coefficient revealed a weak positive correlation between age and PSV ($r = 0.28$, $p = 0.001$), suggesting that older patients tend to have higher PSV values, which are associated with more severe carotid stenosis. The correlation between age and PSV was investigated because older age is known to increase the likelihood of atherosclerotic changes in the arteries, including the carotid arteries (Figure 1).

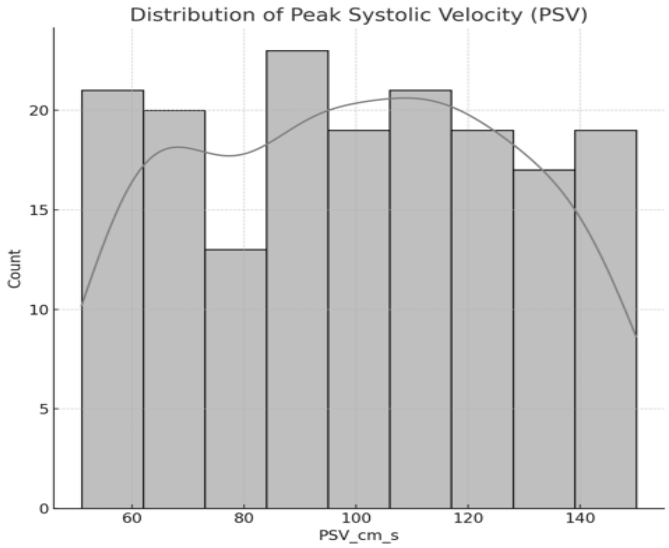

Figure 1: Histogram of PSV Distribution

Statistical analyses were conducted at a significance level of 0.05. Descriptive statistics were used for continuous variables, and chi-square tests for categorical variables. ANOVA assessed the relationship between hospital stay duration and stenosis severity, while Pearson's correlation coefficient evaluated the relationship between age and PSV. Additional analyses followed significant ANOVA results.

DISCUSSION

This study highlights the significant prevalence of CAS in STEMI patients. Among the 172 patients, 50% had moderate stenosis, and 22.1% had severe stenosis. The mean PSV values increased with stenosis severity, confirming the expected relationship between PSV and CAS. Additionally, severe stenosis was associated with longer hospital stays, with patients exhibiting severe stenosis requiring more extended hospitalization. Hypertension was identified as a key risk factor for severe stenosis, consistent with existing literature on hypertension and vascular diseases [1]. These findings suggest that early carotid CAD screening could improve patient management and clinical outcomes in STEMI patients. This study is one of the first to examine carotid CAD in STEMI patients in Pakistan, contributing valuable insights to the limited local data on this association. While similar global studies exist, this research's focus on the Pakistani population using carotid Doppler ultrasound for diagnosis sets it apart. International studies have documented the relationship between carotid CAD and coronary artery disease (CAD). For instance, studies have demonstrated the predictive value of carotid intima-media thickness and carotid plaques in STEMI patients, emphasizing the role of non-invasive markers like CIMT and carotid plaques in predicting STEMI risk [12]. The current

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study's findings, linking severe carotid stenosis with worse clinical outcomes, align with these findings. Furthermore, studies from Europe and other regions highlight the connection between diabetes and carotid CAD, which is similar to our study's findings. Diabetes is recognized for contributing to the progression of carotid atherosclerosis [13]. In Asia, studies have reported the high prevalence of carotid CAD in patients with metabolic syndrome, reinforcing the need for carotid screening in high-risk populations. Our study found a similar pattern, with a high prevalence of carotid CAD in patients with hypertension and obesity [14]. In Bangladesh, a high rate of carotid CAD in elderly patients undergoing coronary artery bypass grafting (CABG) emphasizes the importance of carotid screening for those with concurrent CAD [15]. In Europe, prospective studies have highlighted the predictive role of carotid plaques in ischemic stroke and vascular dementia, further supporting the relevance of carotid screening in patients with cardiovascular diseases [16]. Additionally, studies in the U.S. have emphasized the importance of screening and early intervention in asymptomatic patients with carotid CAD, particularly for managing long-term risks [17]. Current findings support this, as patients with mild to moderate stenosis were still at risk for prolonged hospitalizations and adverse outcomes. Research on carotid CAD and STEMI in Pakistan remains limited, with studies focusing more on carotid CAD in stroke patients [6]. Current study addresses this gap, providing insights into the impact of carotid CAD on STEMI patient outcomes in Pakistan. While research by Yaqoob *et al.* explored Doppler ultrasound for screening cardiac surgery patients for CAS [18]. No studies have yet specifically targeted STEMI patients, indicating the need for further research in this area. Current findings underscore the clinical importance of identifying severe carotid stenosis as a comorbidity in STEMI patients. The association between severe stenosis and prolonged hospital stays highlights the need for early detection and management [19, 20]. The strong link between hypertension and severe stenosis further emphasizes the necessity of comprehensive cardiovascular risk management in STEMI patients.

CONCLUSIONS

This study highlights the high prevalence of moderate to severe CAS in STEMI patients, with severe stenosis associated with longer hospital stays and a higher prevalence of hypertension. Early detection of carotid CAD using Doppler ultrasonography may aid in identifying patients at risk, potentially improving clinical management of STEMI patients with carotid artery disease.

Authors Contribution

Conceptualization: OK
Methodology: OK, TIK, CH, YA
Formal analysis: OK, TIK, CH
Writing review and editing: OK, TIK, CH, YA

All authors have read and agreed to the published version of the manuscript

Conflicts of Interest

All the authors declare no conflict of interest.

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