



## Original Article

## Carotid Artery Hemodynamics Among Diabetic and Hypertensive Patients

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## ABSTRACT

Carotid Doppler ultrasonography serves as a non-invasive gold standard technique/tool to access and monitor carotids hemodynamics and morphology. **Objective:** To find out the hemodynamics of carotid artery in diabetic and hypertensive patients. **Method:** Cross sectional study conducted at University Ultrasound Clinic Green Town. All patients were investigated with Toshiba Xario XG with 5-7.5MHz linear probe. Study included diabetic and hypertensive individuals, whereas patients with history of carotid endarterectomy, carotid stenting and co-morbidity were excluded. Total 200 participants were recruited, 41 were diabetic and hypertensive, while 159 were normal subjects. Statistical analysis was performed using SPSS version 21. **Results:** From 200 participants were recruited, out of them 41 patients with 20.5% were positive with diabetes and hypertension and 159 patients with 79.5% were negative with diabetes and hypertension. Right common carotid artery intima media thickness (IMT) mean  $\pm$  S.D was  $0.659 \pm 0.114$ mm with p-value (0.022). Left common carotid end diastolic velocity mean  $\pm$  S.D was  $16.719 \pm 6.303$ cm/s with p-value (0.002). **Conclusions:** Our findings revealed that common carotid artery IMT and EDV were significant in hypertensive and diabetic patients. Indeed, hypertension and diabetes are mainly associated with vascular complications.

## INTRODUCTION

Hypertension is a global issue. Overall, 80% of worldwide cardiovascular-related deaths occur in low to middle income countries. Whereas, it is predicted that non communicable forms of cardiovascular disease (CVD) will become the leading cause of death and disability, globally, by 2020 [1]. Prevalence of hypertension in Pakistan is 35.1% [2]. Hypertension is generally defined as the presence of a chronic elevation of arterial blood pressure above a certain threshold value, cutoff points in BP level of  $>140/90$  mm Hg [3]. Progression is strongly associated with range of conditions from hypertension to acute coronary

syndromes, stroke, and chronic heart failure. Hypertension is further divided into Stage 1, Stage 2, Stage 3 and Stage 4 [4]. Diabetes mellitus is a chronic, complex illness which requires continuous medical care. The American diabetes association has recommended three tests for the diagnosis of diabetes which includes FPG, 2-h PG, and HbA1c. Fasting plasma glucose test values of ( $\geq 7.0$  mmol/L)  $\geq 126$  mg/dL, 2-h PG value of  $\geq 200$  mg/dL (11.1 mmol/L), and A1C is 7.0% is indicative of diabetes—[5]. Diabetes is further divided into Type 1 diabetes, Type 2 diabetes, other specific types of diabetes due to other causes and Gestational

diabetes mellitus. Progression is highly associated with diabetic retinopathy, peripheral neuropathy, autonomic neuropathy, micro vascular complications and cardiovascular disease (CVD). Greyscale ultrasonography along with color flow Doppler imaging simultaneously provides a real time dramatic color portrayal of blood flow within the lumen of the vessel. While in addition, flow patterns are displayed with pulsed wave Doppler imaging and the local hemodynamic consequences of the vessel can be identified. Ultrasonography along with color and pulsed wave Doppler can show the segments of the common carotid artery, internal carotid artery and external carotid artery. The right carotid artery usually arises from the right brachiocephalic artery until there is a variation. However, the left common carotid artery arises from the aortic arch [8]. Blood flow velocities in Common carotid artery were computed as Peak systolic velocity (PSV) = 108.2 cm s<sup>-1</sup> and End diastolic velocity (EDV) = 19.4 cm s<sup>-1</sup> [9]. Common carotid arteries (CCA) bifurcates into internal carotid artery (ICA) and external carotid artery (ECA). ICA is located posterior and lateral to the ECA. ICA has a slightly larger lumen than ECA. The ECA has branches such as the lingual artery, but the ICA does not and the Doppler spectrums from the ICA show a lower resistance pattern [1]. This study is therefore an effort to check the difference in carotid artery hemodynamics in hypertensive and diabetic patients in comparison with normal subjects.

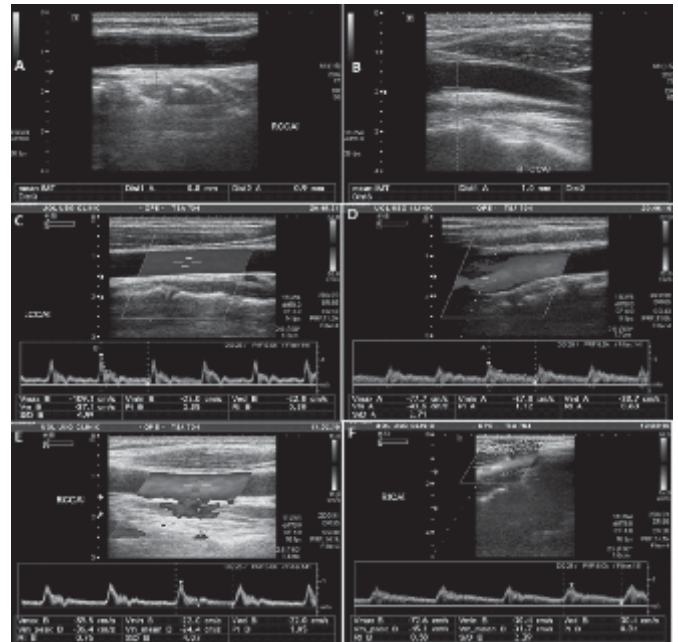
**Methods:**

Cross sectional study performed at University Ultrasound Clinic Green Town, Lahore, Pakistan. Total 200 participants were enrolled in this research voluntarily after written informed consent, 41 were diabetic and hypertensive, while 159 were normal subjects. Patients with history of carotid endarterectomy, carotid stenting and co-morbidity were excluded. The patients were examined with Toshiba XarioXG with 5-7.5MHz linear probe. Power Doppler, Color Doppler along with spectral Doppler were applied to determine about blood flow velocities, Insonation angle of <60° at the center of vessel where blood flow velocities are laminar. The examination was carried out following the protocol of AIUM vascular ultrasound practice guidelines [10,11]. Statistical analysis was performed using SPSS version 21.

**Results:**

Total 200 participants were recruited in study, out of them 41 patients with 20.5% were positive with diabetes and hypertension and 159 patients with 79.5% were negative with diabetes and hypertension, e.g (Table 1, Figure 1 A-F). Total 200 participants were recruited in this study, out of them 67 were male with 33.5% and 133 were female with 66.5%, e.g (Table 2). Right common carotid artery intima media thickness mean ± S.D was 0.659±0.114mm with p-

value (0.022). Left common carotid end diastolic velocity mean ± S.D was 16.719±6.303cm/s with p-value(0.002), (Table 3 and 4)



**Figure 1A:** Increased intima-media thickness (IMT) seen in right common carotid artery in patient of hypertension and diabetes **B:** Increased intima-media thickness (IMT) seen in right common carotid artery in patient of hypertension and diabetes **C:** Left common carotid artery, PSV: 109.8cm/s, EDV: 22.0cm/s, PI: 2.35, RI: 0.80 and S/D: 4.99 **D:** Left internal carotid artery, PSV: 77.7cm/s, EDV: 28.7cm/s, PI: 1.12, RI: 0.63 and S/D: 2.71 **E:** Right common carotid artery, PSV: 89.5cm/s, EDV: 22.0cm/s, PI: 1.85, RI: 0.75 and S/D: 4.07 **F:** Right internal carotid artery, PSV: 72.6cm/s, EDV: 30.4cm/s, PI: 0.94, RI: 0.58 and S/D: 2.39

Diabetes and Hypertension	Frequency	Percentage
Positive	41	20.5
Negative	159	79.5
Total	200	100.0

**Table 1:** Number of patients positive and negative with diabetes and hypertension

Gender	Frequency	Percentage
Male	67	33.5
Female	133	66.5
Total	200	100.0

**Table 2:** Number of male and female participants in study

Diabetes and Hypertension		N	Mean ± S.D	t-test	p-value
RTCCA IMT	Yes	41	0.659±0.114	2.315	0.022
	No	159	0.589±0.182		
RTCCA PSV	Yes	41	67.729±16.931	-1.482	0.140
	No	159	73.394±22.905		
RTCCA EDV	Yes	41	18.919±7.972	-0.546	0.586
	No	159	19.643±7.462		
RTCCA RI	Yes	41	0.707±0.127	-0.717	0.474
	No	159	0.719±0.087		
RTCCA PI	Yes	41	1.604±0.543	-0.132	0.895
	No	159	1.616±0.481		
RTCCA S/D	Yes	41	3.800±1.188	-0.193	0.847
	No	159	3.842±1.251		
RTICA PSV	Yes	41	67.141±18.398	0.402	0.688
	No	159	65.890±17.591		
RTICA EDV	Yes	41	23.324±8.878	0.128	0.899
	No	159	23.122±9.077		
RTICA RI	Yes	41	0.618±0.158	0.149	0.881
	No	159	0.614±0.133		
RTICA PI	Yes	41	1.270±0.559	0.234	0.816
	No	159	1.243±0.691		
RTICA S/D	Yes	41	3.047±1.290	0.793	0.428
	No	159	2.898±1.001		

**Table 3:** Carotid artery hemodynamics in hypertension

Diabetes and Hypertension		N	Mean ± S.D	t-test	p-value
LTCCA IMT	Yes	41	0.668±0.115	1.733	0.085
	No	159	0.608±0.214		
LTCCA PSV	Yes	41	68.990±15.475	-1.673	0.096
	No	159	74.547±19.747		
LTCCA EDV	Yes	41	16.719±6.303	-3.098	0.002
	No	159	20.478±7.074		
LTCCA RI	Yes	41	0.723±0.106	0.947	0.345
	No	159	0.707±0.092		
LTCCA PI	Yes	41	1.694±0.501	1.630	0.105
	No	159	1.563±0.444		
LTCCA S/D	Yes	41	4.025±1.293	1.373	0.171
	No	159	3.744±1.136		
LTICA PSV	Yes	41	67.441±19.072	-0.269	0.788
	No	159	68.396±20.529		

LTICA EDV	Yes	41	21.973±9.867	-1.238	0.217
	No	159	24.523±12.191		
LTICA RI	Yes	41	0.655±0.119	1.465	0.145
	No	159	0.618±0.150		
LTICA PI	Yes	41	1.387±0.632	1.148	0.252
	No	159	1.263±0.617		
LTICA S/D	Yes	41	3.623±2.434	1.831	0.069
	No	159	3.085±1.426		

**Table 4:** Carotid artery hemodynamics in diabetes  
Right common carotid artery intima media thickness mean ± S.D was 0.659±0.114mm with p-value (0.022). Left common carotid end diastolic velocity mean ± S.D was 16.719±6.303cm/s with p-value(0.002).

**DISCUSSION :**

Carotid artery ultrasonography remains a long-standing and reliable tool in the current armamentarium of diagnostic modalities used to assess vascular morbidity at an early stage [2]. Early ultrasonographic assessment of carotid artery among hypertensive and diabetic patients can indicate structural arterial wall abnormalities and hemodynamics. Study is suggesting, common carotid artery doppler ultrasound must be performed among hypertensive and diabetic individuals. A cross sectional study conducted by G, Mancia et al., indicated that hypertension can cause alterations in the arterial wall of common carotid artery [13]. Results of the current study were similar to the study described above. A study suggested that blood pressure fluctuations can cause structural changes in arterial wall (IMT) [14]. Findings of current research were found similar, as mean IMT was found significant among hypertensive and diabetic patients e.g. (Figure 1A,B), (Table 3,4). Evidence of the role of increased IMT in prediction of cardiovascular complications near future is seen in another study conducted in patients of hypertension [15]. Another study postulated that coexisting hypertension with diabetes has a profound effect on the carotid artery IMT [16]. Moreover, studies have shown that factors which contribute in distensibility of the vascular wall include diabetes [17,18] and hypertension [19]. The hallmark of our research, similar to other studies, was that increased IMT was seen among hypertensive and diabetic patients. Whereas, there are several studies which suggested same findings. Velocity measurements are global standardization of flow parameters. Study conducted by EM Rohren et al, concluded that carotid waveform and hemodynamics can disclose variety of abnormalities in patients [20]. Findings of current study were consistent with their results.

Common carotid artery examination should be recommended for all older and younger patients with diabetes and hypertension. A research conducted by H Chung et al., highlighted that among carotid Doppler parameters, common carotid artery end-diastolic velocity was the independent predictor for future cardiovascular events in hypertensive and diabetic subjects [22]. Agunloye AM et al., revealed that among hypertensive patients, the common carotid artery EDV are significantly associated with stroke risk [23]. The hallmark of this study, similar with both studies described above, was that end diastolic velocity in common carotid artery can be a predictor in hypertensive and diabetic patients for future complications e.g. (Figure1C-F)(Table 3,4) and so they can be prevented. DAM Al-Eqabi et al., have termed that common carotid artery EDV is more sensitive parameter to predict patient conditions in type 2 diabetes. Therefore, DAM Al-Eqabi exhorts that carotid artery hemodynamics can reflect arterial stiffness, atherosclerosis process, hemodynamic stress, and blood viscosity. Another study observed postulated carotid hemodynamic alterations as a useful marker to predict future complications in hypertensive individuals. End diastolic velocity (EDV) were significantly correlated with hypertension and tobacco smoking rather than diabetes. Findings of current study were inconsistent with their results, as our research concluded that end diastolic velocity (EDV) were significantly correlated with hypertension and diabetes.

## CONCLUSIONS :

The study highlighted that common carotid artery intima media thickness (IMT) and common carotid artery end diastolic velocity were significantly correlated with hypertension and diabetes. Our findings revealed that common carotid artery IMT and EDV were significant in hypertensive and diabetic patients. Indeed, hypertension and diabetes are mainly associated with vascular complications.

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