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# Ultrasound Findings of Carotid Arteries in Patients with Type-2 Diabetes Mellitus

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## Abstract

**Background and objectives:** Type 2 diabetes mellitus is common public health problem nationally and globally. Early detection of the vascular changes with inexpensive and non-invasive techniques is important in the process of management of type 2 diabetes mellitus.
The aim of this study was to determine the frequency and grading of carotid artery atherosclerosis using color doppler ultrasound in type 2 diabetes mellitus.

**Methods**: A cross-sectional study was implemented in Radiology Department of Rizgari Teaching Hospital in Hawler city-Kurdistan Region during the period of six months from 1st of March to 1st of September, 2022. Sixty cases of type 2 diabetic patients included in the study and referred from Layla Qasim diabetic center and Rizgari Hospital Outpatient. Left and right carotid arteries (common, internal and bulb) were examined by ultrasound and intima-media thickness were measured, plaque, stenosis and occlusion were looked for. Patients more than 18 years old with type 2 diabetes mellitus included in the study and patients with recent stroke, type 1 diabetes and history of neck surgery were excluded.

**Results**: The mean intima-media thickness of type 2 diabetic patients were higher in both right and left carotid artery bulb (65% and 73.3%) than common (6.7% and 21.7%) and internal carotid arteries (16.7% and 21.7%). The stenosis was observed in 21.7% in each right and left carotid bulb with less proportion of stenosis in common (0% and 1.7%) and internal carotid arteries (8.3% and 3.3%). There was a significant association between smoker and elderly age type 2 diabetic patients and carotid artery stenosis (p=0.03 and p=0.001 respectively).

**Conclusions:** Diabetes mellitus is a common cause of atherosclerotic changes in carotid arteries mainly in the bulb and more on left side. Smoking and elderly age are the common associated factors.

**Keywords:** Doppler ultrasonography, Kurdistan region, Stenosis, Type 2 diabetes mellitus

## Introduction

The type 2 diabetes mellitus (DM) is a chronic metabolic disorder represented a public health challenge all over the world.

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Type 2 DM is accompanied with high rates of morbidity and mortality that is commonly related to atherosclerotic complications.[1]

It was shown that elderly age, obesity, type 2 DM and hypertension are the main risk factors for development of future atherosclerotic disorders.[3] However, effects of these risk factors are different in regard to various population and ethnicity. Moreover, there is high evidence on different effects of hyperglycemic status with different outcomes on vascular changes leading to suggestion of genetic differences regarding the effect of DM on atherosclerosis.[4]

The vascular complications in type 2 DM are caused by changes in vessels wall attributed to dysfunctional endothelial and smooth muscle cells.[5] Development of advanced glycation end products is leading to reactive oxygen species, which in turn causing peroxidation of lipid and developing oxidized free fatty acids that are considered as the potential for endothelial dysfunction and atherosclerosis development.[6] Recently, the type 2 DM is categorized as the common contributor of coronary artery diseases.[7-9] Ultrasound examination is a non-invasive, inexpensive and valid imaging tool used for evaluation of intima-media thickness (IMT) of carotid artery.[10] On the other hand, the sophisticated cardiac imaging modalities are highly sensitive and specific than ultrasound in diagnosing cardiovascular diseases and checking their severity. However, these modalities could not be used as screening tools for cardiovascular changes due to their accompanied adverse effects, technical difficulty and high cost. That is why, using applicable, non-invasive and low cost techniques in screening of subclinical and silent atherosclerosis with acceptable prediction of changes are needed clinically.[11]

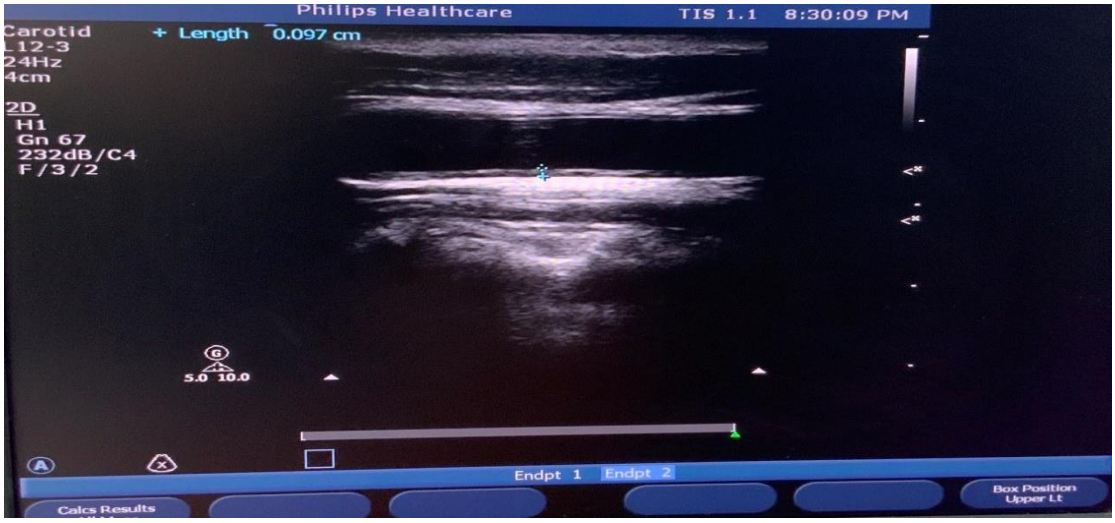
Type 2 DM is regarded as the common independent risk factor for developing stroke with incidence range of 37-42%, specifically in older age population.[2]

Carotid ultrasonography is considered as the common applicable inexpensive imaging tool in predicting atherosclerotic disorders and many literatures had shown that different ultrasound parameters of carotid artery like IMT, carotid plaque, plaque number and plaque area could be used as early markers of cardiovascular changes.[12] Examining the IMT with use of ultrasonography is essential in checking atherosclerotic lesions and cardiovascular diseases development especially in carotid and peripheral arteries.[13] Carotid IMT by ultrasonography is the distance between a double-line reflex pattern representing the luminal-intimal and the medial-adventitial interfaces corresponds well with IMT measured in histological specimens.[14] The intima-media thickness of carotid artery is regarded as predictive sign for early atherosclerotic changes and strong marker of cardiovascular diseases such as stroke and myocardial infarction.[15] This study conducted to evaluate the frequency and degree of atherosclerosis changes of carotid arteries in type 2 diabetic patients in our city and to find the significant risk factors and to compare it with other studies in the world.

## Patients and methods

A cross-sectional study implemented in Radiology Department of Rizgari Teaching Hospital in Hawler City-Kurdistan Region of Iraq during the period of six months from 1st of March, to 1st of September, 2022. The studied population was all type 2 diabetic patients referred to Radiology Department for Doppler ultrasonography examination (Figure 1 and 2). Inclusion criteria were adults (age≥ 18 years) with type 2 diabetes mellitus with at least one year of DM duration. Exclusion criteria were younger

age, type 1 diabetic patient, neck surgery, recent stroke or transient ischemic attack (within 6 weeks) and patients refused to participate. The study ethics were implemented in regard to Helsinki Declaration by approval of Ethical Committee of Kurdistan Higher Council of Medical Specialties (No.1138 in 5th June 2022), documented approval of health authorities and informed oral consent of enrolled patients. A convenient sample of sixty cases of type 2 diabetic patients was enrolled after eligibility to inclusion and exclusion criteria.




Figure( 1): Measurement of carotid intima media thickness.

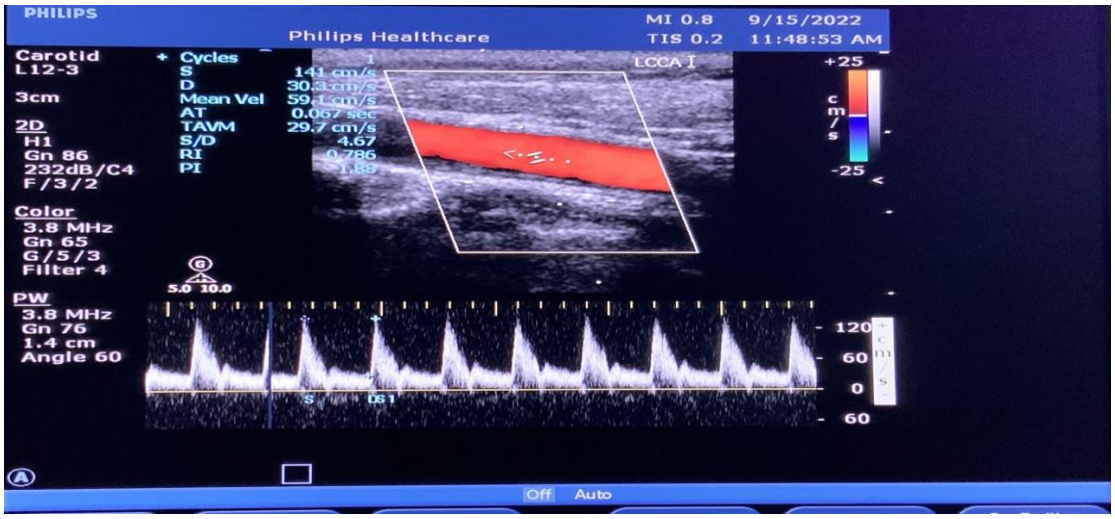



Figure (2): Doppler flow imaging and Spectral analysis of common carotid artery.

Information of type 2 diabetic patients about the age ,sex, smoking , family history , Hb1Ac level, hyperlipidemia ,alcohol intake and duration of the disease were collected by the researchers directly from the patients through a prepared questionnaire designed by the researchers according to previous literatures[3,10,13]. The decision of Doppler ultrasonography was taken randomly as patients referred to researcher mainly from Lailya Qasim diabetic center and from Rizgari Hospital Outpatient. Using a high

frequency linear probe of 7.5 MHz of ultrasound machine (Philips HD 11-EX, version 2010) and the sonographic examination of the common carotid artery, bulb and internal carotid arteries of type 2 diabetic patient was done. The examination included first the transverse scan of carotid artery from as low in the neck as possible to as high in the neck as possible behind the angle of the mandible. Using of gray scale ultrasound imaging, three measurements of IMT of carotid arteries were taken. IMT was measured at its thickest point on the far wall (distal wall=posterior wall) of CCA, bulb and ICA. In the presence of plaque, the maximum thickness of plaque was measured. The areas of abnormal flow by color Doppler ultrasound recognized, then spectral Doppler examination was undertaken, peak systolic velocity (PSV) and end diastolic velocity (EDV) measurements are taken from carotid arteries. Degree of stenosis was assessed by two types of data: first, Direct measurement of the diameter of stenosis and second, by area stenosis measured by cross sectional area of intra-stenotic color filled lumen (stenotic area) and it's relation to original vascular cross section.

The patient's data were entered and interpreted statistically by SPSS program-26. Suitable statistical tests (Fishers exact test) for data were implemented accordingly and p value of ≤0.05 was regarded significant.

## Results

60 patients with type 2 diabetes mellitus were included in the study. IMT of common carotid arteries, bulb and internal carotid arteries were measured, and if plaque present then it's characteristic described. Table (1) shows general characteristics of the patients included in the study.

**Table (1):** Distribution of general characteristics according to carotid artery stenosis.

| Variable | Carotid artery stenosis | | | | p value |
|---|---|---|---|---|---|
| | Yes | | No | | |
| | No. | % | No. | % | |
| Age | | | | | 0.001 S |
| <50 years | 1 | 5.3 | 7 | 17.1 | |
| 50-59 years | 5 | 26.3 | 24 | 58.5 | |
| 60-69 years | 4 | 21.1 | 8 | 19.5 | |
| ≥70 years | 9 | 47.4 | 2 | 4.9 | |
| Gender | | | | | 0.7 NS |
| Male | 6 | 31.6 | 15 | 36.6 | |
| Female | 13 | 68.4 | 26 | 63.4 | |
| DM duration | | | | | 0.9 NS |
| <10 years | 7 | 36.8 | 15 | 36.6 | |
| 10-20 years | 9 | 47.4 | 20 | 48.8 | |
| >20 years | 3 | 15.8 | 6 | 14.6 | |
| HbA1c level | | | | | 0.9 NS |
| Normal | 3 | 15.8 | 7 | 17.1 | |
| High | 16 | 84.2 | 34 | 82.9 | |
| HT | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| Yes | 14 | 73.7 | 26 | 63.4 | 0.43 NS |
| No | 5 | 26.3 | 15 | 36.6 | |
| Hyperlipidemia | | | | | 0.3 NS |
| Yes | 11 | 57.9 | 29 | 70.7 | |
| No | 8 | 42.1 | 12 | 29.3 | |
| Heart diseases | | | | | 0.5 NS |
| Yes | 5 | 26.3 | 8 | 19.5 | |
| No | 14 | 73.7 | 33 | 80.5 | |
| Smoking | | | | | 0.03 S |
| Yes | 6 | 31.6 | 4 | 9.8 | |
| No | 13 | 68.4 | 37 | 90.2 | |
| Alcohol consumption | | | | | 0.49 NS |
| Yes | 0 | - | 1 | 2.4 | |
| No | 19 | 100.0 | 40 | 97.6 | |
| Family history of DM | | | | | 0.17 NS |
| Yes | 14 | 73.7 | 36 | 87.8 | |
| No | 5 | 26.3 | 5 | 12.2 | |

*NS=Not significant, S=Significant.*

Results of the measurements demonstrates atherosclerotic changes were more in the bulb than the common and internal carotid arteries and more in left than the right. Table (2) explains the results of right side carotid artery and table 3 the findings of left carotid artery.

**Table (2):** Doppler ultrasonography findings of right sided carotid artery.

| Variable | No. | % |
|---|---|---|
| Right common carotid artery | | |
| IMT mean±SD (0.9±0.1 mm) | | |
| ≥1.1 mm | 4 | 6.7 |
| Plaque | 1 | 1.7 |
| Surface of plaque (Irregular) | 1 | 100.0 |
| Texture of plaque(Calcified) | 1 | 100.0 |
| Stenosis | 0 | 0 |
| Occlusion | 0 | 0 |
| | | |
| PSV mean±SD (82±17.1 cm/s) | | |
| EDV mean±SD (21±5.7 cm/s) | | |
| RI mean±SD (0.74±0.07) | | |
| Right carotid bulb | | |
| IMT mean±SD (1.5±0.7 mm) | | |
| ≥1.1 mm | 39 | 65.0 |
| Plaque | 21 | 35.0 |
| Surface of plaque | | |
| Smooth | 10 | 47.6 |
| Irregular | 11 | 52.4 |
| Texture of plaque | | |
| Hypoechoic | 7 | 33.3 |
| Hyperechoic | 3 | 14.3 |

| | | |
|---|---|---|
| Hetrogenous | 6 | 28.6 |
| Calcified | 5 | 23.8 |
| Stenosis | 13 | 21.7 |
| Diameter of stenosis (41.3±17.2 %) | | |
| Area of stenosis (42.8±17.6 %) | | |
| Occlusion | 0 | 0 |
| | | |
| Right internal carotid artery | | |
| IMT mean±SD (0.9±0.3 mm) | | |
| >1.1 mm | 10 | 16.7 |
| Plaque | 8 | 13.3 |
| Surface of plaque | | |
| Smooth | 5 | 62.5 |
| Irregular | 3 | 37.5 |
| Texture of plaque | | |
| Hypoechoic | 3 | 37.5 |
| Hyperechoic | 1 | 12.5 |
| Hetrogenous | 2 | 25.0 |
| Calcified | 2 | 25.0 |
| Stenosis | 5 | 8.3 |
| Diameter of stenosis (47.6±11 %) | | |
| Area of stenosis (46.6±11.3 %) | | |
| Occlusion | 0 | 0 |
| PSV mean±SD (84.32±35.2 cm/s) | | |
| EDV mean±SD (28±9 cm/s) | | |
| RI mean±SD (0.62±0.11) | | |
| Total | 60 | 100.0 |

There was a significant association between elderly age type 2 diabetic patients and carotid artery stenosis (p=0.001). No significant differences were observed between type 2 diabetic patients with or without carotid artery stenosis regarding gender, DM duration, HbA1c level, HT, hyperlipidemia, heart diseases, alcohol and family history of DM (p>0.05). A significant association was observed between smoking and carotid artery stenosis (p=0.03). (Table 3).

**Table (3):** Doppler ultrasonography findings of left sided carotid artery.

| Variable | No. | % |
|---|---|---|
| Left common carotid artery | | |
| IMT mean±SD (0.9±0.3 mm) | | |
| ≥1.1 mm | 13 | 21.7 |
| Plaque | 2 | 3.3 |
| Surface of plaque | | |
| Irregular | 2 | 100.0 |
| Texture of plaque | | |
| Hypoechoic | 1 | 50.0 |
| Calcified | 1 | 50.0 |

| | | |
|---|---|---|
| Stenosis | 1 | 1.7 |
| Occlusion | 0 | 0 |
| PSV mean±SD (87.5±22.5 cm/s) | | |
| EDV mean±SD (22.7±7.1 cm/s) | | |
| RI mean±SD (0.73±0.08) | | |
| Left carotid bulb | | |
| IMT mean±SD (1.4±0.5 mm) | | |
| ≥1.1 mm | 44 | 73.3 |
| Plaque | 23 | 38.3 |
| Surface of plaque | | |
| Smooth | 15 | 65.2 |
| Irregular | 8 | 34.8 |
| Texture of plaque | | |
| Hypoechoic | 8 | 34.8 |
| Hyperechoic | 2 | 8.7 |
| Hetrogenous | 5 | 21.7 |
| Calcified | 8 | 34.8 |
| Stenosis | 13 | 21.7 |
| Diameter of stenosis (35.3±18.7 %) | | |
| Area of stenosis (36.1±18.6 %) | | |
| Occlusion | 1 | 1.7 |
| IMT mean±SD (0.9±0.3 mm) | | |
| >1.1 mm | 13 | 21.7 |
| Plaque | 7 | 11.7 |
| | | |
| Surface of plaque | | |
| Smooth | 2 | 28.6 |
| Irregular | 5 | 71.4 |
| Texture of plaque | | |
| Hypoechoic | 1 | 14.3 |
| Hetrogenous | 1 | 14.3 |
| Calcified | 5 | 71.4 |
| Stenosis | 2 | 3.3 |
| Diameter of stenosis (29±7.1 %) | | |
| Area of stenosis (29±12.7 %) | | 1.7 |
| Occlusion | 1 | |
| PSV mean±SD (83±27.3 cm/s) | | |
| EDV mean±SD (32.5±13 cm/s) | | |
| RI mean±SD (0.6±0.1) | | |
| Total | 60 | 100.0 |

## Discussion

Present study showed that mean IMT of type 2 diabetic patients was higher in both right and left carotid artery bulb (65% and 73.3%) than common and internal carotid arteries with high mean IMT for left carotid artery than right carotid artery (65% vs. 73.3%). These findings are close to results of Polak and O'Leary`s study which stated that the doppler sonography of common carotid artery is predictive for atherosclerosis and the doppler sonography of carotid artery bulb and internal carotid artery are also strongly predictive for atherosclerosis.[16] In Iraq, a study conducted on 101 patients with type 2 diabetes mellitus reported that doppler ultrasonography of carotid artery IMT

is a prognostic for artery atherosclerosis.[17]

In current study, the stenosis was observed in 21.7% in each right and left carotid bulb of type 2 diabetic patients with less proportion of stenosis in common and internal carotid arteries. These findings are close to results of cross sectional study in Pakistan which revealed that 28.9% of type 2 diabetic patients had carotid artery stenosis detected by color doppler ultrasonography and the prevalence of stenosis was high in carotid artery bulb.[18] Generally, our study found that spectral doppler ultrasonography recognized right carotid artery stenosis in 18 type 2 diabetic patients and left carotid artery stenosis in 16 type 2 diabetic patients. These finding are lower than results of single center cross sectional study in Serbia which showed that about half of type 2 diabetic patients had stenosis of carotid arteries.[19] This difference might be due to discrepancy in risk factors for atherosclerosis between different communities in addition to differences in methodology and sample size between studies.

In present study, the plaques formation was correlated to IMT as it was commonly higher in both right and left carotid bulb (35% and 38.3%, respectively) of type 2 diabetic patients with less predominance in common and internal carotid arteries. These findings are nearly similar to results of Hussein study in Iraq that studied the doppler ultrasound use for diagnosis of preclinical atherosclerosis in carotid arteries.[20] Our study showed that means of PSV, EDV and RI of carotid arteries were decreased in type 2 diabetic patients. These findings are consistent with results by Adekoya et al who documented a significant reduction of flow velocities of doppler ultrasonography among patients with type 2 diabetes mellitus.[21]

The current study showed a significant association between elderly age type 2 diabetic patients and carotid artery stenosis (p=0.001). Consistently, Safri et found that older age patients with type 2 diabetes mellitus with long duration of DM are accompanied with high rates of carotid artery stenosis detected by doppler ultrasonography.[22]

Our study also showed a significant association between smoking and carotid artery stenosis (p=0.03). This finding coincides with results of Sultana and Islam cross sectional study in Bangladesh which reported that smoking accelerates the atherosclerosis changes and stenosis of carotid arteries of type 2 diabetes mellitus patients.[23]

In conclusion, duplex doppler ultrasonography is valid tool for screening and diagnosis of atherosclerotic changes and stenosis of carotid artery in type 2 diabetic patients. A high prevalence of intima-media thickening, stenosis and plaque formation is recorded in carotid artery bulb of type 2 diabetic patients. Elderly age and smoking are the common coexisting risk factors with type 2 diabetes mellitus for carotid artery stenosis. We recommended early and frequent screening of type 2 diabetic patients by use of duplex doppler ultrasonography of carotid arteries in order to detect the subclinical atherosclerosis.

**Conclusions:** Diabetes mellitus is a common cause of atherosclerotic changes in carotid arteries mainly in the bulb and more on left side. Smoking and elderly age are the common associated factors.

## Conflicts of interest:

None

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