

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

Shino Bahaadin Taha* Aska Faruq Jamal**

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.

* M.B.Ch.B, trainee at Kurdistan Board/Diagnostic Radiology-Rizgari Teaching Hospital in Hawler city-Kurdistan region/Iraq. * E-mail: shinobahadin@yahoo.com

**MBCbB, C.A.B.R., Consultant Radiologist-Rizgari Teaching Hospital-Hawler city-Kurdistan region/Iraq. Email: Aska_faruq@yahoo.com

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

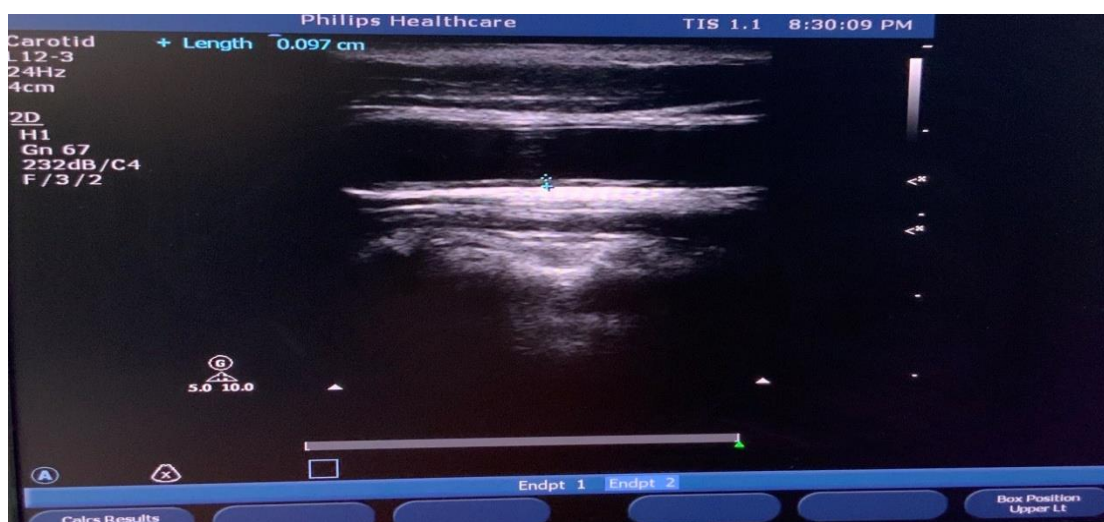
Carotid ultrasonography is considered as the common applicable inexpensive imaging tool in predicting atherosclerotic disorders and many literatures had shown that different ultrasound parameters of carotid artery like IMT, carotid plaque, plaque number and plaque area could be used as early markers 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 $\geq$ 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					



Ultrasound Findings of Carotid Arteries.....

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
Heterogenous	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
Heterogenous	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

Acknowledgment:



Gratitude and thanks for the staff of Radiology Department of Rizgari Teaching Hospital.

References:

- 1.Wang CCL, Hess CN, Hiatt WR, Goldfine AB. Atherosclerotic cardiovascular disease and heart failure in type 2 diabetes—mechanisms, management, and clinical considerations. *Circulation*. 2016;133(24):2459.
- 2.Kissela BM, Khoury J, Kleindorfer D, et al. Epidemiology of ischemic stroke in patients with diabetes: the greater Cincinnati/Northern Kentucky Stroke Study. *Diabetes Care*. 2005;28(2):355-9.
- 3.Carpenter M, Sinclair H, Kunadian V. Carotid intima media thickness and its utility as a predictor of cardiovascular disease: a review of evidence. *Cardiol Rev*. 2016;24(2):70-5.
- 4.Buse J. Type 2 Diabetes mellitus In: Larsen PR, Kronenberg HM, Melmed S, Polonsky KS, editors. *Williams textbook of endocrinology*. Philadelphia: WB Saunders Co; 2003.
- 5.Chaudhuri J, Bains Y, Guha S, et al. The role of advanced glycation end products in aging and metabolic diseases: bridging association and causality. *Cell Metab*. 2018;28(3):337-52.
- 6.Shah MS, Brownlee M. Molecular and cellular mechanisms of cardiovascular disorders in diabetes *Circ Res*. 2016;118(11):1808-29.
- 7.Vrsalovic M, Vucur K, Vrsalovic Presecki A, Fabijanic D, Milosevic M. Impact of diabetes on mortality in peripheral artery disease: a meta-analysis. *Clin Cardiol*. 2017;40(5):287-91.
- 8.Aronson D, Edelman ER. Coronary artery disease and diabetes mellitus. *Cardiol Clin*. 2014;32(3):439-55.
- 9.Hill MD. Stroke and diabetes mellitus. *Handb Clin Neurol*. 2014;126:167-74. doi: 10.1016/B978-0-444-53480-4.00012-6.
- 10.Naqvi TZ, Lee M-S. Carotid intima-media thickness and plaque in cardiovascular risk assessment. *JACC Cardiovasc Imaging*. 2014; 7(10):1025-38..
- 11.Katakami N, Matsuoka Ta, Shimomura I. Clinical utility of carotid ultrasonography: application for the management of patients with diabetes. *J Diabetes Investig*. 2019;10(4):883-98.
- 12.Stein JH, Korcarz CE, Hurst RT, et al. Use of carotid ultrasound to identify subclinical vascular disease and evaluate cardiovascular disease risk: a consensus statement from the American Society of Echocardiography Carotid Intima-Media Thickness Task Force endorsed by the Society for Vascular Medicine. *J Am Soc Echocardiogr*. 2008;21(2):93-111.
- 13.Wada S, Koga M, Toyoda K, et al. Japan Statin treatment against recurrent stroke (J-STARS) echo study collaborators. Factors associated with intima-media complex thickness of the common carotid artery in Japanese noncardioembolic Stroke patients with hyperlipidemia: the J-STARS echo study. *J Atheroscler Thromb*. 2018; 25:359-73.
- 14.Polak JF, Pencina MJ, Pencina KM, O'Donnell CJ, Wolf PA, D'Agostino Sr RB. Carotid-wall intima-media thickness and cardiovascular events. *N Engl J Med*. 2011;365(3):213-21.
- 15.Lorenz MW, Markus HS, Bots ML, Rosvall M, Sitzer M. Prediction of clinical cardiovascular events with



carotid intima-media thickness: a systematic review and meta-analysis. *Circulation*. 2007;115(4):459-67.

Mymensingh Med J. 2020;29(3):572-8.

16. Polak JF, O'Leary DH. Carotid intima-media thickness as surrogate for and predictor of CVD. *Glob Heart*. 2016;11(3):295-312. e3.

17. AL-Siaidy WF, AL-Sabbagh AA, AL-Karawi IN, Mohammed DA. Evaluation of Ankle-Brachial pressure index and carotid intima media thickness by doppler ultrasound in type two Diabetics. *J Fac Med Baghdad*. 2013;55(1):77-82.

18. Ali FS, Bader N, Zuberi BF, Banu S. Frequency of silent carotid artery stenosis in diabetics and its associated factors: An analysis in tertiary care hospital. *Pak J Med Sci*. 2020;36(6):1270.

19. Klimontov VV, Koroleva EA, Khapaev RS, Korbut AI, Lykov AP. Carotid artery disease in subjects with type 2 Diabetes: Risk factors and biomarkers. *J Clin Med*. 2021;11(1):72.

20. Hussein II. Does doppler ultrasonography of carotid arteries explore preclinical atherosclerosis. *Iraqi J Community Med*. 2011;24(3).

21. Adekoya AO, Olatunji AA, Akinola AR, Odunsan O, Adekoya AO, Olawale O. Carotid doppler ultrasonography in patients with Co-existing type 2 Diabetes mellitus and hypertension in Nigeria. *Annals of Health Research*. 2022;8(1):49-62.

22. Safri LS, Lip HTC, Saripan MI, et al. Older age and duration of exposure to type 2 diabetes in selective screening of asymptomatic carotid artery stenosis for primary stroke prevention—A single institution experience. *Prim Care Diabetes*. 2020;14(4):364-9.

23. Sultana N, Islam M. Doppler Evaluation of Carotid Vessels in Type 2 Diabetes.