

Impact of Glycemic Control on Vascular Parameters in Children With Type 1 Diabetes

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Abstract

Purpose: To evaluate the impact of glycemic control on carotid intima media thickness (CIMT) and carotid strain in children with type 1 diabetes (T1D) and to compare these vascular parameters between children with T1D and controls.

Patients and methods: The study was conducted in pediatric endocrinology outpatient clinics in El-Mounira children's hospital, Cairo University in the period between May 2024 till August 2025. The study included fifty patients diagnosed with T1D in addition to twenty-five age and sex matched controls. The patients with T1D were divided according to HBA1C into two groups: a well-controlled group with T1D (HBA1C 7 or less) and poorly controlled group with T1D (HBA1C more than 7). All patients underwent carotid doppler. Carotid intima media thickness and carotid strain were measured.

Results: There was statistically significant difference in CIMT and carotid strain between the group with T1D and control group. There was a significant correlation between HBA1C and carotid intima media thickness. There was a significant negative correlation between duration of diabetes and carotid strain.

Conclusion: Carotid doppler is recommended for predicting early vascular changes in children with type 1 diabetes.

Key words: Type 1 diabetes, glycemic control, carotid intima thickness, carotid strain, carotid doppler.

Introduction

Type 1 diabetes is an autoimmune disease that results in the destruction of pancreatic islet β -cells, leading to metabolic failure requiring lifelong insulin treatment. T1D occurs in individuals with a genetic predisposition, in whom disease onset and progression is triggered by environmental or immunological events. In 2021, there were an estimated 8.4 million people worldwide with T1D, with around 510,000 new cases diagnosed in that year (1).

Individuals with T1D are at risk of acute complications (e.g., severe hypoglycemia, diabetic ketoacidosis) and chronic complications, including both macrovascular and microvascular diseases, and may experience a shorter life expectancy than the U.S. general population (2).

Children with T1D have an almost threefold higher mortality rate compared to the general population which is mainly attributed to early development of cardiovascular disease (CVD). The relative risk of experiencing a coronary heart disease event is respectively 5- and tenfold in men and women with T1D already by an age below 40 years (3).

In children, arterial alterations occur with increased intima-media thickness as well as vascular diameter enlargement. Both conditions correlate with higher cardiovascular risk, and both the array and proportion of these alterations are important hemodynamic parameters (4).

Carotid intima media thickness (CIMT), a surrogate marker of atherosclerosis, predicts cardiovascular events, particularly myocardial infarction, and stroke. CIMT can be measured using ultrasound of the two innermost layers of the carotid artery wall, tunica intima and tunica media. Ultrasound of the CIMT provides an easy, reproducible non-invasive tool to assess the risk of CVD. It can be measured by a trained technician with a mobile ultrasound device in an outpatient setting (5).

Young adults with T1D present with differences in arterial thickness and stiffness when compared with controls. The use of novel high-resolution ultrasound measures describes important relationships between early structural and vascular pathophysiologic changes and are promising tools to evaluate pre-clinical CVD risk in youth with T1D (6).

The previously done studies evaluating carotid intima media thickness and carotid strain in children with T1D have small sample size. More studies are needed to assess these vascular parameters in children with T1D.

Patients and methods

Patients:

Fifty children diagnosed with T1D were recruited from pediatric endocrinology outpatient clinics in El-Mounira children hospital, Cairo University in the period between May 2024 till August 2025. In addition, twenty-five age and sex matched controls were enrolled in this study.

Inclusion criteria:

Children with T1D aged 4 years to 13 years old.

Exclusion criteria:

Presence of any other systemic chronic disease.

Ethical considerations:

The study conformed to the ethical committee rules and was approved by the pediatric department. Informed consent was obtained from the parents.

Funding:

The authors received no financial support for the research, authorship and publication of this article.

Methods:

All patients in the study were subjected to the following:

- Full medical history: Onset of diabetes, attendance and compliance with diabetes education sessions, nutrition regimen either fixed meals or carbohydrate counting, monitoring of glycemic control and daily practice of exercise.
- Clinical examination:
 - Anthropometric measures: body weight and height.
 - Complete examination including cardiovascular, respiratory, abdominal, and neurological examination.
- Investigations:
 - Laboratory: HBA1c, lipid profile.
 - Carotid doppler.

Carotid doppler protocol:

Carotid intima media thickness (CIMT) measurements were recorded using high resolution, non-invasive, semi-automated B-Mode ultrasound with a high frequency linear array probe (5-13MHz). The CIMT was measured on the far wall of the common carotid artery, 1 cm proximal to the bulb at the end- diastolic moment (R-wave), when CIMT is the thickest.

In our study, we measured the systolic diameter (SD) and diastolic diameter (DD) for both common carotid arteries (CCA) from the B/M-mode sonographic registrations among 75 subjects. The derived carotid distensibility (CD) metric (carotid strain) was calculated.

Carotid sonography was performed on a GE LOGIQ 700 system (GE Healthcare, Milwaukee, WI) with a multifrequency 5- to 13-MHz linear array transducer with the subject in a supine position with the neck in hyperextension. Both common carotid arteries were imaged in transverse (short axis) and longitudinal planes using standardized carotid sonographic scanning and reading protocols.

Patients were divided according to HBA1C into two groups: a well-controlled group with T1D (HBA1C 7 or less) and poorly controlled group with T1D (HBA1C more than 7).

Statistical analysis:

Data were statistically described in terms of mean $\pm$ standard deviation ($\pm$ SD), median and range, or frequencies (number of cases) and percentages when appropriate. Numerical data were tested for the normal assumption using Kolmogorov Smirnov test. Comparison of numerical variables between the study groups was done using Student t test for independent samples in comparing normally distributed data or large enough samples, and Mann Whitney U test for independent samples for comparing not-normal data. For comparing categorical data, Chi-square (χ^2) test was performed. Exact test was used instead when the expected frequency is less than 5. Correlation between various variables was done using Pearson moment correlation equation for linear relation of normally distributed variables and Spearman rank correlation equation for non-normal variables/non-linear monotonic relation. Two-sided p values less than 0.05 was considered statistically significant. IBM SPSS (Statistical Package for the Social Science; IBM Corp, Armonk, NY, USA) release 22 for Microsoft Windows was used for all statistical analyses.

Results

During 15 months of study; from May 2024 to August 2025, fifty patients with T1D were enrolled in our study. In addition, twenty-five age and sex matched controls were included (table:1).

Table (1): Categorization of cases and controls

	Group with T1D	Control group	Total
Number of cases	50	25	75
Percentage	66.7%	33.3%	100%

Patients were divided according to HBA1C into two groups: a well-controlled group with T1D (HBA1C 7 or less) and poorly controlled group with T1D (HBA1C more than 7) (table:2).

Table (2): Classification of group with T1D according to HBA1C.

	Well-controlled group with T1D	Poorly controlled group with T1D	Total
Number of cases	21	29	50
Percentage	42%	58%	100%

Demographic data of patients and controls:

When we compared the different demographic data of group with T1D and control group, we found that there was no statistically significant difference in the sex, age, weight and height and they were well matched in both groups (table:3).

Table (3): Demographic data of patients and controls.

	Group with T1D 50 (100%)	Control group 25 (100%)	P value
Gender @			0.317
Male	18 (36%)	12 (48%)	
Female	32 (64%)	13 (52%)	
Age#	9.36 ±2.414	9.00 ±2.398	0.544
Weight standard deviation#	0.172 ±0.8013	0.060 ±0.7309	0.559
Height standard deviation#	0.182 ±0.7300	0.004 ±0.6535	0.307

@Case presented as number and percentage.

#Case presented as mean ± standard deviation.

History taking data of patients:

There was a significant difference in the number of educational sessions attended last year, diabetic ketoacidosis (DKA) attacks last year, and fast food consumed per week between the well-controlled and poorly controlled group with T1D

No significant difference was found in the number of exercise sessions per week, medical advice per year and fruits and vegetables per day (table:4)

Table (4): Comparison of history taking data of patients

	Well controlled group with T1D 21 (42%)	Poorly controlled group with T1D 29 (58%)	P value
Educational sessions attended last year “	7 (5-9)	2 (1-3)	0.016 *
Exercise per week “	2 (1-3)	2 (0-4)	0.854
DKA attacks last year “	1 (0-2)	5 (3-7)	0.017 *
Medical advice last year “	2 (1-3)	1 (0-2)	0.633

Fast food per week “	1 (0-2)	4 (1-5)	0.002 *
Fruits and vegetables per day “	2.5 (1-4)	2 (1-3)	0.366

“Case presented as median (minimum- maximum).

* Significant statistical difference.

DKA: Diabetic ketoacidosis

Clinical data of patients:

No significant difference was found in the duration of diabetes and number of areas of injection between the well-controlled and poorly controlled group with T1D.

There was a significant difference in the insulin dose, carbohydrate counting and the abnormal areas of injection (lipohypertrophy) between the well-controlled and poorly controlled group with T1D (table:5).

Table (5): Comparison of clinical data of patients

	Well controlled group with T1D 21 (42%)	Poorly controlled group with T1D 29 (58%)	P value
Duration of diabetes #	3.538 ±1.6732	3.990 ±1.5405	0.33
Insulin dose #	0.424 ±0.2300	1.131 ±0.2929	0.001*
Number of areas of injection #	2.05 ±0.805	1.93 ±0.753	0.600
Abnormal areas of injection (lipohypertrophy)@	3 (14%)	22 (76%)	0.001 *
Carb counting @	15 (71%)	6 (20%)	0.001 *

@Case presented as number and percentage.

#Case presented as mean ± standard deviation.

* Significant statistical difference.

Laboratory data of patients:

No significant difference was found in the lipid profile between the well-controlled and poorly controlled group with T1D.

There was a significant statistical difference in HBA1C between the well-controlled and poorly controlled group T1D (table:6).

Table (6): Comparison of laboratory data of patients

	Well controlled group with T1D 21 (42%)	Poorly controlled group with T1D 29 (58%)	P value
Elevated lipid profile @	1 (4.8%)	4 (13.8%)	0.383
HBA1C #	6.857 ±0.1568	9.414 ±0.8021	0.0001 *

@Case presented as number and percentage.

#Case presented as mean ±standard deviation.

*Significant statistical difference.

Radiological data of patients and controls:

There was statistically significant difference in CIMT, systolic carotid diameter and carotid strain between the group with T1D and control groups while there was no statistically significant difference in the diastolic carotid diameter (table:7).

Table (7): Radiological data of patients and controls

	Group with T1D 50 (66.7%)	Control group 25 (33.3%)	P value
CIMT #	0.4490 ±0.03808	0.3560 ±0.02500	0.0001 *
Systolic carotid diameter #	5.559 ±0.5208	4.161 ±0.4828	0.0001 *
Diastolic carotid diameter #	5.5052 ±0.60721	5.5028 ±0.44604	0.991
Carotid strain #	0.2038 ±0.054131	0.302 ±0.11225	0.0001 *

#Case presented as mean ±standard deviation.

* Significant statistical difference.

CIMT: carotid intima media thickness

Correlation analysis:

There was a significant positive correlation between HBA1C and carotid intima media thickness and between HBA1C and diastolic carotid diameter. There was a significant negative correlation between duration of diabetes and carotid strain. So, with longer duration of diabetes, there is more decrease in carotid strain (table:8).

Table (8): Correlation between duration of diabetes, HBA1C and vascular parameters

	Duration of diabetes	HBA1C
CIMT \$	r = 0.185 (p=0.2)	r = 0.279 (p=0.050)
Systolic carotid diameter \$	r = -0.069 (p=0.634)	r = 0.219 (p=0.13)
Diastolic carotid diameter \$	r = -0.038 (p=0.793)	r = 0.320 (p=0.023)
Carotid strain \$	r = -0.452 (p=0.001)	r = -0.237 (p=0.097)

\$Case presented as correlation coefficient and P value

Values highlighted indicate significant correlation

CIMT: carotid intima media thickness

Discussion

Type 1 diabetes is regarded as the most chronic autoimmune disease affecting children and adolescents that results from a destruction of pancreatic β -cell and leads to insulin insufficiency and persistent hyperglycemia (7). Long-term complications of T1D, encompassing microvascular (diabetic nephropathy, retinopathy, and neuropathy) and macrovascular diseases, often manifest in adulthood and are associated with significant morbidity and mortality (8).

T1D increases the risk of CVD and individuals with T1D have a sixfold increased risk of stroke compared to non-diabetic individuals. CIMT, a surrogate marker of atherosclerosis, predicts cardiovascular events, particularly myocardial infarction, and stroke. Ultrasound of the CIMT provides an easy, reproducible non-invasive tool to assess the risk of CVD (9).

The aim of this study is to evaluate the impact of glycemic control on CIMT and carotid strain in children with T1D and to compare these vascular parameters between children with T1D and controls.

The study was conducted in pediatric endocrinology outpatient clinics in El-Mounira children hospital, Cairo University in the period between May 2024 till August 2025.

The study included fifty patients diagnosed with T1D in addition to twenty-five age and sex matched controls. The patients with T1D were divided according to HbA1C into two groups: a well-controlled group with T1D (HbA1C 7 or less) and poorly controlled group with T1D (HbA1C more than 7).

Our study showed that there was no statistically significant difference in the sex, age, weight and height between the group with T1D and control group. Similarly, (10) studied a group of 42 patients with T1D and 42 healthy control individuals who were matched for age and sex. Patients with T1D showed higher values of body mass index in comparison with control group, however, no significant difference in age, sex, height and weight was observed between the two groups.

In this study, there was a significant difference in the number of DKA attacks last year between the well-controlled and poorly controlled groups with T1D. In a study of (11), DKA was more prevalent in patients with poorly controlled DM. The HbA1C of more than 10% contributed to a four times greater risk of DKA.

Our study revealed the importance of carbohydrate counting and attendance of educational sessions as there was a significant difference in the number of educational sessions attended last year and carbohydrate counting between the well-controlled and poorly controlled groups with T1D. (12) studied a group of eighty-five patients with T1D evaluating the effect of carbohydrate counting on HbA1C. Their study showed that applying carb counting and subsequent insulin dosage adjustment improved HbA1C.

Concerning lifestyle, our study showed that no significant difference was found in the number of exercise sessions per week, medical advice per year and fruits and vegetables per day between the well-controlled and poorly controlled groups with T1D while there was a significant difference in the number of fast foods consumed per week. This is unlike the results reported by (13) and (14). They showed that exercise is a strong predictor of reduction in HbA1C. (15) reported that there is inverse association between HbA1C and daily fiber intake in patients with T1D.

(16) evaluated insulin injection technique for 301 patients with T1D. There was a significant negative correlation between insulin injection score with fasting blood sugar, two-hour postprandial glucose and HbA1C. (17) studied a group of 847 patients taking insulin for at least 6 months. It was found that patients with lipohypertrophy had higher HbA1c. Higher duration of insulin use (≥ 5 years), reusing needles more often (> 10 times), and injecting at angles other than 90 degrees were independent predictors of lipohypertrophy. In our study, no significant difference was found in the duration of diabetes and number of areas of injection between the well-controlled and poorly controlled groups with T1D. There was a significant difference in the insulin dose and the abnormal areas of injection (lipohypertrophy) between the well-controlled and poorly controlled groups with T1D.

(18) stated that the patients with HbA1C $> 7.0\%$ had significantly higher values of fasting blood glucose, total cholesterol and triglycerides as compared to the patients with HbA1C $\leq 7.0\%$. This is unlike results of our study that stated that no significant difference was found in the lipid profile between the well-controlled and poorly controlled groups with T1D.

This study showed that there was statistically significant difference in CIMT between the group with T1D and control group. Similarly, (19) studied a group of 39 patients with T1D and 25 age and sex matched controls. All participants underwent carotid doppler and carotid intima media thickness was measured. They found that in T1D group, CIMT was significantly increased as compared to controls (0.435 ± 0.06 mm vs 0.379 ± 0.06 mm respectively).

(20) tracked 129 patients with T1D for up to 19 years and analyzed data on HbA1C and indicators related to the severity of diabetic complications (estimated glomerular filtration rate [eGFR], urinary albumin excretion rate [UAE], CIMT). Although the HbA1c and UAE levels improved over time, the eGFR and CIMT worsened.

In the study of (21), patients and healthy controls underwent ultrasound vascular study to measure CIMT. TIR was collected by a continuous glucose monitoring system for 2 weeks, 3 months, and 6 months before the vascular study. Patients with T1D showed a significantly higher CIMT compared with control subjects. No significant relationship between CIMT and TIR collected in the short and long term emerged. This finding doesn't correlate with (22) which revealed that higher TIR was associated with reduced risk of albuminuria, retinopathy, cardiovascular disease mortality, and abnormal carotid intima-media thickness.

In our study, there was a significant correlation between HbA1C and CIMT. In a study of (23) HbA1C data were collected retrospectively over the course of ten years ($HbA_{1c} - \text{mean}_{\text{overall}}$) prior to the clinical study visit that included a clinical examination, biochemical sampling, and ultrasound of the common carotid arteries. There was no correlation between long-term glucose control (HbA1C) and CIMT.

Our study showed that there was a significant statistical difference in carotid strain between the group with T1D and control group. Besides, our study showed that there was a significant negative correlation between duration of diabetes and carotid strain. So, with longer duration of diabetes, there is more decrease in carotid strain. Like our results, (24) stated that there was significant difference in carotid strain between cases and controls. (25) enrolled 30 T1D patients and 30 age- and sex-matched control participants. The population of all study underwent carotid ultrasonography and carotid strain was calculated. No statistically significant difference was found in strain parameter between the cases and controls ($p > 0.05$).

In comparison with the previously published studies, our study has the advantage of having higher sample size while lack of follow up for long period is short coming in our study. It is expected that the results of this study will help in predicting vascular risks for patients with T1D.

Summary and recommendations

Sonographic evaluation of CIMT is a simple, noninvasive, widely available and reproducible imaging parameter. CIMT is an early marker of atherosclerosis, independent predictor of cardiovascular and cerebrovascular disease and used for effectiveness of medical therapies in treating atherosclerosis. DM is considered a disease which accelerates atherosclerotic changes. CIMT is considered to correlate well with the duration of diabetes and various parameters associated with it (26).

The aim of this study is to evaluate the impact of glycemic control on CIMT and carotid strain in children with type 1 diabetes and to compare these vascular parameters between children with type 1 diabetes and controls. The study was conducted in pediatric endocrinology outpatient clinics in El-Mounira children hospital, Cairo University in the period between May 2023 till August 2024.

The study included fifty patients diagnosed with T1D in addition to twenty-five age and sex matched controls. The patients with T1D were divided according to HBA1C into two groups: a well-controlled group with T1D (HBA1C 7 or less) and poorly controlled group with T1D.

All patients were subjected to full history taking, thorough clinical examination, laboratory and radiological investigations including carotid doppler.

When we compared the different demographic data of group with T1D and control group, we found that there was no statistically significant difference in the sex, age, weight and height and they were well matched in both groups.

There was a significant difference in the number of educational sessions attended last year, DKA attacks last year, and fast food consumed per week between the well-controlled and poorly controlled groups with T1D.

No significant difference was found in the number of exercise sessions per week, medical advice per year and fruits and vegetables per day between the well-controlled and poorly controlled groups with T1D.

No significant difference was found in the duration of diabetes and number of areas of injection between the well-controlled and poorly controlled groups with T1D.

There was a significant difference in the insulin dose, carbohydrate counting and the abnormal areas of injection (lipohypertrophy) between the well-controlled and poorly controlled groups with T1D.

No significant difference was found in the lipid profile between the well-controlled and poorly controlled groups with T1D.

There was a significant statistical difference in HBA1C between the well-controlled and poorly controlled groups with T1D.

There was statistically significant difference in CIMT and carotid strain between the group with T1D and control group.

There was a significant correlation between HBA1C and carotid intima media thickness and between HBA1C and diastolic carotid diameter. There was a significant negative correlation between duration of diabetes and carotid strain.

To conclude, carotid doppler is an effective, easy, and noninvasive method for evaluating arterial elasticity. It may provide an early assessment of atherosclerosis in patients with T1D.

Finally, we recommend using carotid doppler in children with T1D for early detection of vascular changes. In addition, long-term follow-up of patients with T1D is recommended for screening vascular changes.

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