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Original Article

Resistive index is an early indicator for flow deterioration in comparison with intima media thickness for patients with hypertension and diabetes in relation to age

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ABSTRACT

Background: Atherosclerosis is well known related to age and certain cardiovascular diseases. Aging is one reason of arteries function deterioration which can cause loss of compliance and plaque accumulation, this effect increases by the presence of certain diseases such as hypertension and diabetes disease.

Aim: To investigate the reduction of blood supply to the brain in patients with diabetes and hypertension with age and the role of resistive index in the diagnosis of reduced blood flow.

Method: Patients with both diseases diabetic and hypertension were classified according to their age to identify the progression of the disease and factors influencing the carotid artery blood flow. By using ultrasound and standard Doppler techniques, the following parameters were measured, lumen Diameter (D), Intima – media thickness (IMT), peak systolic velocity (PSV), end diastolic velocity (EDV), Pulsatility Index (PI), Resistive Index (RI), velocity gradient, and the flow rate.

Results: Results show that a small insignificant increase in the lumen diameter (3.49%), (p value > 0.05) between the old age group and the younger group (35- 55) and (56-75) year old. A significant increase in the intima-media (IMT) thickness, end diastolic velocity (EDV) and RI between both age groups was (33.78%), (-31.76%) and (10%) respectively with significant (p value <0.05). A large reduction for old age group in peek systolic velocity (PSV) (-19.71%), Pressure gradient (-31.11%) and flow rate (-20.91%) with (p>0.05) but all were statistically close to significance.

Conclusion: The increased thickness in IMT did not influence the lumen diameter significantly. RI has the prime effect in the reduction of the blood flow which influenced blood supply to the brain and can indicate the effectiveness of intima media thickness on flow impairment. The changes in PSV, EDV, RI, and PI are also related with reduced compliance.

Key words: Carotid artery atherosclerosis, brain perfusion, intima media and resistive index.

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INTRODUCTION

Many reports appeared in the literature regarding the influence of aging on the arteries can increase the arthrosclerosis and stiffness of the arteries[1]. Hypertension and diabetes have also been reported to induce atherosclerosis and stiffness either each disease alone[2,3] or both occur at the same time[4]. The occurrence of diabetes and hypertension can have more deleterious effect on arteries in old age in particular[5]. These effects can be clearly observed on the major arteries[6]. It has also been reported that diabetes has deleterious effect on capillaries[7]. One very important large artery is the carotid artery as it conveys the blood to the face and more importantly the brain. The thickening of these arteries can influence the blood flow towards the brain and in severe cases may cause brain ischemia or even stroke[8].

The effect of aging on arteries walls can reduce the muscles tone in addition to the atherosclerosis, which in turn, reduce distensibility[9] and has an important influence on the flow of the blood such as (velocity, pulsitility) in other words, if the artery is flexible, (good compliance) it can be stretched and relaxed according the blood pressure inside the artery making it pulsating which can influence the values of peak systolic and end-diastolic velocity[10], on the other hand the increase in the thickness of intima media can change not only the peak systolic and end diastolic velocities but it can induce many other changes such as velocity gradient and resistive index which can have an eventual effect on the blood flow and brain perfusion. In the younger people their arteries are more flexible with higher compliance than the elderly for these reasons our patients were separated into two groups according to their age to investigate the change in blood flow.

The developments of ultrasonography and Doppler have enabled us to measure the intima media thickness, and the blood flow noninvasively. In the present work we have investigated the blood flow characteristic for two age groups patients (middle age 35-55 and elderly 56-75 year old). The investigation included the Intima-media thickness, volume flow rate, resistive index, pulsatility index, peak systolic and end diastolic velocities and pressure gradient.

PATIENTS AND METHODS

The study included 25 patients with hypertension and type 2 diabetes Mellitus (14 females and 11 males, their age range between 35 to 75 year old with mean age of 56.92± 9.79 years), they have been divided into two groups at the age of 55 year old the younger group 10 patients, age range was 35-55 year old mean was 48 ±76 and the older group 15 patients age range 56-75 with mean of 62.73±6.29, to investigate the effect of IMT and RI change on blood PSV and volume flow rate.

The study was conducted in compliance to the medical ethics rules and all participants have given their consent. The study was carried out during the period between October 2017 and May 2018, at National Diabetic center/ AL-Mustansyriah University. The Ultrasound and Doppler machine used in this work was Fukuda Denshi (UF-750XT) with a linear probe (FUT-LD 386-9A) at 6–9MHz. All patients examined by performing chest X ray, ECG examination and tests for liver and kidney functions, patients selected free from any diseases except from diabetes and hypertension. The selection for diabetic patients was carried out on the bases of Fasting Blood Sugar (FBS), so that the Fasting Glucose value ≥110 mg/dl, and /or HbA1c ≥ 7.6%, and for hypertensive patients of blood pressure more than 90/140 mm Hg were included in the study (Table 1).

Patients were advised to lie down on the couch of examination in supine position and extended his/ her neck, putting pillow under the

Table 1. Clinical characteristics of patients

	Mean ±SD The age range (35-55) years	Mean ±SD The age range (56-75) years
Age, years	48 ± 7.65	62.73 ±6.29
Duration of disease (years)	DM 9.2 ± 7.06 HT 4.2 ± 2.09	DM 12.73 ± 6.90 HT 13.86 ± 7.08
BMI (kg/m^2)	26.89 ± 1.94	28.400 ± 3.62
FBS (mg/dl)	204.7 ± 124.96	177.8 ± 83.88
HbA1c (%)	9.13 ± 2.85	8.25 ± 1.59
S. Cholesterol (mg/dl)	211.3 ± 56.06	142.13 ± 30.86
S. Triglycerides (mg/dl)	174.9 ± 75.61	98.06 ±36.58
Smokers, n (%)	-	-

neck, to extend full- length of the common and internal carotid artery. The transducer was placed at the lateral side of the neck where the maximum lumen diameter appeared and the typical double lines of the artery could be seen, Figure 1.

The (IMT) was identified on ultrasound by the presence of the double lines pattern consisting of two parallel echogenic interfaces in the far wall of the common carotid arteries with the first one between the blood and the tunica intima and the other between the tunica media and the tunica adventitia.

The peak systolic velocity (PSV) and end diastolic velocities (EDV) were measured in both the distal internal carotid artery (ICA) at the location where the highest PSV is seen, as the PSV may vary along the length of CCA artery

The IMT measurement of the CCA should be made 2 cm before the bifurcation at a point where the vessel still has a uniform diameter, before its widening towards the bifurcation[11].

Pulsatility index (PI) and resistive index (RI) were measured and recorded.

The average volume flow rate was calculated as

(Lumen cross section area) χ (The average velocity).

The average velocity was obtained from the pulsating index as,

Average velocity = (PSV-EDV) / PI

Statistical analysis

Results were analyzed using Microsoft Office Excel 2007, and were expressed as mean ± standard deviation and percentages. Test for significance was carried out using unpaired t-test and p value <0.05 was considered significant.

RESULTS

Table 2 shows the change between parameters for the two age groups 56-75 year for old and young age group 35-55 year old for left common carotid and internal carotid arteries.

There was insignificant change in lumen diameter between the two age groups (3.49%), p value > 0.05, While the change in (IMT) between both age groups was (33.78%) with significant p-value. The change in (PSV) was (-19.71%) with p value >0.05. On the other hand, the (EDV) change for younger and old group (-31.76%) with significant p-value. The change in (RI) between the two age groups was (10%), and in (PI) was (20.42%), both were significant, p value < 0.05.

The change in the pressure gradient between both age groups were (-31.11%) and in the flow rate, was (-20.91%), both were insignificant, p value > 0.05.

DISCUSSION

Results show changes in the parameters between old age and younger patients. The intima media is significantly thicker in the old age group for LCCA by (33.78%), but the increase in the thickness of intima media did not reduce the lumen diameter significantly, but increased slightly no more than (3.49%) in spite of the large significant change in the IMT thickness, and this is caused by the increase in the artery wall[12]. The very small change in the lumen can be originated from the lack of compliance and elasticity[13], caused by aging and by the effect diseases such as diabetes and/or hypertension[14,15], in addition to other important factors including possible endothelial dysfunction[16], and a decrease in muscle tone with age, which can include the arteries muscles consequently contributes to the reduction of compliance[17].

The very small insignificant change in the lumen diameter in LCCA between the two age groups with a large change in the PSV indicates that the slower velocity may not relate only to the change in the LCCA intima media thickness (as it did not reduce the lumen diameter) but also to the increased artery stiffness influencing PI consequently the flow, and RI which can be more effective as it is linked with the increase in the flow resistance originated from the capillary bed. The increase in the IMT thickness can be an indicator for the smaller vessels plaque buildup with a consequent increase in the resistive index.

Results show that there is an interplay between IMT and the resistive index Figure 2, as it is higher in the old age group than younger group by 10% this index is an indicator of an increased resistance in the distal vessels i.e. capillary bed[18].

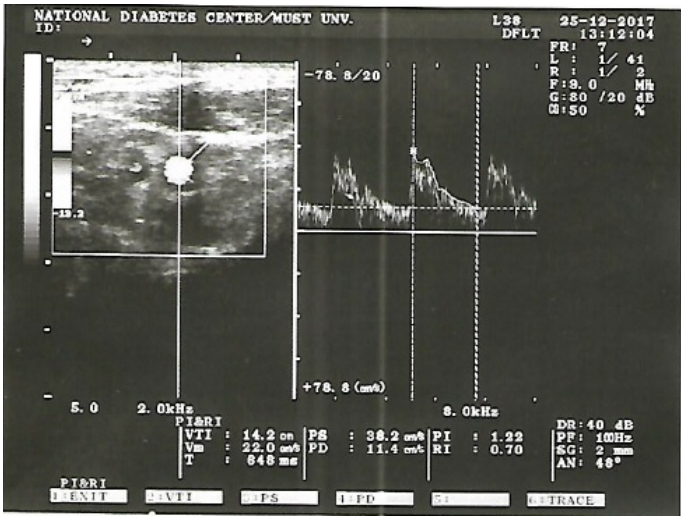

Figure 1. Doppler ultrasound, B-mode image shows the peak systolic velocity and end diastolic velocity and data for other parameters.

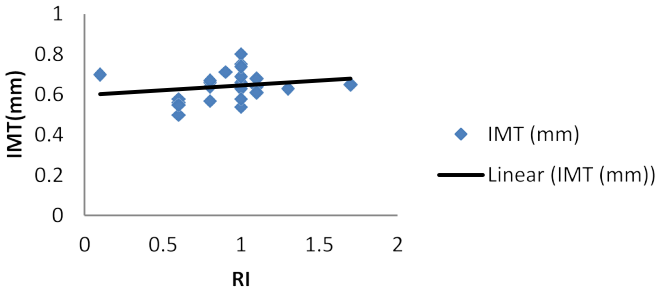

Figure 2. Relationship between Resistive Index (RI), and Intima – media thickness (IMT) in diabetic and hypertension patients.

Table 2. The measured parameters for the left common & internal carotid arteries for two age groups using Doppler and B-mode

Parameter	(DM+HT) Patients (LCCA) Mean ±SD		Change % = (old-young / young) x 100	p-value
	Age range (35-55) years	Age range (56-75) years		
IMT (mm)	0.74 ± 0.32	0.99 ± 0.240	33.78%	<0.05
lumen D(mm)	5.44 ± 0.84	5.63 ± 0.98	3.49%	>0.05
		LICA		
PSV (cm/s)	49.15 ± 22.39	39.46 ±7.93	-19.71%	>0.05
EDV (cm/s)	18.89 ± 7.970	12.89 ± 3.477	-31.76%	<0.05
RI	0.6± 0.065	0.66±0.067	10%	<0.05
PI	1.038 ± 0.229	1.287±0.339	20.42%	<0.05
Pressure gradient (mmHg)	0.9±0.625	0.62±0.26	-31.11%	>0.05
Volume Flow rate (cm^3/sec)	7.03±4.44	5.56±3.27	-20.91%	>0.05

As the lumen diameter is still almost the same with large increase in IMT thickness and the resistive index is significantly increased then the later may be an indicator for blood flow deterioration which may cause brain ischemia or stroke[19]. One benefit of the resistive index is to give an indication of how far the effect of the IMT thickening affecting the blood flow as reflected on the capillary bed resistance.

The pulsating blood velocity appears on the pulsatility index which is higher in the older group by 20.42%. The increased pulsatility index may also be attributed to the less arteries compliance or less distensiblity in the older group leading to blood flow with less change in the lumen size during peak systole while for better compliance arteries as in the younger group can absorb part of the systolic pressure impact (windkessel effect)[20] leading to less variation in the velocity of the blood flow pulses.

Because the blood is impeded through the capillary bed (as seen on the increase in the resistive index) the PSV reduced consequently the volume flow rate is also reduced.

Factors influencing the CA may be summarized as follows

1- by aging the arteries become stiffer or less compliant leading to less distensibility this in addition to the increase of atherosclerosis with age[21].

2- hypertension also increases atherosclerosis and stiffness[22].

3- Diabetes also increases atherosclerosis and stiffness[23].

The concomitant effect of these three factors can induce cardiac overload[24] as well as increasing not only the risk of ischemia but also increasing the risk of brain stroke[25] and heart attack[26]. These effects can be seen in our results the reduction of blood volume flow rate from 7.03 cm^3/s for the younger group down to 5.56 cm^3/s for the elderly group.

Although results for (flow rate, PSV, pressure gradient) are insignificant but the percentage change was close to significance, this is due to the large variation between patients measured parameters giving large standard deviation which needs higher number of patients to show clear significance.

CONCLUSION

1. The resistive index can be an indicator for atherosclerosis role in the impairment of blood vessels function via blood flow deterioration detected by RI and not by the increase in IMT only in other words it can show the extent IMT effect to materialize in blood flow.
2. The intima media is significantly thicker for the old age group patients than in the younger group, but the lumen diameter did not change significantly, for this reason the reduction in the volume flow rate and PSV in the elderly group is primarily related to the increase in the resistance of capillary bed as appeared on RI.
3. A significant change in parameters EDV, RI, and PI between the two age groups were observed and a clear change in PSV, pressure gradient and volume flow rate, these changes have influenced the blood perfusion to the brain.

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Conflicts of interest

There are no conflicts of interest.

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