

Arterial stiffness index as a marker for the occurrence of atherosclerotic cardiovascular disease

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Abstract:

Background: Arterial functional changes reflected by vascular stiffness might occur at early stages of cardiovascular disease before the morphological alterations reflected by increasing the intima media thickness and it is widely used as a very sensitive indicator of functional vascular damage.

Objectives: This study is aimed to correlate ultrasound detected vascular functional changes with the severity and extent of coronary artery disease.

Patients and methods: Sonographic scans were performed on 100 Patients (61males, 39 females) with an age range of (40-65years) for measuring carotid and brachial arteries end diastolic and end systolic diameters to calculate vascular stiffness index . Coronary CT angiography has been used to visualize the atherosclerotic plaque to define the degree of luminal stenosis by creation of high-quality images which are obtained by the multislice CT spiral scanners.

Results: A positive statistical correlation was observed between the stiffness index of both carotid and brachial arteries in single coronary lesion (SCL), multiple coronary lesion (MCL) and control groups in addition to the significant positive correlation between both arteries stiffness index with the percentage of coronary artery stenosis in SCL group. Significant difference between the arterial stiffness index among the study groups is only noticed for carotid artery between the control and MCL groups ($p < 0.05$).

Conclusion: Conduit arterial stiffness index is a good indicator of the severity and extent of coronary artery disease.

Keywords: arterial stiffness index, coronary artery disease.

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Introduction:

Although the increase in arterial intima media thickness (IMT) reflects morphological alterations of the vascular wall, functional changes might occur at an even earlier stage of cardiovascular disease as the case in carotid artery stiffness which is widely used as a very sensitive indicator of functional vascular damage (1).

As the changes in arterial stiffness can be detected even before the appearance of clinically apparent cardiovascular disease, this modulus is regarded either as a marker for the development of future atherosclerotic disease, or it may be more directly involved in the pathological process of atherosclerosis (1). Arterial stiffness indicates the diminished capability of an artery for expansion and contraction in response to the applied pressure changes. The arterial stiffness as one of the terms used for describing

arterial wall properties is usually not homogenous along the arterial tree. Arterial stiffness can be measured locally by the stiffness index β which is the most suitable to determine local arterial stiffness. It can provide important physiological information and are regarded as more sensitive and quantitative than systemic indices (2).

The vascular wall compliance depends mainly on the relative composition of its two scaffolding, structural proteins; collagen and elastin. The relative amount of these two molecules is normally kept stable and relatively constant by a dynamic process of production and degradation. Imbalance which is mainly evoked by the stimulation of an inflammatory process, leads to overproduction of abnormal stiff collagen and diminished amounts of normal elastic elastin, which contribute to the development of vascular stiffness. These molecular changes are subsequently manifested as a doubling to tripling of IMT usually in ages of 20 to 90 years, as well as the involvement of vascular smooth muscle layer by hypertrophy (3).

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Patients and methods:

This observational study was carried out in the Radiology Department at Al-Yarmook Teaching Hospital, Baghdad, Iraq from October 2013 till March 2015). 100 Participants (61males, 39 females) with an age range of (40-65years) were involved in this study. After a 15-minutes rest in a supine position, the systolic blood pressure (SBP) and diastolic blood pressure (DBP) were measured in the right upper arm using a standard mercury sphygmomanometer. Sonography was performed after blood pressure measurements using a high resolution, multi-frequency (3- 12-MHz) linear array ultrasound doppler probe equipped with HD11XE machine (Philips) with an attached electrocardiograph. The end-diastolic and end-systolic lumen diameters for the right common carotid artery at the R- and T-waves of the concomitant electrocardiogram respectively, were imaged and measured 1-2 cm proximal to the bulb (4). Anterolateral approach was used where the transducer was positioned parallel to the anterior border of the sternocleidomastoid muscle (5).

The mean values of three lumen diameter measurements were considered. The same measures were applied on the right brachial artery 5 cm proximal to the antecubital crease of the supinated and abducted right arm.

Subsequently, the strain was calculated as the difference between the carotid lumen systolic (CSD) and diastolic diameter (CDD) divided by the carotid lumen diastolic diameter. Accordingly, the stiffness index of common carotid artery (β CCA) was calculated by the formula: β CCA = \ln (SBP/DBP)/ [(CSD – CDD)/CDD] (6, 7). Where \ln is the natural logarithm. The same formula was used to measure brachial artery stiffness index.

In addition, each patient was submitted to Coronary CT angiography using of 64 slice type (Philips, Holland, 2010) to visualize coronary arteries with the use of IV contrast agent; iodine.

Maximum percent luminal stenosis was measured as: $100 \times \left\{ \frac{\text{the diameter of residual patent lumen}}{\text{the diameter of the normal adjacent vessels}} \right\}$.

In this study, the data were analyzed using Microsoft Excel 2010. P –value <0.05 was considered to be statistically significant. For comparison between three variables, GraphPad Instat program version 3.06 was used. If the data of the three variables passed the normality test for Gaussian distribution, then One-way Analysis of Variance (ANOVA) followed by Tukey-Kramer Multiple Comparisons Test were used to compare between variables. If the data of the three variables did not pass the normality test for Gaussian distribution, then Kruskal-Wallis Test (Nonparametric ANOVA) followed by Dunn Multiple Comparisons Test

were used to compare between variables.. Pearson’s correlation analysis was used to assess the possible relationships between study parameters.

Results

According to coronary CT angiography, the patients are categorized into three groups:

Group I: represents Single Coronary Lesion (SCL) group with involvement of one coronary artery branch. This group consists of (51) patients, 30 (58%) male and 21(42%) females with a mean age of (52±6.1) years.

Group II: represents Multiple Coronary Lesion (MCL) groups with involvement of more than one coronary artery branch. This group consists of (18) patients, 16 (88%) males and 2 (12%) females with a mean age of (51±9.3) years.

Group III: considered as control group, they are without coronary arteries lesion. This group consists of (31) subjects (15males and 16 females) with a mean age of (50.9±8.3) years.

While a positive statistical correlation is found between the stiffness index of carotid and brachial arteries of SCL , MCL and control groups (figure 1), a significant positive statistical correlation was found between the carotid artery SI, brachial artery SI with the percentage of coronary artery stenosis in SCL group (figure 2).

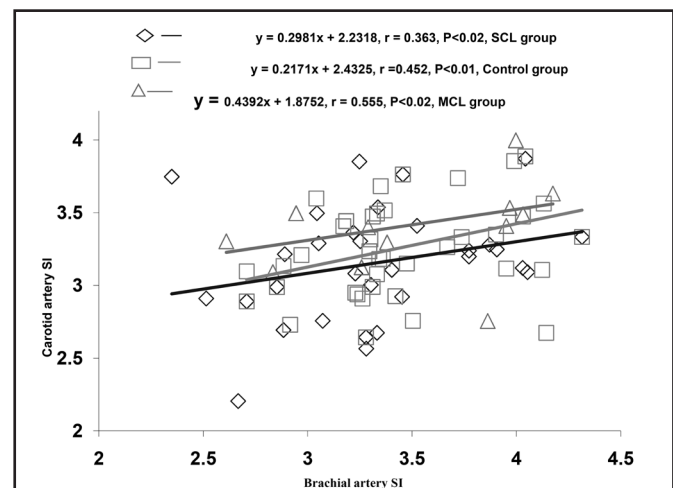


Figure 1: Correlation between stiffness index (SI) of brachial and carotid arteries in control group (n=31), SCL group (n=51), and MCL (n=18).

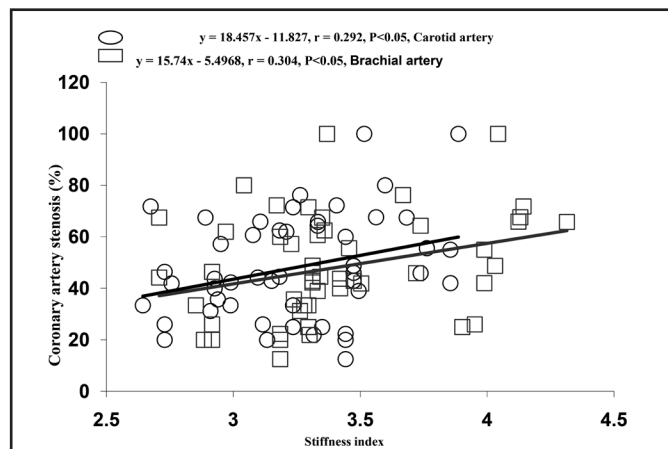


Figure 2: Correlation between carotid and brachial arteries stiffness index and the percentage of coronary stenosis in SCL group (n=51).

There are no significant differences between the arterial stiffness index of carotid and brachial arteries among the studied groups as compared with the significant difference regarding the carotid stiffness index between the control and MCL groups ($p < 0.05$) (Table 1).

Table 1: arterial stiffness index among the studied groups

Variable	SCL group (n=51) a	MCL group (n=18) B	Control group (n=31)C	P a vs b	P a vs c	P b vs c
Brachial SI	3.4±0.4	3.5±0.5	3.3±0.5	NS	NS	NS
Carotid SI	3.2±0.3	3.4±0.4	3.2±0.4	NS	NS	<0.05

Discussion:

To address a question of whether atherosclerosis is a generalized pathological phenomenon affecting all blood vessels or is an isolated one, arterial stiffness index (SI) of the brachial and the carotid arteries measurements are performed. Arterial stiffness (reduced arterial compliance) is a marker of endothelial dysfunction that precedes overt atherosclerosis and is regarded as an important cardiovascular risk factor (8). However, arterial stiffness occurs as a consequence of biological aging, endothelial dysfunction and arteriosclerosis (9).

In the current study, a direct association between carotid and brachial arteries stiffness index and structural changes reflected by coronary atherosclerosis has been reported. The processes underlying the association between arterial stiffness and cardiovascular disease including coronary atherosclerosis may be explained by the effects of adverse haemodynamic consequences of increased stiffness (10). In stiff arteries, blood flow becomes increasingly turbulent, static and even reversed rather than being of a normal laminar flow pattern causing an altered shear stress patterns which causes endothelial dysfunction since structure and function of the endothelium are modulated by hemodynamic forces. As a consequence, impaired NO synthesis, upregulation of pro-inflammatory and pro-atherogenic factors, increased oxidative stress and vasoconstriction will be the outcome (11, 12). The study data were in agreement with previous studies conducted by Giannattasio et al(12), 2007 who proved that vascular distensibility including that of the

carotid artery, are considered as a marker of the severity of coronary atherosclerosis and Alan et al ., 2003 (14) who revealed that stiffness index β is a measure of carotid arterial stiffness and is associated with coronary atherosclerosis. The current data showed that there was a statistical significant correlation between brachial and carotid arteries stiffness index among the studied groups which may be because both are conduit arteries and behave in a same manner. In coronary lesion groups, the conduit arteries with impaired endothelial function are prone to increase in vascular smooth muscle tone and subsequent increased stiffness due to the associated structural changes manifested by elastin fragmentation , degradation and replacement by much stiffer collagen. Furthermore, both proteins become stiffer as a result of cross-linking of peptide chains and calcification (15).

As shown in (table 1), there was no significant difference between the calculated stiffness index of both control with SCL groups and between the coronary lesion groups themselves since the measured blood pressures of these groups patients were within the normal physiological range. The study results showed an agreement with O'Rourke,et al ,2002(16) who suggested that the stiffness of arteries increases in parallel with increase in arterial blood pressure, as a higher distending pressure leads to recruitment of more inelastic collagen fibers. On the other hand, a statistical significant difference was observed between the carotid rather than brachial artery SI of the control group with the patients with multiple coronary vessel atheromas.

These findings are in the same line with a study conducted by Simova et al., 2006(17) which concluded that arterial stiffness indices are clinically acceptable when performed on the common carotid artery. While when these indices are measured on the brachial artery, they showed a high interobserver variability which makes the measure of common carotid artery more suitable and accurate (18).

Conclusion:

Carotid and brachial arterial stiffness measurement can serve as a functional marker for the severity of coronary artery atherosclerotic stenosis. While carotid artery stiffness index is regarded as a marker for the extent of coronary artery disease.

Author's contribution

Study conception and design: Dr Najeeb Hassan Mohammed.

Acquisition of data: Dr. Saba Fawzi Salih, Dr.Sarab Hilal
Analysis and interpretation: Dr. Saba Fawzi Salih, Dr Najeeb Hassan Mohammed.

Drafting of manuscript: Dr. Saba Fawzi Salih, Dr Najeeb Hassan Mohammed.

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