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## Clinical Image

# The Relation between the New Clinical Parameter “Oscillatory Gap” and Carotid Intima Media Thickness as a Marker for Atherosclerosis

## Abstract

**Introduction:** Carotid intima media thickness (CIMT) is an early ultrasonographic marker of atherosclerosis. A new clinical marker “oscillatory gap” (OG) was found to increase with advanced atherosclerosis.

**Aim:** We aim to find a relationship between this clinical marker, OG, and a known ultrasonographic marker of atherosclerosis as CIMT.

**Patients and Methods:** Patients who underwent ultrasonographic assessment of CIMT in our center due to different indications were enrolled. The blood pressure (BP) of all cases was measured. The oscillatory systolic BP (OSBP) was defined as the point at which the mercury starts to oscillate. The auscultatory systolic BP (AUSBP) was defined as first Korotkoff sound. The difference between OSBP and AUSBP was calculated for OG. The correlation between OG and the CIMT was statistically calculated.

**Results:** The study comprised 85 patients with mean age  $61.7 \pm 12.9$  years. They included 47 patients with significant OG ( $\geq 10$  mmHg) and 38 patients with non-significant gap ( $<10$  mmHg). There was a significant correlation between OG and CIMT ( $p < 0.05$ ). There was a highly significant difference between both groups regarding CIMT ( $p = 0.000$ ). A cutoff value of 10mmHg for OG could predict increased CIMT  $\geq 8$ mm with a sensitivity of 92% and specificity of 85%.

**Conclusion:** OG could be a marker of advanced atherosclerosis. It correlates significantly with CIMT. A cutoff value of 10mmHg of OG can predict CIMT  $\geq 8$ mm.

## Abbreviations

CIMT: Carotid Intima Media Thickness; OG: Oscillatory Gap; BP: Blood Pressure; OSBP: The Oscillatory Systolic; AUSBP: The Auscultatory Systolic BP

## Introduction

Measurements of arterial stiffness have clarified the results of clinical trials, demonstrating differing impacts on clinical outcomes, despite similar reductions in blood pressure (BP) [1]. There are significant associations between aortic atherosclerosis and major cardiovascular events [2].

Carotid intima media thickness (CIMT) and distensibility represent structural and functional vessel wall properties, but the pathophysiological mechanism of their correlation is unclear: a strong linkage of the 2 markers as well as the

possibility of 2 independent processes have been discussed [3]. Increased CIMT and decreased distensibility are correlated with generalized atherosclerosis [3,4]. CIMT is a measure of early atherosclerosis and vascular remodeling which correlates highly with standard cardiovascular risk factors [5]. This has been acknowledged by the FDA who have approved it as a marker of atherosclerosis [6].

A new clinical marker “oscillatory gap (OG)” which could be named after “Tahlawi gap”, the first one who prescribed it, was found to increase with the advancing of arterial atherosclerosis. Hence, this gap could predict cardiovascular atherosclerotic diseases, regardless of the presence of hypertension [7].

We aim to find a relationship between this clinical marker, Tahlawi gap, and a known ultrasonographic marker of atherosclerosis as CIMT.

## Patients and Methods

### Study design

This was a cross-sectional study enrolling 85 patients who underwent carotid Duplex a tour center owing to different indications. We included all age groups and both sexes.

### Ethical approval

The study was approved by the Ethical Committee of our center. Written informed consent was obtained from all of the patients.

### Measurements

High-resolution B mode ultrasonography was performed with a 7.5 MHz linear array imaging transducer (Vivid 7; GE Corporation, Milwaukee, WI, USA) in a quiet, semi-dark room. Subjects were asked not to drink coffee or tea for at least 2 hours before the detection. For the common carotid artery (CCA) examination, the patients were lying in the supine position, with slight hyperextension and rotation of the neck to the opposite side [8].

Magnified pictures were frozen incidentally with the R wave on the ECG. The IMT values were defined as the distance between the characteristic echoes from the lumen-intima and the media-adventitia interfaces. Because the near wall is different for accurate measurement, CIMT was measured on the longitudinal views of the distal 1 cm of the far wall of each CCA (1 cm proximal to the beginning of the dilatation of the carotid bulb). An image was deemed acceptable if a length of greater than 1 cm of continuous IMT could be visualized. Measurement was made at a plaque-free site. CIMT was calculated as the mean from four measurements (two on each side) [9].

The presence of one or more CIMT  $\geq 0.8$  mm in one major area was considered to be evidence of significant CIMT atherosclerosis (CIMT [+]) [10].

### BP measurement

BP pressure was measured in all the cases. Brachial BP was measured by two trained different observers according to a highly standardized protocol, using a mercury sphygmomanometer with an appropriately sized cuff. One sphygmomanometer was placed on the right arm, and after at least 5 min of rest in the sitting position, three BP measurements were obtained, allowing for a 1min interval between measurements. In cases of consistent systolic BP differences between arms, the arm with the higher BP value was used. The mercury was reduced by 2mmHg s<sup>-1</sup>.

Oscillatory systolic blood pressure (OSBP) was defined as the point at which the mercury started to oscillate before the auscultation of any sounds. The first oscillation was considered if the mercury oscillated to a level of at least 1mmHg. This point was before the first KorotKoff sound. Auscultatory systolic blood pressure (AUSBP) was defined as the first KorotKoff

sound. The difference between OSBP and AUSBP was calculated and called the 'OG' or (Tahlawi gap) (Figure 1) [7].

## Results

The study comprised 85 patients with age ranged from 35 to 90 year old. Characteristics of the 85 patients in the study are presented in Table 1. The results show a highly significant correlation between Tahlawi gap and the presence of hypertension ( $p < 0.01$ ).

Regarding CIMT, there was a significant correlation between Tahlawi gap and CIMT ( $p < 0.05$ ). CIMT has also a significant correlation with the presence of diabetes ( $p < 0.05$ ). There was a highly significant correlation between CIMT and the presence of hypertension, the systolic BP and the OSBP,  $p < 0.01$  for each Table 2.

We divided the study populations into 2 groups according to the amount of Tahlawi gap. Patients with Tahlawi gap  $\geq 10$  mmHg were considered as significant Tahlawi gap patients, and those had Tahlawi gap  $< 10$  mmHg were considered non-significant gap group. The study group included 47 patients

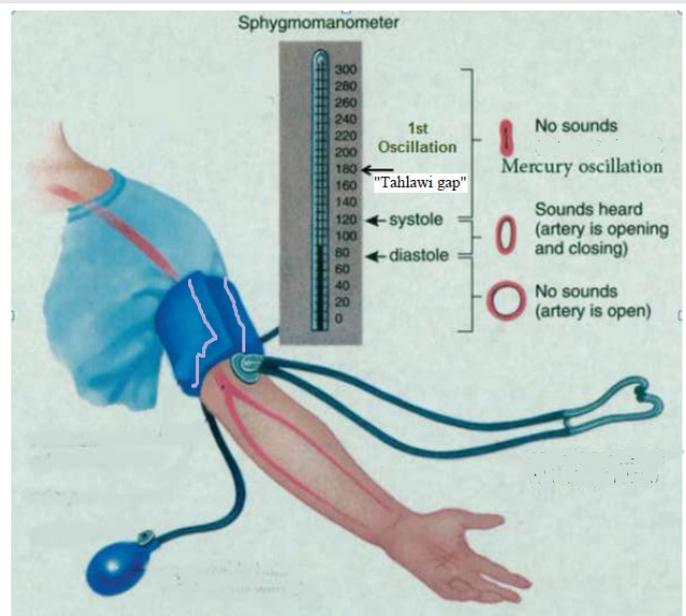


Figure 1: Measurement of blood pressure with detection of Tahlawi gap.

Table 1: Patient characteristics.

Character	Mean $\pm$ SD
Age	61.7 $\pm$ 12.9
Sex	F=27(32%) M=58(68%)
DM	51(60%)
HTN	58(68%)
SBP	138.3 $\pm$ 27.3
DBP	81.3 $\pm$ 11.9
CIMT	9.6 $\pm$ 3

DM: Diabetes Mellitus; HTN: Hypertension; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; CIMT: Carotid intima media thickness.

with significant Tahlawi gap and 38 patients with non-significant gap. There was a very high significant difference between both groups with and without significant Tahlawi gap regarding CIMT. CIMT was higher in those with significant Tahlawi gap ( $p=0.000$ ). However, there was no significant difference between both groups regarding other risk factors.

We considered CIMT  $\geq 8\text{mm}$  as an evidence of significant CIMT atherosclerosis (CIMT [+]) (10).

In order to define the optimal cutoff value for Tahlawi gap to predict increased CIMT  $\geq 8\text{mm}$ , receiver-operating curve (ROC) analysis was performed. A cutoff value of 10mmHg for Tahlawi gap can predict CIMT [+ ] with a sensitivity of 92% and specificity of 85%. The area under the curve was 0.7, which indicates good predictive value (Figure 2).

## Discussion

In the current work we study the relation between the new clinical parameter, Tahlawi gap, and CIMT.

It has previously been shown that auscultatory gap (gap between first and then subsequent continuously heard Korotkoff sounds) correlates with carotid atherosclerosis and arterial stiffness regardless of the presence of hypertension [11].

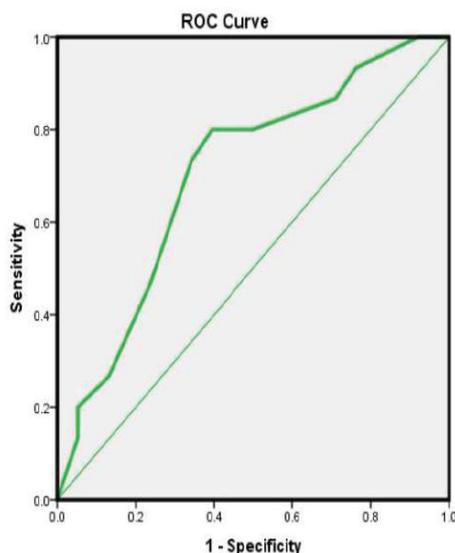
**Table 2:** Correlation between CIMT and age, hypertension, presence of DM and Tahlawi gap.

CIMT	Age	Hypertension	Sys BP	DM	Tahlawi Gap
P value	0.018*	0.005**	0.007**	0.029*	0.03*
r	0.323	0.377	0.367	0.300	0.299

\*Significant

\*\* Highly significant

DM: Diabetes Mellitus; HTN: Hypertension; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; CIMT: Carotid intima media thickness; Sys BP: Systolic blood pressure.



**Figure 2:** Roc curve: The area under the curve was 0.7.

In one of our previous work, we found that the difference between the oscillatory and auscultatory systolic pressures, called the 'oscillatory gap' or 'Tahlawi gap', could be a new clinical marker for the cascade of arterial atherosclerosis, which can be reflected in the coronary arteries. It was found to correlate significantly with the presence of coronary artery disease [7].

The presence of Tahlawi gap could be explained by the fact that the velocity of transmission and the propagation of vibrations in a material depend on the elasticity of its media and its inertia [12].

Stiff tubes tend to transmit vibrations at higher frequencies than compliant ones. Stiff tubes, with low internal or external damping, can transmit these vibrations throughout the structure [13]. Hence, the vibration of blood in more rigid vessels causes the walls of these vessels to oscillate more than elastic vessels, which dampen these oscillations. These oscillations are reflected to the mercury in the sphygmomanometer earlier than the sound that is auscultated. This difference generates the Tahlawi gap [7].

In this work we study the relation between this gap and CIMT which has been approved by the FDA as a marker of atherosclerosis [6].

B-mode ultrasonography is a relatively inexpensive, noninvasive, safe technique to evaluate the carotid arteries for plaque and to measure CIMT [14].

CIMT has been shown to correlate highly with arterial stiffness but not endothelial function [15]. Some studies have looked into the relationship between coronary angiography findings and CIMT [16,17].

Epidemiological studies reported a predictive value of increased CIMT for cardiovascular events as myocardial infarction and stroke, independent of traditional cardiovascular factors [18,20]. For these reasons, CIMT was included in the in European Society of Hypertension guidelines as target organ damage (class II, level B) in hypertensive patients [21].

In the current study we found a significant correlation between Tahlawi gap and CIMT. This correlation may confirm that Tahlawi gap is a real marker of atherosclerosis and arterial stiffness. In addition, higher values of Tahlawi gap may carry the risk of target organ damage in the form of increased CIMT.

In this study, we found a highly significant positive correlation between Tahlawi gap and hypertension. This is consistent with the finding of our previous study which shows the presence of a highly positive correlation between Tahlawi gap and hypertension [7].

In the same time we found a highly significant correlation between CIMT and the presence of hypertension. Accordingly, these results can indicate that target organ damage due to hypertension may be more manifest in the presence of wide Tahlawi gap.

Previous studies proved that CIMT is an early marker of atherosclerosis [22]. Measurement of CIMT is widely used and predicts cardiovascular events in subjects without clinically evident disease [23]. Hence, CIMT thickening is found when the vessels develop atherosclerosis and becomes stiffer. Thus Tahlawi gap is more evident with thickened CIMT. This is because significant Tahlawi gap need stiff non-elastic vessels to occur.

In the current study, we found that a cutoff value of 10mmHg of Tahlawi gap can predict the increased CIMT  $\geq$  8mm with good sensitivity and specificity. This means that the significant Tahlawi gap can predict atherosclerosis.

The correlation between Tahlawi gap and CIMT as well as with hypertension indicates that Tahlawi gap could be a marker of advanced atherosclerosis. In the same time, Tahlawi gap could be considered as a risk factor for development of cardiovascular events.

## Conclusion and Recommendation

Tahlawi gap could be a marker of advanced atherosclerosis. It correlates significantly with CIMT. A cutoff value of 10mmHg of Tahlawi gap can predict CIMT $\geq$ 8mm. Patients with significant Tahlawi gap should be stratified as high risk for atherosclerosis and receive aggressive treatment for controlling the hypertension and dyslipidemia.

## Conflict of interest

There is no conflict of interest concerning this manuscript. Authors' contributions ME: participated in the design of the study, participated in the sequence alignment and drafted the manuscript. AE: carried out the measurement of CIMT and analysis of the data. MG: participated in the design of the study and performed the statistical analysis. All authors read and approved the final manuscript.

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