Original Article

Correlation Between the Intima-Media Thickness of the Proximal and Distal Common Carotids

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Abstract

Background: **Increased IMT (intima-media thickness) in carotids is used as an early atherosclerosis marker and to evaluate the risk of cardiovascular problems. Ultrasound is used in the evaluation because it is accessible and low cost. Measurements for different carotid regions are described.**

Objective: **To compare the proximal and distal region IMTs for the bilateral common carotid and guide its use in clinical practice.**

Methods: **The IMT was measured in the proximal and distal common carotid arteries of 798 individuals (35-74 years old) of both genders using high-resolution ultrasound. Pearson's correlation coefficient was used to establish associations. The analyses were initially performed for the entire sample as well as subgroups with IMT <0.90 mm (49% of the sample) and ≥0.90 mm for at least one measurement site. The statistical significance was $p < 0.05$.**

Results: **The correlations investigated were significant. In the group with an IMT <0.90 mm, the correlations were between 0.44 and 0.62. In the subgroup with an IMT ≥0.90 mm, the correlations were significantly reduced to between 0.20 and 0.40.**

Conclusion: **The data suggest that the IMT is more uniform along the carotid during early development and tends develop focally as it progresses. Therefore, in clinical evaluations of patients, the common carotid length should be investigated bilaterally to better use the available software and discern the IMT. (Arq Bras Cardiol. 2013;101(3):211-216)**

Keywords: **Carotid Artery, Common; Carotid Intima-Media Thickness; Cardiovascular Diseases; Carotid Artery Diseases.**

Introduction

Carotid intima-media thickening (IMT) is used in clinical practice as a subclinical atheromatosis marker[1-7] and is a robust predictor for cardiovascular problems[1,2]; it is also a substitute ateromatosis marker[3]. It is clinically used to determine the risk score for coronary problems, as proposed in 2002 by the *American Heart Association* and the *American College of Cardiology*[4]. *Patients in the middle range of this score with an* IMT ≥ 0.90 mm should receive a more aggressive approach to prevent ischemic events[5].

IMT values are non-uniform in heterogeneous carotid regions[6]. It was difficult to measure IMT in patients due to such differences. The European[7] and American[5] Consensus standardized the measurements and recommended measuring the posterior wall of the common carotid 1 cm from the bulb, in addition to other technical norms.

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We ask whether clinically relevant information is lost because atherosclerosis is systemic and focal. Is the subclinical atheromatosis disease manifested by increased IMT in the common carotid a homogeneous phenomenon or is it also focal?

The aim of this study was to compare IMT in different areas in the common carotid arteries of participants in a research project investigating the biological and social determinants for chronic diseases in the Brazilian population[8].

Methods

The Population Studied

A sectional study was performed on individuals who participated in baseline exams for the Longitudinal Study of Adult Health (Project ELSA-BRASIL) at the ELSA-ES Research Center. ELSA-BRASIL seeks to identify the biological and social determinants of chronic diseases in a cohort of volunteers. The volunteers are active or retired civil servants from six higher education and research institutions responsible for developing this study[8]. At the baseline, 15,105 participants who were 35-74 years old were included, and 1,055 were employees at the Federal University of Espírito Santo (Universidade Federal do Espírito Santo - UFES). The data described in herein include

IMTs collected from 798 participants in ELSA-UFES; the data were collected by the same investigator. Comorbidities were identified (hypertension and diabetes mellitus), and tobacco smoking habits were recorded through participants' self-reporting.

Acquiring Images

The images were collected concomitantly with other clinical data and the laboratory data typically collected for treatment in ELSA-BRASIL. A Toshiba model SSA-790A Aplio, version XG (Japan), was used. The participants were positioned supine with their head at a 45º angle in the direction opposite from the side examined. A linear broadband transducer (PLT-704AT) was used with a 7.5 MHz (5.0 to 11.0 MHz) central frequency at 4 cm of depth without magnification. Bilateral images were collected at the distal common carotid 1 cm from the bulb in accordance with the norms established by the American Consensus (American Society of Echocardiography – ASE)[5]; images were also collected for the proximal common carotid in the portion immediately parallel bilaterally to the transducer at the base of the neck (this location was distinct for the participants' anatomy). The images were acquired through a cross-sectional cut, which allowed visualization of the distal intimal-medial layer and preferably the proximal layer simultaneously. The posterior wall was measured using software from the equipment certified for clinical use[9], which calculates the average for the three semi-automated measurements in 0.5 cm-long segments (Figure 1). Method not used in ELSA-BRASIL.

Data Analysis

IMT was normally distributed in the sample. The individuals with IMT exceeding 1.5 mm were excluded from analysis because they carried atheromatous plaque, as defined by the ASE[5]. IMT measured at the four points were associated using Pearson's correlation coefficient. To verify the association behavior after thickening, a separate analysis was conducted in the groups with IMT < 0.90 mm at each point tested and in the group in which at least one of the four measurements had an IMT ≥ 0.90 mm (subgroups < 0.90 and ≥ 0.90, respectively).

The cut-off point used to separate the subgroups was selected because, according to measurements from many American and European studies[5,7], an IMT ≥ 0.90 validates thickening in the intima-media space. The analyses were performed using SPSS 18.0. The significance level was $p < 0.05$.

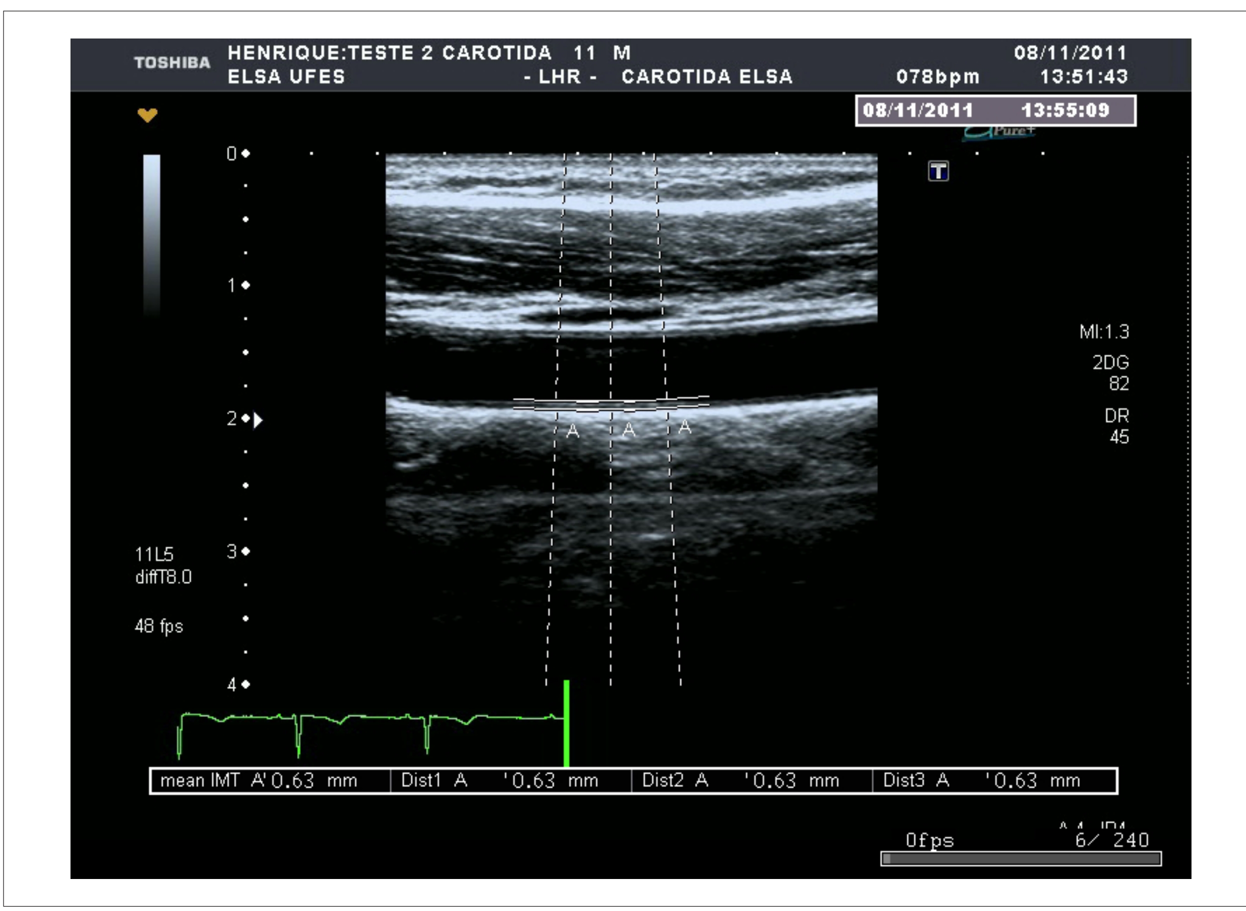

Figure 1 – *Measurement of the intima-media thickness (IMT) in the primitive carotid, indicated by the horizontal lines on the vessel wall.*

Results

In the sample studied (798 participants), 45.7% were male, 34.2% were hypertensive, 26% were smokers or ex-smokers, and 11% were diabetic. The numbers of participants according to age are as follows: 144 (35-44 years), 312 (45-54 years), 251 (55-64 years) and 91 (65-74 years). Seven individuals were excluded from the analysis because an IMT was >1.5 mm for at least one point. Thus, 791 individuals remained, and the minimum number of individuals with valid data at each point was 778. The data loss herein was due to technical problems with reliable IMT measurements.

A subgroup comprising 388 individuals (48.6%) showed no intima-media complex thickening; the four measurements produced IMT values <0.90 mm. An additional 403 individuals produced IMT values ≥ 0.90 mm for at least one of the four measurements. Table 1 shows the IMT characteristics for these two groups.

There was an increase in mean amplitude for the four measurement sites from 0.46 mm in the subgroup < 0.9 to 0.84 mm in the subgroup ≥ 0.90, corresponding to a nearly two-fold increase (data not shown in the tables).

Tables 2 to 4 show Pearson's correlation coefficients for the IMTs measured for the entire group and in the subgroups < 0.9 and ≥ 0.90.

Figures 2 and 3 show the IMT dispersion for the subgroup ≥ 0.90 at the points with the highest (right and left distal) and lowest correlations (left distal and right proximal).

Discussion

In the original group, statistical analyses showed that the highest correlation was r = 0.69 for the measurements conducted on the right and left distal carotids, and the lowest correlation was observed for the left distal and right proximal sides (r = 0.56). These values indicate a moderate to strong correlation. After separating the groups, we found that the correlation was similar for the subgroup <0.9 mm with r-values between 0.61 and 0.44 for the points with higher and lower correlations. By observing the data for the group wherein at least one point was

Table 1 – Intima-media thickness (IMT) in the right (R) and left (L) carotid arteries in the subgroups without IMT (<0.90 mm) and the subgroup with at least one point thickened (≥0.90 mm)

		< 0.90 mm	(n = 388)			≥ 0.90 mm	(n = 403)	
Carotid	Mean±sd	Median	P5	P95	Mean±sd	Median	P5	P95
R-Proximal	0.69 ± 0.10	0.68	0.53	0.85	0.85 ± 0.12	0.85	0.63	1.17
L-Proximal	0.73 ± 0.09	0.74	0.56	0.87	0.93 ± 0.14	0.93	0.73	1.48
R-Distal	0.70 ± 0.10	0.70	0.53	0.87	0.91 ± 0.15	0.91	0.67	1.45
L-Distal	0.71 ± 0.09	0.71	0.55	0.86	0.93±0.14	0.93	0.70	1.46

IMT given in mm; SD: standard deviation; and P5 and P95: 5% and 95% percentiles, respectively.

Table 2 – Pearson's correlation for the entire sample

PEARSON 's COR	R PROX	R DISTAL	L PROX	L DISTAL
R PROX	1	0,61*	0,61*	0,56*†
R DISTAL	–	1	0,64*	0,69*‡
L PROX		–	1	0,68*
L DISTAL			–	1

** - Significant correlations at the level p< 0,01(bi caudal); †: lowest correlation value; and ‡: highest correlation value.*

Table 3 - Pearson's correlation for the subgroup < 0.90 mm

PEARSON 's COR	R PROX	R DISTAL	L PROX	L DISTAL
R PROX	1	0.47*	0.48*	0.44*†
R DISTAL	–	1	0.49*	0.62*‡
L PROX		–	1	0.54*
L DISTAL			–	1

** - Significant correlations at the level p< 0,01(bi caudal); †: lowest correlation value; and ‡: highest correlation value.*

Table 4 – Pearson's correlation for the subgroup ≥0.90 mm

PEARSON 's COR	R PROX	R DISTAL	L PROX	L DISTAL
R PROX	1	0.32*	0.31*	0.20*†
R DISTAL	—	1	0.33*	0.40*‡
L PROX		—	1	0.39*
L DISTAL			—	1

** - Significant correlations at the level p< 0,01(bi caudal); †: lowest correlation value; and ‡: highest correlation value.*

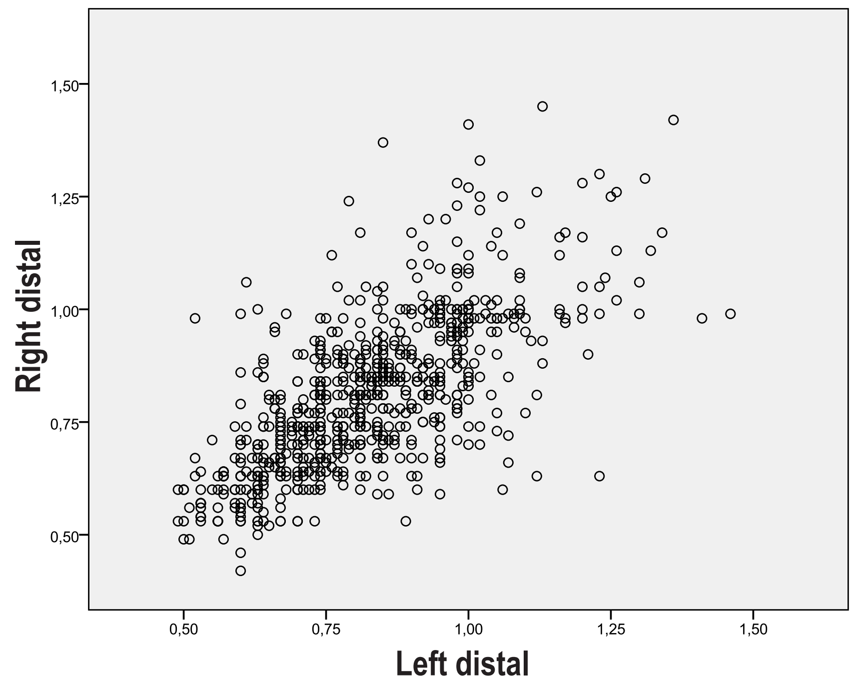

Figure 2 - *Correlation between IMT (mm) measured on the right and left distal carotid artery.*

0.9 mm (subgroup ≥ 0.90 mm), we found a marked decrease in the correlation, from 0.4 to 0.2. We observed a decrease from 0.61 to 0.40 for the highest correlation (right and left distal) and from 0.44 to 0.20 for the original lowest correlation (left distal and right proximal).

In a similar study with 14,106 participants, Howard et al. compared IMT bilateral measurements at different sites in common carotids 1 cm distal to the bulb (same location as the study herein), in the bulbs and at the internal carotid origin. The best correlation coefficient was 0.49 between the common right and left distal carotids. Herein, the best correlation was also observed between these locations[10].

When we analyzed the subgroup ≥0.90 for the determination coefficient (r^2), which is the proportion of variance in a group that is explained by another group, the values were 0.15 for the distal carotids and 0.04 for the left distal and right proximal sites (which had the lowest correlation). Thus, only 15% of the variability in the group with the best correlation was associated with variability on one side relative to the other. Additionally, an insignificant amount (4%) was explained for the group with lower correlation. In a study by Howard et al., 25% of the variance in the common left distal is explained by a variance in the right distal, which highlights that the small correlation observed indicates a lower significance in studies where only a portion of the carotid is used to measure IMT. However, the authors emphasize that this small correlation is sufficient to establish the distal common carotid as a measurement reference if the study is epidemiological and uses a sufficient sample, as demonstrated in several cohort studies[6].

Although that study compared different portions of the carotid artery (common, bulb and internal) than our study, certain similarities were observed. The study by Howard et al. suggests that the low correlation between different locations on the same side is most likely due to sites with different levels of shear stress. The study herein shows a low correlation for common carotid areas with theoretically similar stress levels. This study also highlights the good correlation when IMT is normal and that the

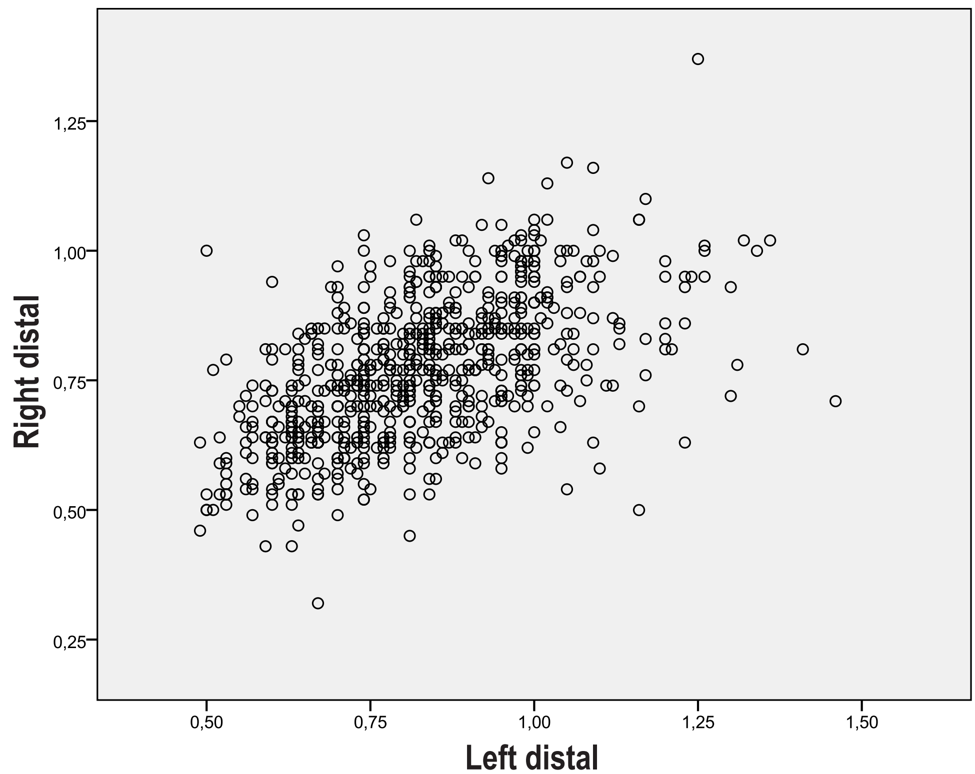

Figure 3 - *Correlation between IMT (mm) in the right proximal and left distal carotid artery.*

correlation is lost upon thickening. This finding shows that IMT and PTCA are local phenomena.

By analyzing the scatter plots (Figures 2 and 3) for the strong and weak correlations, we observed greater dispersion for the measurements with thickening, especially for thickening exceeding 0.90 mm, which explains the reduced correlation. With high values at a given location, we cannot reliably predict values for other locations due to the low correlation (the phenomenon is focal and translates into a greater dispersion range at such locations).

If we measure only one element, high IMT values may be lost, which impedes its clinical utility. Using the distal portion of the common carotid in epidemiological studies to measure IMT is justifiable because the common carotid is superficial and parallel to the skin and is thus easily accessible for ultrasounds. In addition, epidemiological studies typically include large samples, which facilitates precise inferences for parameters with a central trend (mean and median), even when those parameters have large dispersions. Standardizing the measurement location also facilitates future meta-analyses, which is a fundamental step towards establishing evidence-based guidelines.

Conclusions

To increase the precision for determining the risk for patients at the boundary values of the Framingham score, the data herein suggest that thickening of the entire common carotid artery must be tracked bilaterally in clinical practice. This behavior would prevent data loss because intima-media complex thickening is heterogeneous. Additionally, the commercially available software measures hundreds (sometimes thousands) of points for only 1 cm at the carotid, as this region is targeted for epidemiological research. In contrast, for clinical practice, the data suggest that we should measure a greater length or measure various points to account for focal thickening. We believe that the sensible and effective use of such software for clinical practice should include at least one scan across the common carotid to search for the thickest portions.

Author contributions

Conception and design of the research, Acquisition of data and Writing of the manuscript: Roelke LH; Analysis and interpretation of the data and Statistical analysis: Roelke LH, Rodrigues SL, Lotufo PA, Mill JG; Obtaining funding: Mill JG; Critical revision of the manuscript for intellectual content: Rodrigues SL, Lotufo PA, Mill JG.

Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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Study Association

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