Carotid intima-media thickness measurement through semi-automated detection software and analysis of vascular walls

G. NOVO, R. DI MICELI, D. ORLANDO, M. LUNETTA
M. PUGLIESI, M. FIORE, P. SPATAFORA, S. NOVO

Center for the Early Diagnosis of Preclinical and Multifocal Atherosclerosis, "Paolo Giaccone" University Hospital, Section of CardioAngiology, Department of Internal Medicine and Cardiovascular Diseases, Palermo, Italy

***Aim*. The aim of the present study was to compare the semi-automatic measurement of carotid intima thickness (RF-QIMT - Esaote, Italy), with the conventional method.**
***Methods*. We enrolle 81 patients, mean age 46 years ±15, with no history of cardio-cerebrovascular events and we assessed the traditional cardiovascular risk factors. We examined the IMT of the common carotid artery with manual and RFQIMT method (based on the "Radio Frequency" signal), according to the ASE protocol.**
***Results*. Semi-automatic measurement was on average lower than manual measurement (617 µm ±191 *vs*. 676 µm ± 222) with a statistically significant difference (P<0.01). In agreement with manual measurements, the values of RF-QIMT increased with increasing age and presence of cardiovascular risk factors.**
***Conclusion*. The RFQIMT measurement was, on average, lower than manual measurement, this means that probably, age- and gender-related reference values of RFQIMT need to be revised.**
[Int Angiol 2013;32:349-53]

Key words: **Carotid intima-media thickness - Radio frequency identification device - Cardiovascular diseases.**

The measurement of carotid intima thickness (CIMT) with ultrasonography (US) B-mode is a non-invasive, sensible, reproducible and low cost technique, to quantify subclinical vascular changes and to estimate cardiovascular risk. Carotid IMT has been independently associated with risk of ischemic coronary events and stroke in middle-aged and older individuals.[1] Therefore, the 2010 ACCF/AHA guideline recommend its use to improve stratification of patients at intermediate risk.[2] The accuracy and reproducibility of measurement are crucial to detect subclinical damage and its changes over time, indeed, the American Society of Echocardiography (ASE) Taskforce recommends use of a semi-automated border detection program with validated accuracy.[3]

The main aim of our study was to compare the manual measurement of carotid intima-media thickness with semi-automatic method of radiofrequency: Quality Intima-Media Thickness (RF-QIMT).

Materials and methods

The investigation was carried out on subjects, referred to our outpatient clinic of cardiovascular prevention from August 2011 to March 2012. We studied patients without history of cardiovascular and cerebrovascular events and we investigated about the presence of cardiovascular risk factors (age, sex, hypertension, family history of cardio-cerebrovascular events, dyslipidemia, cigarette smoking and diabetes mellitus). The patients underwent ultrasound scan of carotid arteries using a My Lab 70 machine (Esaote, Italy), equipped with a 7.5-10 MHz linear probe in B-mode frequency. Each patient underwent measurement of intima-media thickness, according to ASE protocol,[3] with conventional method and RFQIMT semiautomatic method.

IMT measurement

The IMT measurement was carried out at the distal cm of common carotid in longitudinal planes on the farthest wall in three projections on each side: anterior, lateral, and posterior. CIMT values greater than or equal to seventy-fifth percentile were considered high and indicators of increased cardiovascular risk. Values between the twenty-fifth and seventy-fifth percentile were considered medium and indicative of cardiovascular risk unchanged. Values less than or equal to twenty-fifth percentile were considered at low cardiovascular risk.[3] Carotid plaque was defined as the presence of focal wall thickening that was at least 50% greater than that of the surrounding vessel wall or as a focal region with CIMT greater than 1.5 mm that protruded into the lumen that was distinct from the adjacent boundary.[3]

Semiautomatic measurement of IMT was performed using the RFQIMT software (Esaote, Italy) based on "radio frequency" (RF-data processing). The signal in Radio Frequency is the electrical representation of the echo that arrives from the tissue as response to an ultrasound stress; the measurements are submillimetric (micrometers) and they are completely independent from the processing parameters of the images (Depth, Dynamic Range, zoom) that in some way alter the B-mode image. In the final report, the IMT value of examined patient is related to that expected in relation to age and gender, which is why entering these data, at first, into the software is required.[4] When signal of semiautomatic detection of IMT is stable, the software recognizes it, thus making a self-control of the quality. Such real-time feedback enable the examiner to optimize the probe position to have the best scan plane with respect to the far wall of the CCA; Figure 1 is an example of RFQIMT detection.

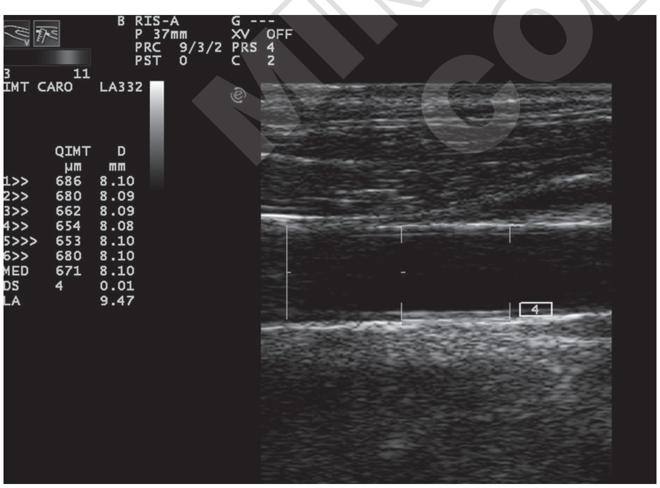

Figure 1.—Example of RFQIMT detection.

Statistical analysis

Data were expressed as mean±standard deviation (SD) or as a percentage. Numeric variables were compared using the Student's *t*-test. The differences were considered significant when $P<0.05$. Agreement between the two methods was assessed by intraclass correlation coefficient (ICC) and Bland-Altman plots.

Results

We enrolled 81 patients, aged between 23 and 73 years. Table I summarizes the general characteristics of population.

RFQIMT and IMT results detection

The IMT mean value measured by standard methods was 676±222 µm. The IMT mean value measured with the semi-automated method was 618±191 µm. Comparing the IMT mean values, obtained with manual and semiautomatic (RFQIMT) measurements, we found higher values in the manual measurement compared to the semiautomatic method, with a statistically significant difference (676 µm, 618 µm; $P<0.01$). There was a positive linear correlation between the manual and semi-automatic measurements ($r=0.63$). Substantial agreement was obtained as indicated in Table II, and in Figure 2. According to manual measurement, semiautomated method reflected the risk profile of studied population: IMT increased with the number of risk factors and with age (Figures 3, 4). The measured de-

TABLE I.—*Clinical characteristics of the studied population.*

Average age	46±15
M/F	49/32
Hypertension (%)	38.5
Dyslipidemia (%)	19.3
Diabetes mellitus (%)	8.4
Cigarette smoking (%)	18.1
Family history of CVD (%)	24.1

TABLE II.—*Agreement between conventional and automated technique in the IMT measurement.*

SITE	ICC (95% CI)
Total common carotid	0.7687 (0.6846-0.8303)
Right common carotid	0.8309 (0.7370-0.8912)
Left common carotid	0.7002 (0.5338-0,8072)

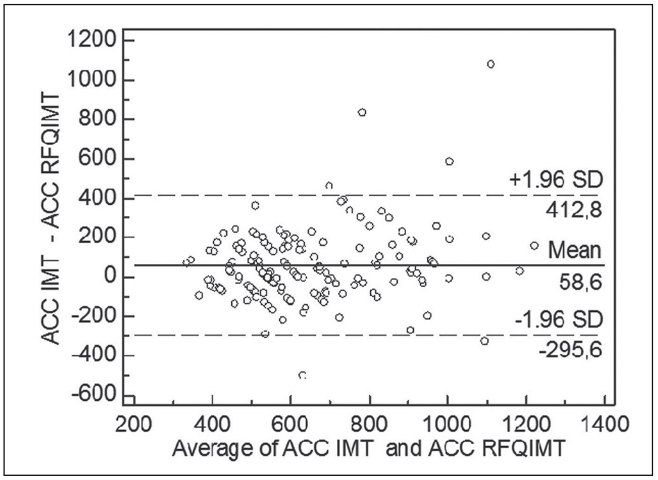

Figure 2.—Bland-Altman plot, conventional and automated method in the IMT measurement.

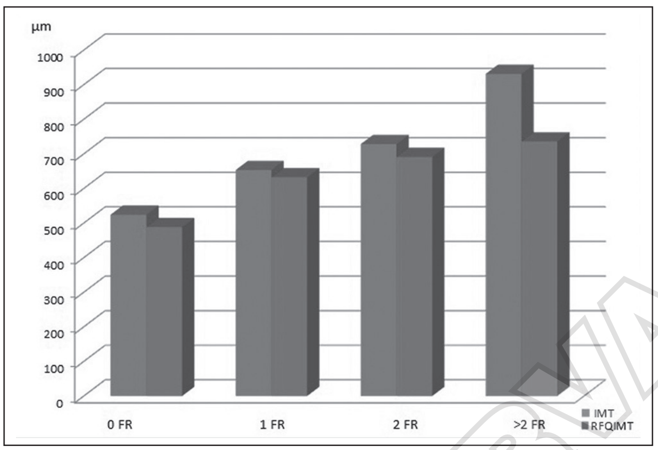

Figure 3.—Mean CIMT and RFQIMT in relation to number of risk factors.

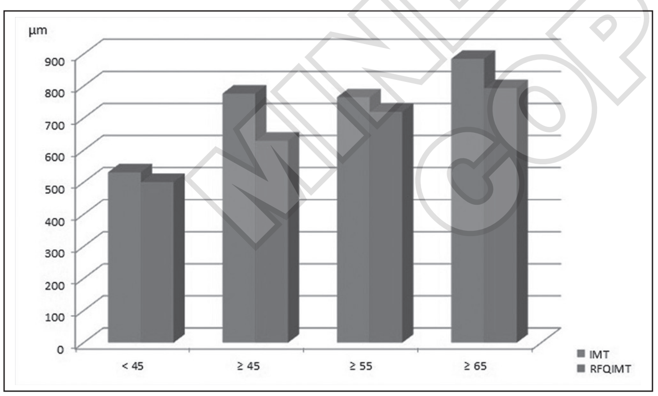

Figure 4.—Mean CIMT and RFQIMT in relation to various age groups.

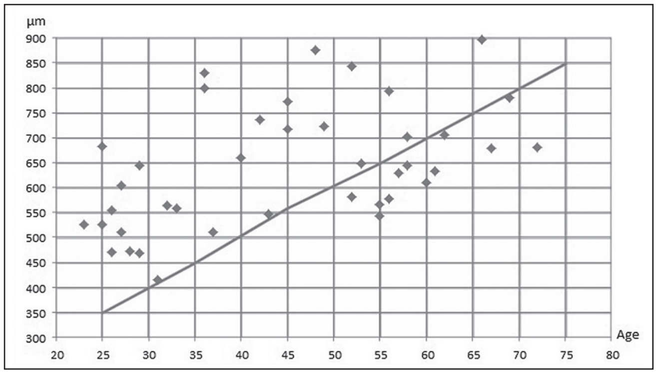

Figure 5.—RFQIMT of males, in relation to age.

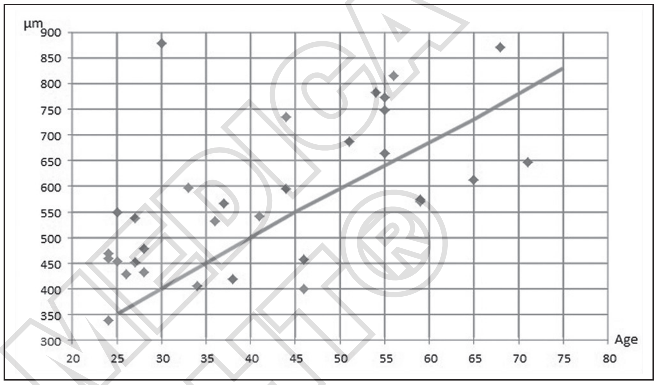

Figure 6.—RFQIMT of females, in relation to age.

rived from the manual measurement remained higher than that obtained with semiautomatic measurement (Figures 3, 4). Figures 5 and 6 represent the distribution of RFQIMT values of the studied population, respectively for males and females, in relation to reference values for age and sex according to ARIC study.[4]

Discussion

Carotid IMT has been independently associated with increased risk of ischemic coronary events and stroke in middle-aged and older individuals.[1] The risk of incident CHD events increases in a continuous fashion as carotid IMT increases (RR increases approximately 15% per 0.10-mm increase in carotid IMT); furthermore, the finding of atherosclerotic plaque, increases the predicted CAD risk at any level of carotid IMT.[5] The assessment of IMT is particularly useful in patients at intermediate risk, in which conventional methods underestimate the risk.[4, 6-8] In light of all this evidence, the 2010 ACCF/AHA guideline for Assessment of Cardiovascular Risk in Asymptomatic Adults, recommended the measurement of carotid IMT in asymptomatic adults at intermediate risk (class IIa, level of evidence B).[2] The ASE task force recommends use of a semi-automated border detection program with validated accuracy.[3]

There is few data in the literature regarding comparison between manual and semi- automatic methods. In a study on 80 healthy participants (mean age 35±14 years; range, 18-55 years; 24 male) and 70 patients (mean age, 50±7 years; range, 38-66 years; 42 male) with cardiovascular risk factors, carotid ultrasound images were obtained by high-resolution B-mode ultrasound with a 7.5- to 12-MHz linear array transducer (MyLab25; Esaote S.p.A., Genoa, Italy). Automatic measurement of CIMT obtained through an edge detector named FOAM showed an average bias of 0.001±0.0035 against manual measurement. The intraobserver variability, evaluated with the Bland-Altman method, showed a bias which was not significantly different from 0 with a satisfactory SD of the differences (0.001 mm). Whereas in the manual measurement a little bias was present (0.012) and SD of the differences was greater (0.044).[9] Another study evaluated measurement reproducibility and accuracy of semi-automated carotid intima-media thickness (CIMT) border detection program (AUTO): images from 6 carotid segments were acquired in 50 subjects, for a total of 300 segments using an 8.0-MHz linear array transducer (Acuson Sequoia; Siemens Medical Solutions, Malvern, Penn). Mean and maximum CIMT values were measured blindly at a reference (REF) lab and in duplicate by experienced (EXP) and novice (NOV) readers using manual (MAN) and AUTO methods. The study concluded that AUTO CIMT measurement program improved reproducibility and was accurate. Compared with MAN tracing, the AUTO method agreed better with the REF lab and decreased reading time.[10] Similar results come from a study in 40 patients, using an 8.0-MHz linear- array transducer (8L5, Acuson Sequoia, Siemens Medical Solutions, Mountain View, CA, USA) and semiautomated border detection program (BDP). It was mastered easily by a NOV reader and appeared suitable for use in an office setting.[11]

In our study we compared the manual measurement of carotid IMT with the semi- automated method based on radio frequency, developed by Esaote (RFQIMT). According to the manual measurement, the semi-automated measurements increase with increasing risk factors and we found a significant correlation between conventional and semi-automatic measurements. The values obtained with semi-automatic method, were significantly lower than manual measurements. This could mean that to consider IMT as increased, when using RFQIMT, reference values in relation to sex age and ethnicity need to be revised.

Conclusions

The RFQIMT measurement was on average lower than manual measurement, this means that probably, age- and gender-related reference values need to be revised when using RFQIMT method.

References

1. Lorenz MW, Markus HS, Bots ML, Rosvall M, Sitzer M. Prediction of clinical cardiovascular events with carotid intima-media thickness: a systematic review and meta-analysis. Circulation 2007;115:459-67.
2. Greenland P, Alpert J, Beller GA, Benjamin EJ, Budoff MJ, Fayad ZA *et al*. 2010 ACCF/AHA Guideline for Assessment of Cardiovascular Risk in Asymptomatic Adults. J Am Coll Cardiol 2010;56;e50-e103.
3. Stein JH, Korcarz CE, Hurst RT, Lonn E, Kendall CB, Mohler ER *et al*. Use of carotid ultrasound to identify subclinical vascular disease and evaluate cardiovascular disease risk: a consensus statement from the American Society of Echocardiography Carotid Intima-Media Thickness Task Force. J Am Soc Echocardiogr 2008;21:93-111.
4. Nambi V, Chambless L, Folsom A, He M, Hu Y, Mosley T *et al*. Carotid intima-media thickness and the presence or absence of plaque improves prediction of coronary heart disease risk in the Atherosclerosis Risk in Communities (ARIC) study. J Am Coll Cardiol 2010;55:1600-7.
5. Belcaro G, Nicolaides AN, Ramaswami G, Cesarone MR, De Sanctis M, Incandela L *et al*. Carotid and femoral ultrasound morphology screening and cardiovascular events in low risk subjects: a 10-year follow-up study (the CAFES-CAVE study). Atherosclerosis 2001;156:379-87.
6. Novo S, Carità P, Corrado E, Muratori I, Pernice C, Tantillo R *et al*. Preclinical carotid atherosclerosis enhances the global cardiovascular risk and increases the rate of cerebro and cardiovascular events in a five-year follow-up. Atherosclerosis 2010;211:287-90.
7. Novo S, Visconti CL, Amoroso GR, Corrado E, Fazio G, Muratori I *et al*. Asymptomatic carotid lesions add to CV risk prediction. Eur J Cardiovasc Prev Rehabil 2010;17:514-8.
8. Sehestedt T, Jeppesen J, Hansen TW, Wachtell K, Ibsen H, Torp-Petersen C *et al*. Risk prediction is improved by adding markers of subclinical organ damage to SCORE. Eur Heart J 2010;31:883-91.

9. Faita F, Gemignani V, Bianchini E, Giannarelli C, Ghiadoni L, Demi M. Real-time measurement system for evaluation of the carotid intima-media thickness with a robust edge operator. J Ultrasound Med 2008;27:1353-61.
10. Stein JH, Korcarz CE, Mays ME, Douglas PS, Palta M, Zhang *et al*. A Semiautomated Ultrasound Border Detection Program That Facilitates Clinical Measurement of Ultrasound Carotid Intima-Media Thickness. J Am Soc Echocardiogr 2005;18:244-51.
11. Gepner AD, Korcarz CE, Aeschlimann SE, LeCaire TJ, Palta M, Tzou WS *et al*. Validation of a carotid intima-media thickness border detection program for use in an office setting. J Am Soc Echocardiogr 2006;19:223-8.

Received on November 9, 2012; resubmitted November 21, 2012; accepted for publication on November 23, 2012.

Corresponding author: R. Di Miceli, Chair of Cardiovascular Disease, Center for the Early Diagnosis of Preclinical and Multifocal Atherosclerosis, Section of CardioAngiology, Department of Internal Medicine and Cardiovascular Diseases, "Paolo Giaccone" University Hospital, via del Vespro 139, 90127, Palermo, Italy. E-mail: dimiceliriccardo@libero.it

INTERNATIONAL ANGIOLOGY A. OLIARO, *Managing Editor*

Published by Edizioni Minerva Medica, Corso Bramante 83-85, Turin, Italy (Casella postale 491 - 10100 Torino) - Tel. (011) 67.82.82 - Fax (011) 67.45.02
Printed by Edizioni Minerva Medica, Tipografia di Saluzzo, Corso IV Novembre 29-31, Saluzzo, Italy - Tel. (0175) 24.94.05 - Fax (0175) 24.94.07
[Autorizzazione Tribunale di Torino N. 2983 del 15-X-1980]