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ORIGINAL ARTICLE

Measurement of Common Carotid Artery Intima-Media Thickness Using Automated Measurement Software

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ABSTRACT

Background: While the conventional vernier method has been the basic standard evaluation method, it has become possible to measure the intima-media thickness (IMT) of successive areas using commercial computer software. **Methods**: The common carotid artery (CCA) IMT was assessed by manual measurements and with the newly developed B-mode ultrasound IMT measurement software, Intimascope. The manual measurements of the CCA-IMT were performed using the automated range calibrated trackball on the scanner approximately at 10 mm proximal to the carotid bulb. Using the Intimascope, four IMT values were measured: (1) the Y type IMT, (2) maximum IMT, (3) three-point average IMT, and (4) total average IMT. The intra- and interobserver reliability of the automatic detection and manual measurements were analyzed. **Results**: High-resolution B-mode ultrasound measurements of the CCA-IMT were performed in 51 consecutive patients, with a mean of 64 years of age. The values of CCA-IMT, used for the total average IMT measurement, were highly correlated with the conventional manual measurements. Intraobserver reliability was high for all measurement methods (0.617 for manual measurement). The reliability was highest for the Y-evaluation IMT measurement, followed by total average IMT measurement. Interobserver reliability was high for all measurement methods except the maximum IMT measurement. The interobserver reliability for manual measurements was 0.631. The reliability was highest for the Y-evaluation IMT measurement and the three-point average IMT measurement. **Conclusions**: Carotid IMT measurement using automated software provided reproducible results of IMT measurements comparing manual method. ***Journal of Neurosonology 2(1):27-30, 2010***

Key Words: Intima-media thickness, Computerized analyzing system, Reliability

INTRODUCTION

Intima-media thickness (IMT) is increasingly used as a surrogate end point for vascular outcomes in many clinical trials aimed at assessing the effect of interventions that lower the risks for stroke and myocardial infarction.[1,2] Increased IMT of common carotid artery (CCA) has been associated with an increased risk of stroke and myocardial infarction.[3-5] However, there have been several discordances in measuring IMT of CCA in prior studies.[5] These include the details of the ultrasound protocols, namely the precise definitions used for the carotid segments investigated, the use of the mean or maximal IMT, the measurement of the near and far wall or only far wall IMT, and whether IMT was measured only on one side or on both sides. In addition, the B-mode ultrasound with visual measurement is the standard diagnostic method, which allows for *in vivo* measurement of IMT. Measurement of the IMT is based on manual tracing of the different echo interfaces on the ultrasound

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image in most cases.[5] Manual measurements are influenced by the handling of the trackball, as well as the experience and subjective judgments of the sonographer.[6] Since IMT is increasingly used in multicenter clinical trials, it is important that standardized methods needs to be implemented to allow consistency of data collection and analysis.[1] This would help to improve the power of such studies and to facilitate the merging of large databases for meta-analyses. While the conventional vernier method has been the basic evaluation method, it has recently become possible to measure the IMT of successive areas by commercially available computerized software.[6-10] Intimascope (Media Cross Co. Ltd., Tokyo, Japan) is newly developed B-mode ultrasound software for measuring IMT.

The main objective of the present study was to evaluate the intra- and interobserver reliability of manual and automated measurement of CCA-IMT.

METHODS

Between June 2009 and August 2009, patients presenting to the neurology outpatient clinic for the evaluation of headache were prospectively enrolled. The patients were 40 years of age or older, had no history of a stroke and provided informed consent.

High-resolution B-mode ultrasound measurements were performed according to the guidelines of the Mannheim IMT Consensus using a GE Voluson 730 ultrasound scanner with a linear transducer. The IMT was defined as the distance from the leading edge of the lumen-intima interface to the leading edge of the media-adventitia interface of the far wall.[1] A single longitudinal lateral image of the CCA was obtained proximally to the carotid bulb, with the patient in the supine position, the head straight, and the neck extended, bilaterally. The manual measurements of the CCA-IMT were performed using the automated range calibrated trackball on the scanner approximately at 10 mm proximal to the carotid bulb. The CCA-IMT was measured consecutively at the same day by 4 different observers (CJW, BDS, BJS, and HSW) to assess the interobserver variability and then once 4 times by one observer (HSW) to assess the intraobserver variability. All scanned IMT images were saved as a JPG file individually on the ultrasound and transferred to a PC for automated measurements.

Intimascope, the automated IMT measurement software, uses an algorithm for the delineation of lumen-intima and media-adventitia interfaces.[9] The start and end points of the measurement area were set manually by the operator. Two lines along the boundaries of the IMT were automatically drawn by the tool provided that corresponded to the measurement points within the set segment. Areas of unclear, irregular boundaries, or plaques within the selected segment were not included in the calculations. Plaque was defined as a focal structure that encroached into the arterial lumen at least 0.5 mm or was 50% of the surrounding IMT value or had a thickness >1.5 mm as measured from the media-adventitia interface to the intima-lumen interface.[1] Using the Intimascope, four IMT values were measured: (1) the Y type IMT evaluation, which a method for calculating the outer average of 0.5 cm remote right and left point from the maximum IMT point; (2) the maximum IMT evaluation; this method uses only the maximum IMT value at one point; (3) the IMT evaluation determined by the average of three points; this method averages the three points of center, left 1 cm, right 1 cm by a template cutting the image to evaluate the IMT; (4) the total average IMT evaluation; this averages the total auto detected points for the IMT evaluation. SPSS version 12.0 Windows software was used for the statistical analysis. Reliability was estimated by Cronbach

Table 1. Baseline demographics of patients

	Patient (n=51)
Demographics	
Age (years)	63.56 (12.63)
Female	20 (39.2%)
Medical history	
Hypertension	23 (45.1%)
Diabetes mellitus	7 (13.7%)
Hypercholesterolemia	5 (10%)
Smoking within the past month	16 (31.4%)

Data are means (SD) or numbers (%) unless otherwise indicated.

alpha at the 95% confidence interval.

RESULTS

High-resolution B-mode ultrasound measurements of the CCA-IMT were performed in 51 consecutive patients (20 women, 39.2%) with a mean age of 64 (range, 44-90 years). Table 1 shows the baseline demographics of the enrolled patients. A total of 87 CCA-IMT were measured manually and automatically during the trial period. Table 2 shows the results of the CCA-IMT measurements. The CCA-IMT values were higher for the maximum IMT measurements and lower for the three-point average IMT measurements. The values of CCA-IMT in the total average IMT measurement were highly correlated with the conventional manual measurements.

Intra- and interobserver reliability were analyzed using Cronbach alpha analysis (Table 3). Intraobserver reliability was high for all measurement methods and for the manual measurements, which was 0.617. Reliability was highest for the Y-evaluation IMT measurements, followed by the total average IMT measurements, three-point average IMT measurements, maximum IMT measurements, and conventional manual measurements.

Interobserver reliability was also high among all measurement methods except for the maximum IMT measurement. Interobserver reliability for the manual measurements was 0.631. Reliability was highest for the Y-evaluation IMT measurements, followed by the three-point average IMT measurements, conventional manual measurements, total average IMT measurements, and maximum IMT measurements.

Table 2. Values of the CCA-IMT

Conventional manual measurement	0.71 (0.16)
Y-evaluation IMT measurement	0.75 (0.12)
Maximum IMT measurement	0.98 (0.21)
Three-point average IMT measurement	0.67 (0.12)
Total average IMT measurement	0.69 (0.13)

Data are means (SD) unless otherwise indicated. Measurements are given in millimeter. CCA; common carotid artery, IMT; intima-media thickness.

DISCUSSION

Computer software assisted automated IMT measurement systems have recently been developed and introduced into clinical practice. In this study, the newly developed IMT measurement software, Intimascope, was used and the intra- and interobserver reliability evaluated. The results of this study showed that the IMT measurement software, Intimascope, was easy to use and highly reliable.

The normal upper limit of IMT is between 0.5 mm during early childhood and 0.8 mm by 80 years of age in healthy individuals; its progression strongly depends on atherosclerotic factors.[11] While the carotid IMT is a strong predictor of future vascular events,[12,13] measurement sensitivity is of great importance since the differences between normal and pathological findings are in the 1/10 of a millimeter range.[6] The axial resolution of B-mode ultrasonography is >/=0.1 mm, which causes difficulties with respect to accuracy and reproducibility. However, Intimascope can measure IMT with a 10 times higher axial resolution at an estimated scale of 0.01 mm.[9]

Theoretically, the three-point average IMT measurement of the Intimascope most closely resembles the manual measurement method. In this study, however, the values of the CCA-IMT on the total average IMT measurement were highly correlated with the conventional manual measurements. Since a computer cannot automatically locate the maximum IMT in the Intimascope, the examiner performing the measurements must match the center of a template with the maximum IMT for an accurate measurement. The values of the CCA-IMT for the maximum IMT measurement were larger for five values, but had a relatively lower reliability. The peak IMT was an effective method for evaluating the IMT

Table 3. Intra- and interobserver reliability of IMT measurements

	Intraobserver	Interobserver
Conventional manual measurement	0.617	0.631
Y-evaluation IMT measurement	0.824	0.959
Maximum IMT measurement	0.667	0.511
Three-point average IMT measurement	0.705	0.680
Total average IMT measurement	0.810	0.617

Data are the value of Cronbach alpha at the 95% confidence interval. IMT; intima-media thickness.

with plaque. Intraobserver reliability was higher than interobserver reliability in this study. This might be because the rater was somewhat unfamiliar with the new measurement software. During measurements, the margin of error is great and meticulous attention to detail is necessary for an accurate measurement. Improvements with experience are expected. The limitations of this study include the small sample size. In addition, comparisons of the two methods of measurement were not performed for other conditions. While there are several arguments for and against each IMT measurement protocol available for clinical use, it is essential to use a standardized protocol in future studies. The results of this study showed that the new measurement software used was reliable for IMT measurements. Carotid IMT measurements using the Intimascope may provide a more precise and reproducible index of atherosclerosis than the conventional IMT measurements.

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