ORIGINAL ARTICLE

# The Novel Technique of using Superb Microvascular Imaging to Determine Carotid Intima-media Thickness

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## Abstract

**Objective:** The objective of this study was to investigate the interobserver reliability when measuring the carotid intima media thickness (IMT) using superb microvascular imaging (SMI) and B-mode ultrasonography. **Methods:** Two sonologists were selected to scan the left common carotid artery and measure IMT first with B-mode and then with SMI on 20 patients. They were blinded to each other results. Intraclass correlation coefficients (ICCs) were calculated to estimate the inter-rater reliability using both the modes of scanning. **Results:** Interobserver agreement when using SMI, for both near wall and far wall, was almost perfect (ICC, 0.870; 95% confidence interval [CI], 0.700–0.946). Interobserver agreement when using B-mode was poor for near wall (ICC, 0.396; 95% CI, −0.048–0.708) and moderate for far wall (ICC, 0.474, 95% CI, 0.070–0.749). **Conclusions:** SMI proved to be a greatly reliable tool in the measurement of carotid IMT.

**Keywords:** B-mode ultrasonography, Carotid artery, Interobserver reliability, Intima-media thickness, Superb microvascular imaging

## INTRODUCTION

Carotid artery intima-media thickness (IMT) is thought to be strongly linked with the risk of myocardial infarction and stroke in asymptomatic older adults.[1] IMT of >0.9 mm or over the 75th percentile is considered abnormal.[2] Carotid IMT has been traditionally measured using high-resolution B-mode ultrasonography.[3]

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Superb microvascular imaging (SMI) is a technique that analyzes clutter motion and uses an adaptive algorithm to identify and remove tissue motion and reveal a more accurate blood flow depiction.[4] Although SMI yields high frame rates, high resolution, high sensitivity, and fewer motion artifacts (without the use of contrast), we thought of employing it to visualize the wall of the carotid artery.

Despite the known fact that its prime advantage is to detect low-velocity flow, we discovered the interesting utility of SMI in visualizing a vessel containing high-velocity flow such as the carotid artery. It was noticed that, by increasing the color gains, a greater level of contrast was created between the luminal flow (hyperechoic) and the carotid wall (anechoic), thus providing a crisp image of the IMT, making it easier to measure it.

However, before generalization of SMI as a new technique, its reliability must be verified. There have been no relevant studies in this field. The aim of this study was to investigate the interobserver reliability when measuring the IMT using SMI and B-mode ultrasonography.

## METHODS

This study was conducted at the Institute of Ultrasound Imaging, which is affiliated with Thomas Jefferson University Hospital, Philadelphia, USA. The study protocol was approved by the Ethics Review Board of the Ultrasound Society of Pakistan. A total of 20 patients were voluntarily participated in this study and provided signed informed consent.

Patients between the ages of 30 and 50 years were selected. Patients with a plaque or a carotid thickness of >1.5 mm were excluded from the study. Two sonologists were selected to perform the scan first with B-mode and then with SMI and B-mode simultaneously. They scanned the same patients on the same day. Both had an experience of >20 years in the field of ultrasound. They were blinded to each other's results.

The scan was performed using a 7.5 MHz linear probe (Aplio 300, Toshiba, Japan). The patient was made to lie down in the supine position, and the left common carotid artery (CCA) was scanned. Longitudinal and transverse images were recorded on a digital format. The section measured was approximately 1 cm from the carotid bulb.

Each sonologist first visualized the left CCA longitudinally on B-mode. The probe was placed as parallel as possible to the vessel wall. The depth and gain setting were adjusted to get a better view. Thereafter, the sonologist switched on SMI mode. Immediately, twin images would appear on the screen, the left image showing live scanning of the left CCA through B-mode and on the right, it would show live scanning of the same segment on SMI. Therefore, scanning by both methods was seen simultaneously. The region of interest (that automatically appears on the side being scanned through SMI) was steered approximately 10º to the right to enhance the carotid flow as shown in Figure 1. The knob for color gain was increased to obtain complete filling of the vessel. This also increased the level of contrast between the lumen and the wall. Cine loop (i.e., a series of images acquired in rapid sequence by the scanner) was utilized to obtain the best possible image. Monochrome SMI was used on which the vessel wall appeared anechoic in contrast to the flow in the vessel which appeared echogenic. The carotid wall appeared as an anechoic strip between two highly echogenic lines on SMI. On B-mode, the wall appeared hypoechoic and hazy. Near and far walls were measured on both images. Caliper used was the positive sign which gives more accurate measurements. All images were digitally recorded, saved, and measured.

Statistical analysis was performed using SPSS Statistics version 22 software (IBM Corporation, Armonk, NY). The interobserver reliability was calculated using the interclass correlation coefficient (ICC). The ICC was interpreted as follows: Poor: 0.40 or less; moderate: 0.41–0.60; substantial: 0.61–0.80; and almost perfect: 0.81–1.00.[5] A graphic representation illustrating the agreement between the IMT measurements was also provided using Bland–Altman plots.

## RESULTS

A total of 20 patients met our criteria and were included in the study. The ultrasound scan took approximately 10 min per patient for both sonologists. Interobserver reliability using ICC values for IMT measurements is shown in Table 1. Interobserver agreement when using SMI, for both near wall and far wall, was almost perfect (ICC, 0.870; 95% confidence interval [CI], 0.700-0.946). Interobserver agreement when using B-mode was poor for near wall (ICC, 0.396; 95% CI, –0.048–0.708) and moderate for far wall (ICC, 0.474, 95%

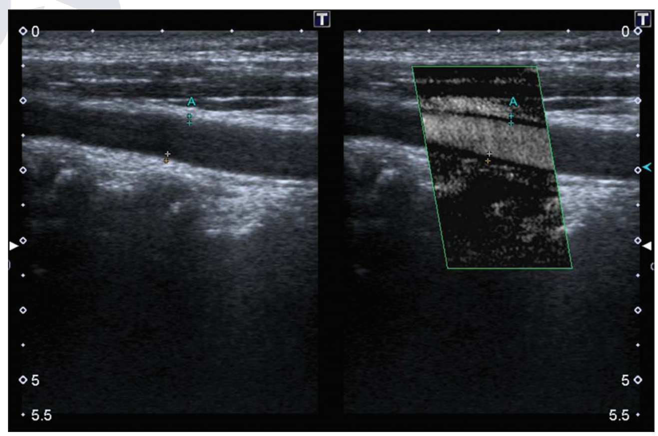

**Figure 1:** A 35 year old female who presented for regular checkup. High-resolution Ultrasonography showing twin-view of left Common Carotid Artery by B-mode (on the the left) and SMI (on the right).

**Table 1:** Inter-rater reproducibility of left common carotid artery IMT using SMI and B-mode

| Mode | ICC | 95% CI |
|---|---|---|
| Near wall | | |
| B-mode | 0.396 | –0.048–0.708 |
| SMI | 0.870 | 0.700–0.946 |
| Far wall | | |
| B-mode | 0.474 | 0.070–0.749 |
| SMI | 0.870 | 0.700–0.946 |

IMT: Intima-media thickness, SMI: Superb microvascular imaging, ICC: Intraclass correlation coefficients, CI: Confidence interval

CI, 0.070–0.749). Bland–Altman plots (Figures 2 and 3) showed greater agreement between IMT measurements when using SMI for both near and far walls.

## DISCUSSION

To the best of our knowledge, this is the first study providing evidence in favor of the application of SMI to improve the reliability of sonographic measurements of the carotid IMT. Previous studies have aimed to investigate the reliability of B-mode when measuring the IMT. However, a few issues were noted.

Noise has been a major issue in ultrasound imaging. Speckle noise is an interference caused by the scattering of the sound waves. This would reduce the quality of the image, thereby creating a pixelated effect.[6] The use of SMI solved this issue and gave us a crisp image, thereby making it easier to identify the boundaries of the wall.

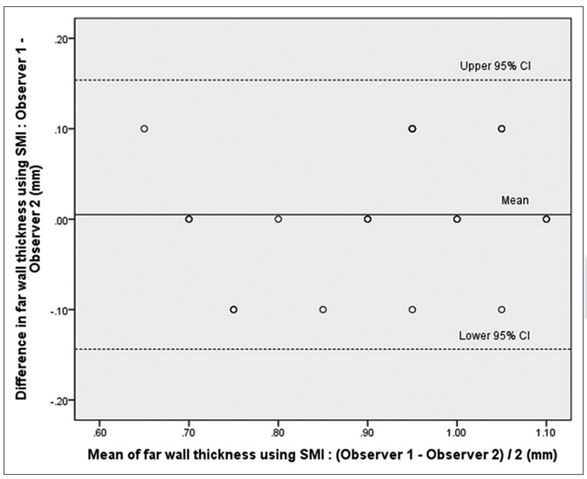


**Figure 2:** Bland-Altman plot for interobserver variability of Observer 1 and Observer 2; Difference in far wall thickness using SMI (vertical axis) is plotted against the mean of far wall thickness using SMI (horizontal axis).

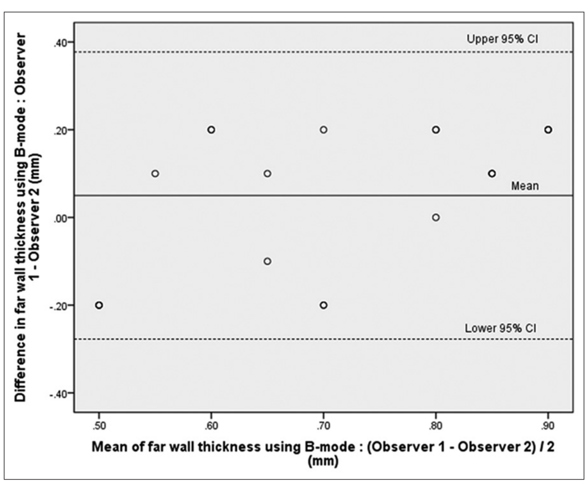


**Figure 3:** Bland-Altman plot for interobserver variability of Observer 1 and Observer 2; Difference in far wall thickness using B-mode (vertical axis) is plotted against the mean of far wall thickness using B-mode (horizontal axis).

When using B-mode, the intima layer is poorly represented. It is seen fused with the media layer due to the poor difference in the acoustic impedance of the two adjacent layers.[7] The media layer is seen as dark gray (hypoechoic), whereas the adventitia layer appears bright gray (echogenic). The IMT is measured as the distance between the lumen-intima and media-adventitia boundaries. When using SMI, segmentation of the carotid wall is not possible; however, due to the increased level of contrast created between the highly echogenic lumen flow and anechoic wall, the visualization of the wall was easier. The wall can be sharply demarcated between two highly echogenic lines.

By segmenting a cine loop, we were able to visualize the carotid in different phases of the cardiac cycle. Each measurement was made 1 cm from the carotid bulb to improve the reproducibility of the measurements. Using twin-view, we were able to do live scanning of the same segment by both SMI and B-mode at the same time. This may have played a part in improving the reliability of the measurements.

According to the Mannheim Carotid IMT Consensus (2004–2006), when using B-mode, IMT should be preferably measured on the far wall. Since IMT values from the near wall depend in part on the gain settings, they may be less reliable.[8] When we used SMI, the near wall and far wall had an equal thickness in 95% of the cases. We believe that this may be due to the fact that SMI removes tissue motion, making near wall and far wall measurements equally reliable.

Excellent reproducibility of IMT measurements is important for several reasons. IMT measurement is an important indicator of carotid atherosclerosis later in life.[9] Prior studies have also shown that increased carotid IMT occurs in HIV-infected patients despite antiretroviral therapy.[10] Since ultrasound is largely operator dependent, we believe that a clearer image obtained by SMI aids in improving the reliability of the IMT measurements, thereby making ultrasound an excellent tool for predicting chances of stroke, MI, and atherosclerosis later in life.

We evaluated the reliability of the two techniques. However, we agree that it is important to evaluate the validity as well. For that, further studies need to be carried out.

## CONCLUSION

We believe that SMI is a greatly reliable tool in measuring carotid IMT measurements and further studies should be carried out to investigate its feasibility.

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