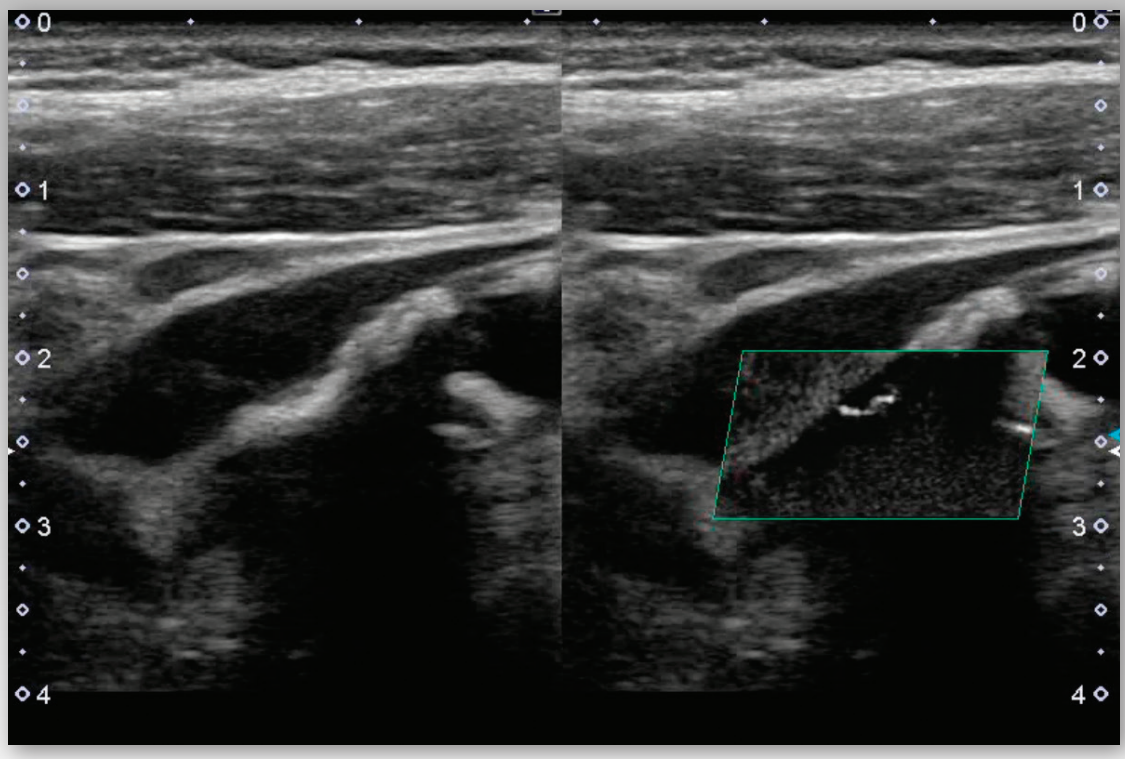
Canon

UL White Paper

Superb Micro-Vascular Imaging

SMI: Seeing Through the Clutter



Maria Stanczak, M.S., RDMS, RVT
Huan Dong, M.D.
Flemming Forsberg, Ph.D.

According to the World Health Organization cardiovascular diseases are the primary cause of death globally[1]. Atherosclerosis, the primary cause of cardiovascular disease, is a chronic, inflammatory condition that results in plaque formation. The extracranial arteries are commonly affected by this condition, which if left untreated can lead to carotid arterial stenosis (CAS; narrowing of the carotid artery).

Conventional ultrasound is often used to assess the luminal diameter, as well as the velocity of blood flow through the carotid arteries in order to determine CAS as a surrogate marker for stroke risk. However, current literature suggests that plaque vulnerability (plaque prone to rupture) should also be considered when assessing a patient's risk of stroke, yet this evaluation is often overlooked or limited due to modality ineffectiveness[2]. Assessment of other factors beyond luminal stenosis including intraplaque hemorrhage, plaque neovascularity, and a thin fibrous cap may improve patient risk stratification and outcomes[3]. Hence, there remains a need for non-invasive imaging methods to better stratify unstable plaques. To fill this void and others, Canon Medical Systems, Inc. has developed Superb Micro-vascular Imaging (SMI), a unique vascular imaging mode designed to improve visualization of microvasculature.

	0	1	2	3
Ultrasound	No flow visualized within plaque	Minimal flow visualized only with SMI	Many areas of flow visualized with SMI and minimal flow visualized with traditional power Doppler	Prominent flow visualized with SMI and traditional power Doppler
Pathology	No vessels visualized within plaque	Few small vessels visualized within plaque	Small vessels and 1-2 larger vessels visualized within plaque	Many large and small visualized within plaque

Table 1. The four point scale used to analyze sonograms and plaque specimens

The presence of newly developed microvessels, termed neovascularization, is one element that is often associated with plaque hemorrhage and/or rupture. Current non-contrast sonographic techniques are suboptimal when evaluating this type of high risk plaque formation[4]. Computed tomographic angiography (CTA), which can be used to assess the degree of carotid arterial stenosis, also fails to accurately characterize vulnerable plaques. The innovative SMI mode, available on Canon Medical's Aplio™ Platinum Series, Xario™ 200 Platinum Series and new Aplio i-series ultrasound systems, is an image processing technique that utilizes advanced clutter suppression to extract microvascular flow signals, thus improving the ability to detect slow blood flow. Conventional Doppler imaging uses a wall filter to minimize motion artifacts and clutter. However, the resultant Doppler signal suffers from a loss of low velocity flow components, as both true blood flow components and artifacts below a specified velocity threshold are filtered out. Conversely, SMI is capable of identifying motion signals caused by structures other than blood flow and separate them from the Doppler signal. This effective technique allows for the inclusion of low flow velocities within the displayed signal. SMI can function in two modes: color (cSMI) with a color overlay similar to conventional color Doppler imaging or monochrome (mSMI), which depicts flow in grayscale only. Each mode provides a unique dual ability to customize flow information.

Our research team at Thomas Jefferson University has performed an investigative pilot study to assess the ability of SMI (cSMI and mSMI) to detect neovascularization in chronic, calcified carotid artery plaques. The prospective clinical trial was approved by the university's Institutional Review Board (IRB) and included patients (17) with confirmed CAS. All patients were

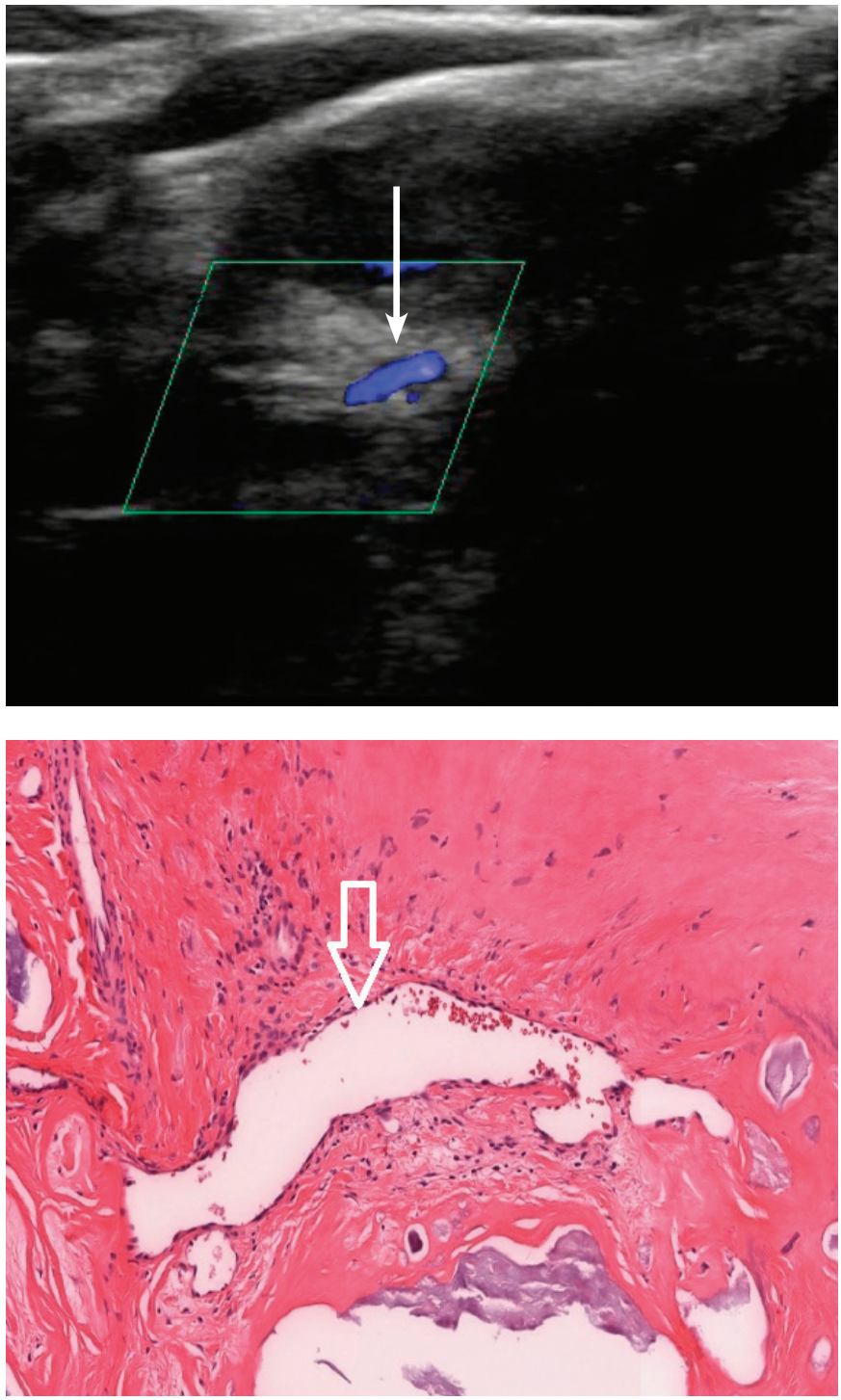


Figure 1. A carotid bulb plaque demonstrating a large neovessel (arrows) detected with cSMI and confirmed by histology.

scheduled for preoperative CTA evaluation for a pending carotid endarterectomy. Bilateral still images and cine clips of the extracranial arteries were acquired using the 7.5 MHz linear array probe. Image parameters (depth, overall gain, and focus) were optimized for each patient independently. Initial grayscale assessments were performed to localize the plaque. Subsequent targeted scanning of the plaque was then performed utilizing conventional power Doppler and SMI modes. Additional spectral waveforms were obtained to confirm flow if plaque neovascularization was suspected. Image analysis was conducted by two independent readers (one radiologist and one sonographer); while pathology specimens were analyzed by a blinded pathologist.

Evidence of intraplaque neovascularity (sonographic and pathologic) was scored using a four point scale (Table 1). SMI modes (cSMI and mSMI) were evaluated and compared to conventional techniques (CTA and ultrasound), while using pathology as a reference standard (Figure 1).

Although the study is ongoing, initial results are promising. SMI detected intraplaque neovascularity in 22 out of 32 examined vessels, while conventional power Doppler detected flow in only nine, and CTA 0 ($p < 0.01$). In one particular case, SMI detected flow in an internal carotid artery diagnosed by CTA and conventional ultrasound as being completely occluded (Figure 2). Visualization of flow hemodynamics was

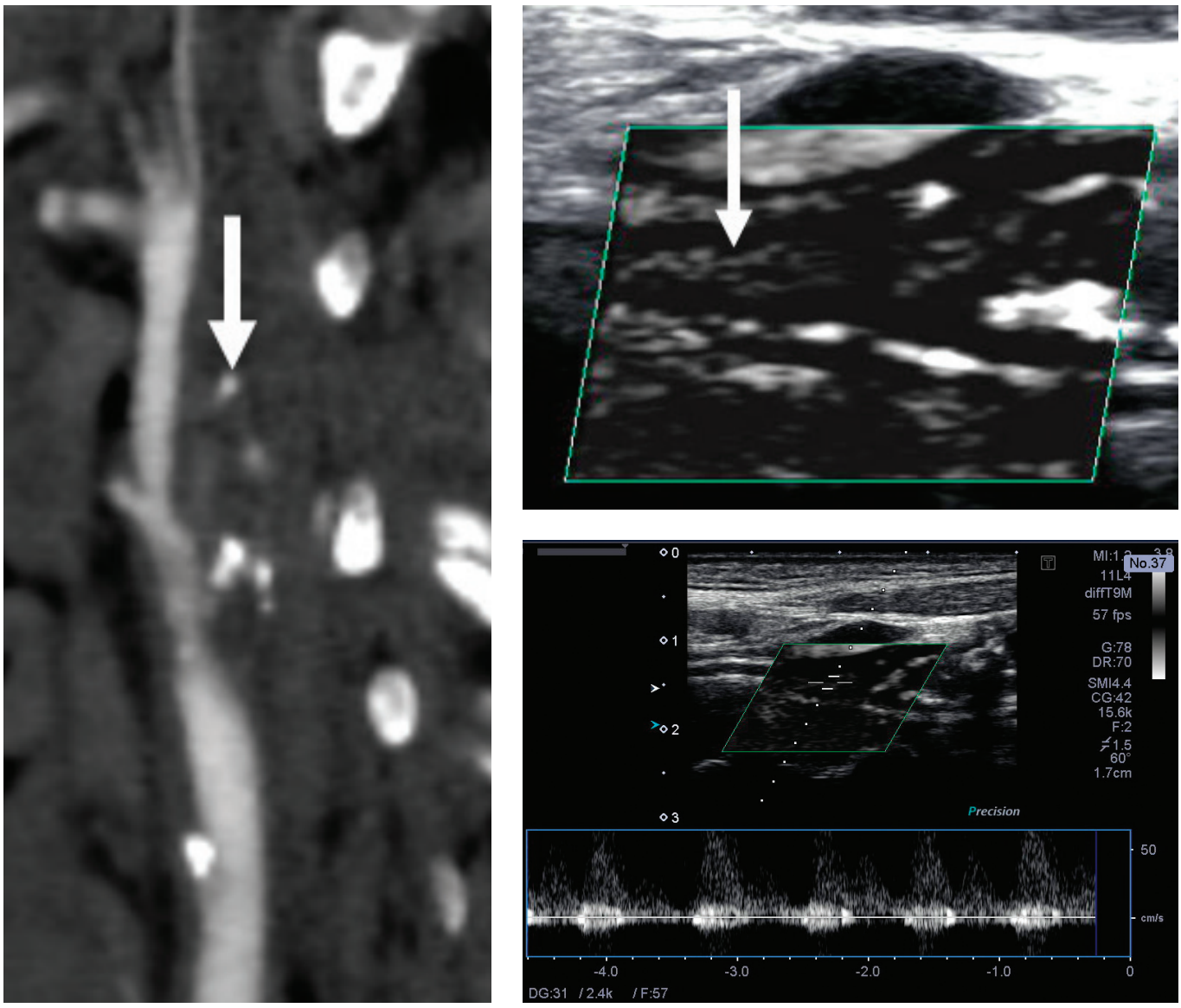


Figure 2. CTA image (left) displaying an occluded internal carotid artery (arrow) and mSMI image (top, right) detecting flow within the same vessel (arrow) and confirmed with cSMI and spectral Doppler (bottom, right).

also enhanced with SMI (Figure 3). The results of our study further validated SMI's ability to identify neovascularity by determining there was no significant statistical difference between both ultrasound readers and pathology (mean scores for ultrasound 1.4 and pathology 1.7; $p > 0.08$).

SMI is a technological advancement in vascular imaging. A new tool added to an old medium expanding our clinical armamentarium, SMI improves overall detection of flow and provides a contemporary and exciting look into flow hemodynamics. By improving our ability to obtain flow information, this application has the potential to alter the way we interrogate chronic calcified plaques and interpret hemodynamics.

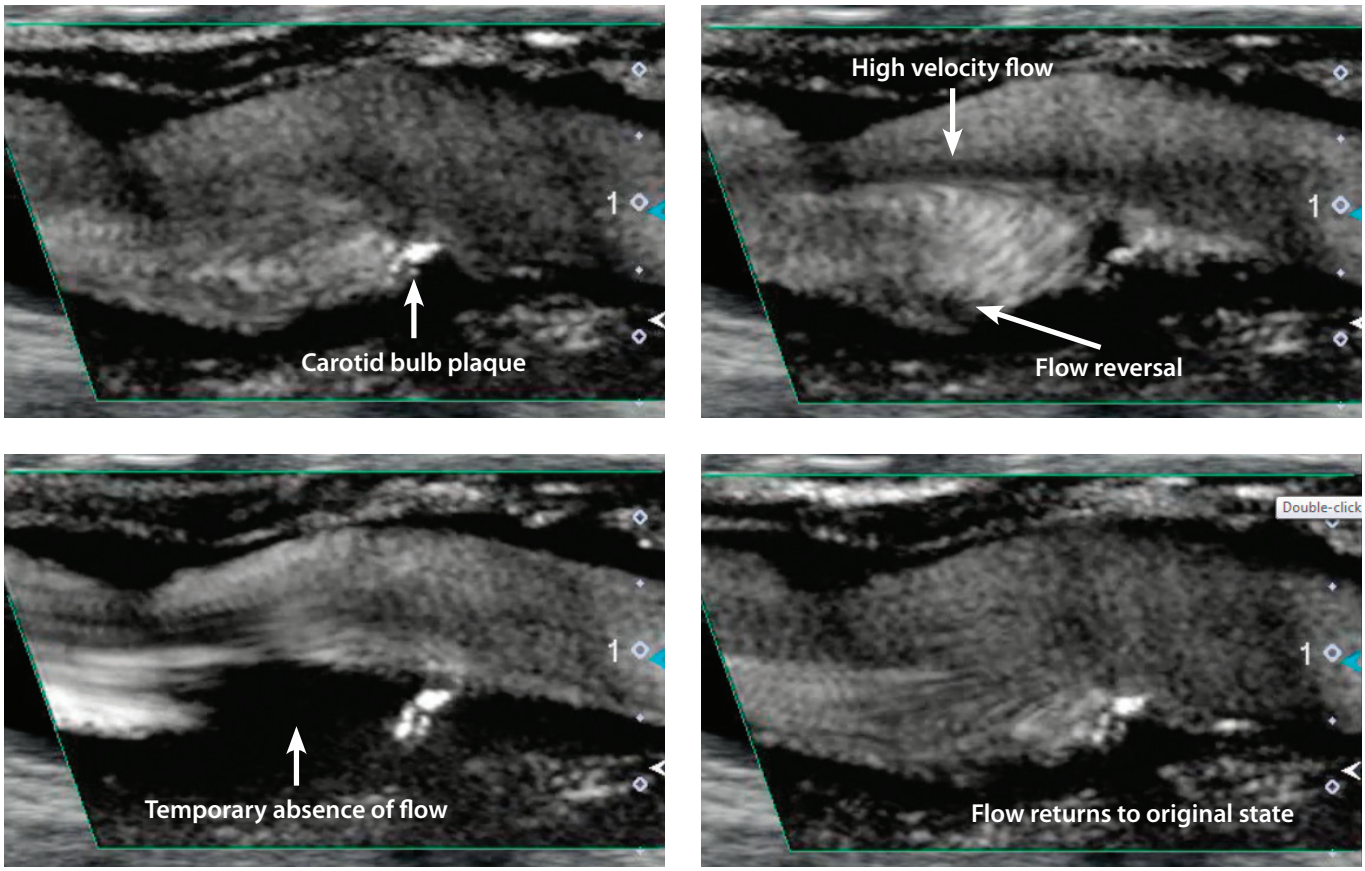


Figure 3. Flow hemodynamics surrounding a carotid bulb plaque obtained using mSMI. To see mSMI in action, please use the QR code or this URL: https://medical.canon.com/go/Aplio-WP

REFERENCES

1. *World Health Organization (2016, June) Cardiovascular diseases (CVD's) fact sheet. Retrieved 2016, August: http://www.who.int/mediacentre/factsheets/fs317/en/*

2. *Erlov T, Cinthio O, Edsfeldt A, et al. Determining carotid plaque vulnerability using ultrasound center frequency shifts. Atherosclerosis. 2016 Mar:246:293-300.doi: 10.1016/j.atherosclerosis.2016.01.019. Epub 2016 Jan 15.PMID:26824224.*

3. *Brinjikji W, Huston J 3rd, Rabinstein AA, Kim GM, Lerman A, Lanzino G. Contemporary carotid imaging: from degree of stenosis to plaque vulnerability. J Neurosurg. 2016 Jan; 124(1):27-42. doi: 10.3171/2015.1.JNS142452. Epub 2015 Jul 31. Review. PubMed PMID: 26230478.*

4. *Alonso A, Artemis D,Hennerici MG. Molecular imaging of carotid plaque vulnerability. Cerebrovasc Dis. 2015 Jan: 39(1):5-12.doi 10.1159/000369123. Epub 2014 Dec 24.PMID: 25547782.*

The clinical results described in this paper are the experience of the author. Results may vary due to clinical setting, patient presentation and other factors.

Follow us: https://us.medical.canon @CanonMedicalUS +CanonMedicalUS Canon Medical Systems USA, Inc. +CanonMedicalUS

CANON MEDICAL SYSTEMS USA, INC.
https://us.medical.canon

2441 Michelle Drive, Tustin CA 92780 | 800.421.1968

ULWP12824US MOIUS0093EBA

Made For life