Assessment of carotid plaque morphology using photoacoustic imaging

Marc van Sambeek
Min Wu, Roy van Hees, Jan-Willem Muller, Camillo Cano Barrera,
Amihr Golampour and Richard Lopata

Catharina Hospital Eindhoven
Eindhoven University of Technology
Disclosure

Marc van Sambeek

I have the following potential conflicts of interest to report:
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In 1977 Harrison and Marshall demonstrated that 66% of symptomatic patients undergoing CEA < 4 weeks of their most recent event had thrombus overlying the carotid stenosis, compared with 21% of patients waiting for a longer period.  

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A carotid plaque becomes symptomatic by plaque rupture
68% of heart attacks and most strokes are caused by plaque rupture and thrombosis, not stenosis.
The composition and mechanical properties of the individual carotid plaque can be different. This influences the plaque vulnerability.

To prevent (recurrence of) cerebrovascular incidents, assessment of **plaque vulnerability** is important.
Vulnerable plaque
- thin fibrous cap
- large lipid-rich necrotic core
- plaque inflammation
- vascular remodeling
- neovascularization
- intra-plaque hemorrhage
Photoacoustic imaging (PAI) has the advantage of detecting tissue-specific optical contrast due to the presence of certain chromophores in the tissue that is not visible in ultrasound imaging.

A chromophore is the part of a molecule responsible for its color. Visible light that hits the chromophore can be absorbed by exciting an electron from its ground state into an excited state. The chromophore is the moiety that causes a conformational change of the molecule when hit by light.
The portable photo acoustic-ultrasound imaging system and the hand-held probe.
Experimental setting

In vivo setting

In this study (N=23), PA/US imaging was performed during carotid endarterectomy surgery. The intraoperative PA imaging enables investigation of the PA signals originating from the plaques without interfering superficial tissue, such as the skin and muscle layers, while still keeping in vivo pulsatile motion.
In vivo setting

(a) US image; (b) overlaid PA/US image (at 808 nm); (c) photo of the carotid plaque during the CEA surgery; (d) Mason’s trichrome staining of the artery.
CONCLUSIONS

In this study, we demonstrated the capability of PA imaging to detect plaques with intraplaque hemorrhages in humans by performing the first pilot clinical study of PA imaging in patients during carotid endarterectomy surgery.

Our results are a next step in the clinical translation of PA imaging for non-invasive applications.