Assessment of carotid plaque morphology using photoacoustic imaging

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Disclosure

Marc van Sambeek

I have the following potential conflicts of interest to report:

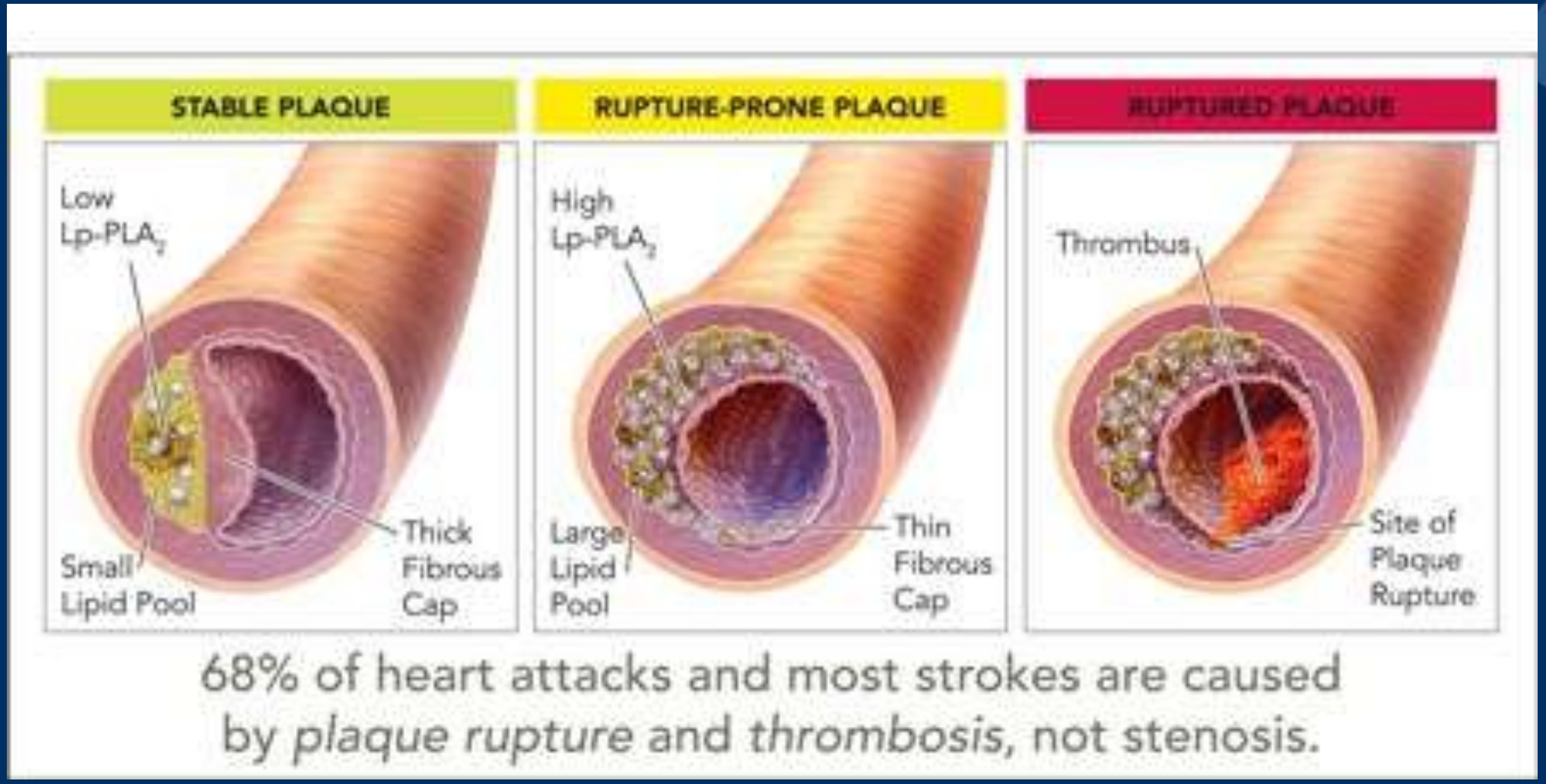
- Consulting and speakersfee
  - WL Gore & Associates
  - Medtronic
- Unrestricted research grants
  - Medtronic
  - W.L Gore & Associates
  - Philips Medical Systems

Plaque rupture

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.

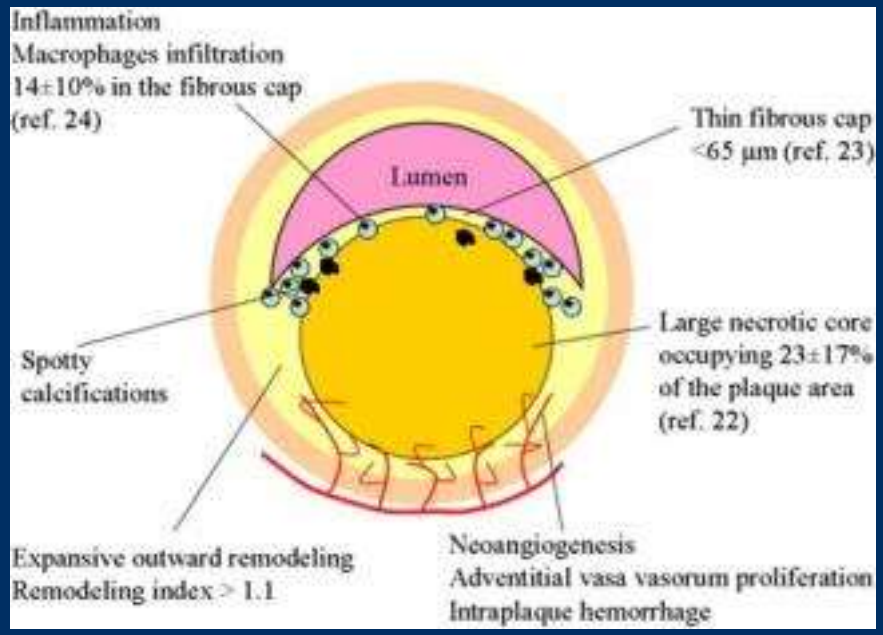
Brit J Surg 1977;64:511-2

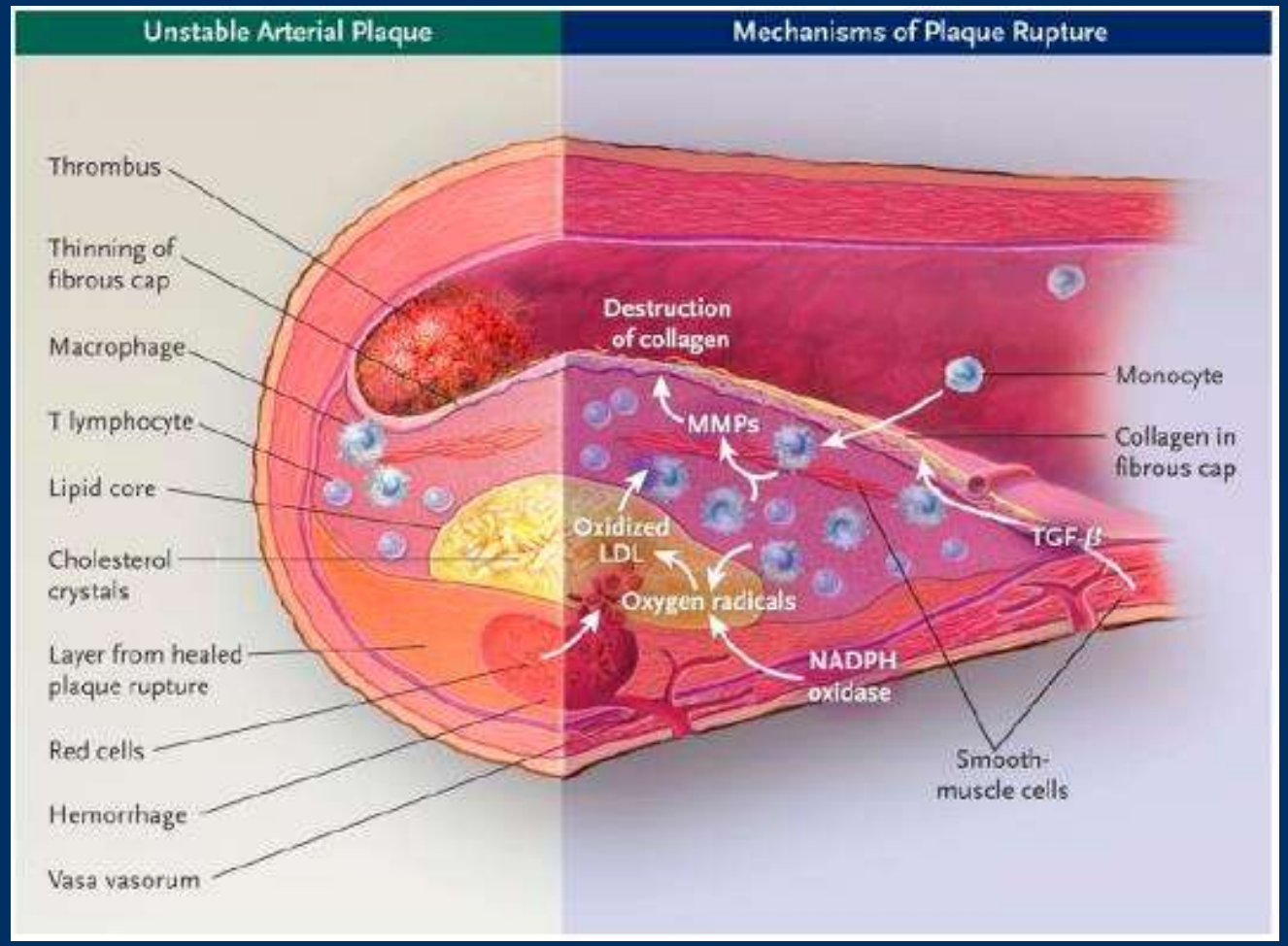
A carotid plaque becomes symptomatic by plaque ruptuur


STABLE PLAQUE
RUPTURE-PRONE PLAQUE
RUPTURED PLAQUE
Low Lp-PLA2
Small Lipid Pool
Thick Fibrous Cap
High Lp-PLA2
Large Lipid Pool
Thin Fibrous Cap
Thrombus
Site of 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

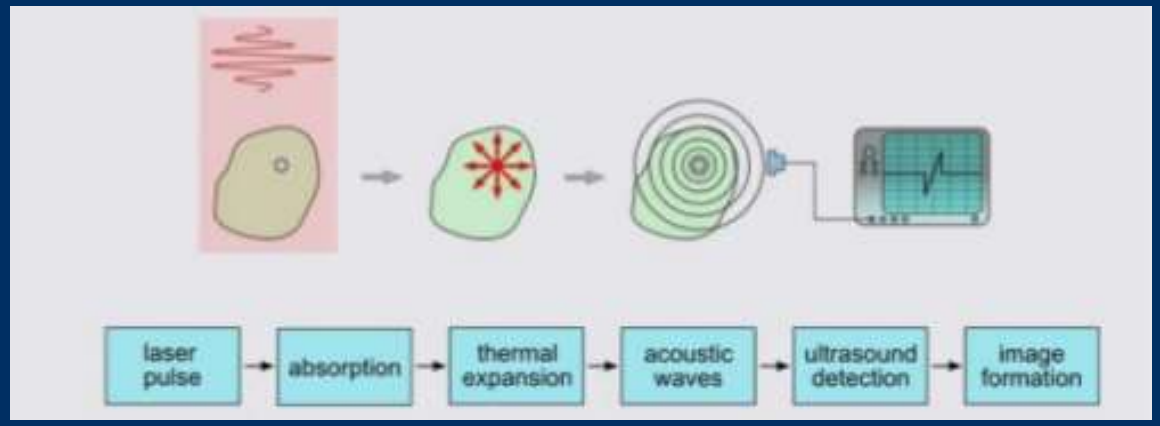


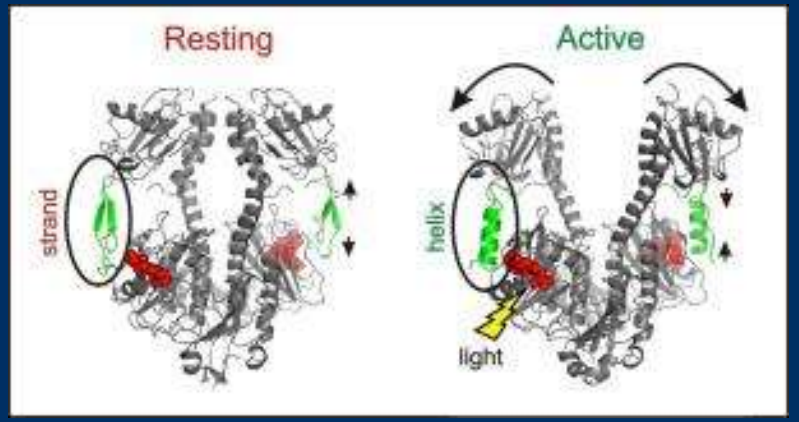


Vulnerable plaque

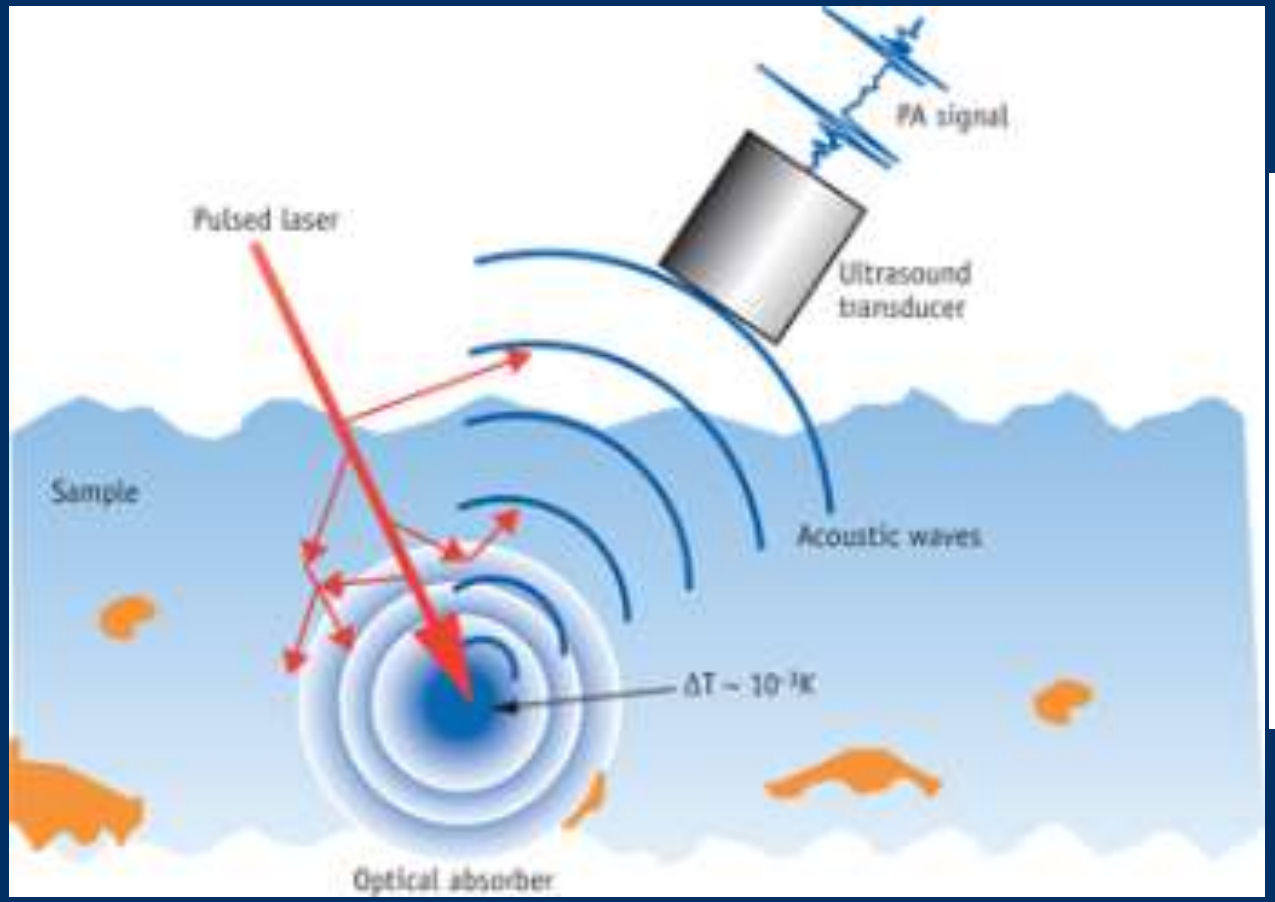
- thin fibrous cap
- large lipid-rich necrotic core
- plaque inflammation
- vascular remodeling
- neovascularization
- **intra-plaque hemorrhage**

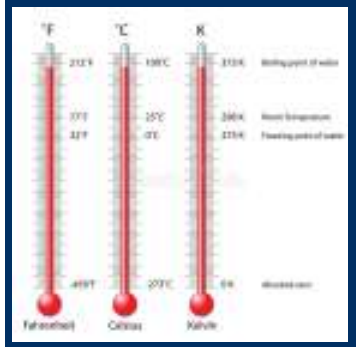
Photoacoustic imaging (PAI) has the advantage of detecting tissue-specific optical contrast due to the presence of certain chromophores in the tissue that is not visible in ultrasound imaging.





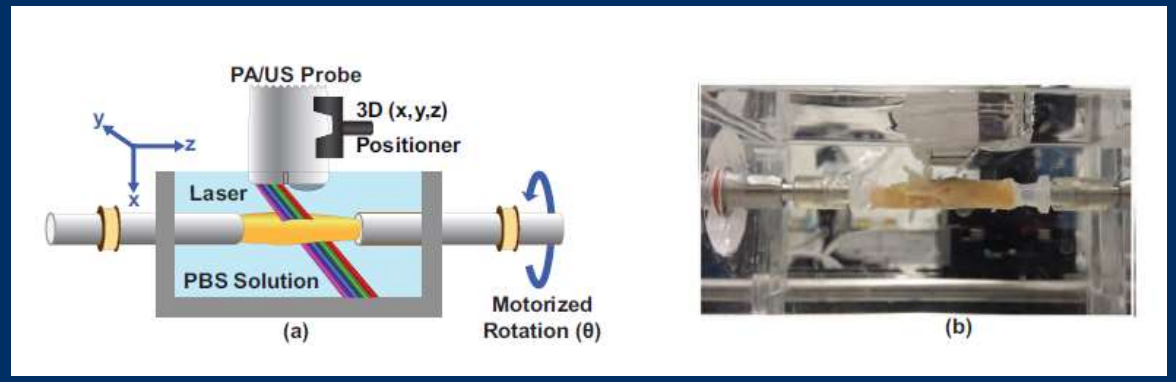
*A **chromophore** is the part of a molecule responsible for its color.*
Visible light that hits the chromophore can be absorbed by exciting an electron from its ground state into an excited state.
The chromophore is the moiety that causes a conformational change of the molecule when hit by light.

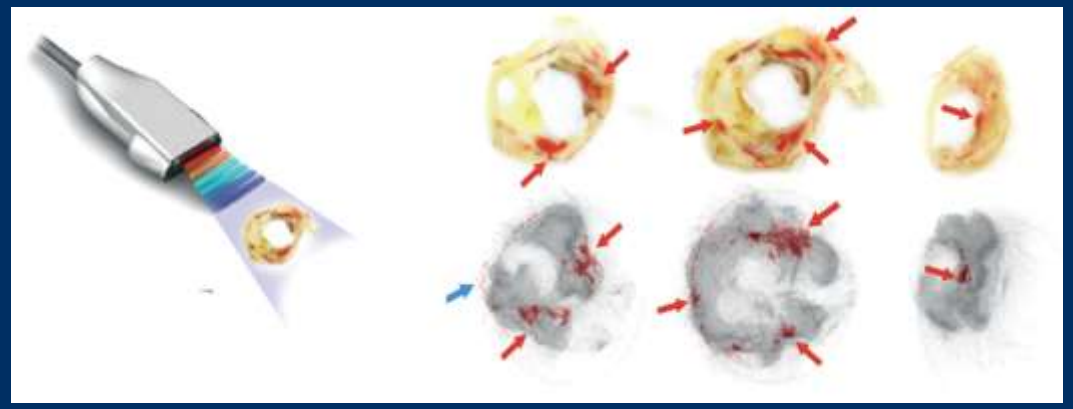

PA signal
Pulsed laser
Ultrasound transducer
Sample
Acoustic waves
ΔT ~ 10⁻³K
Optical absorber


°F
°C
K
Fahrenheit
Celsius
Kelvin

The portable photo acoustic-ultrasound imaging system and the hand-held probe.

Experimental setting

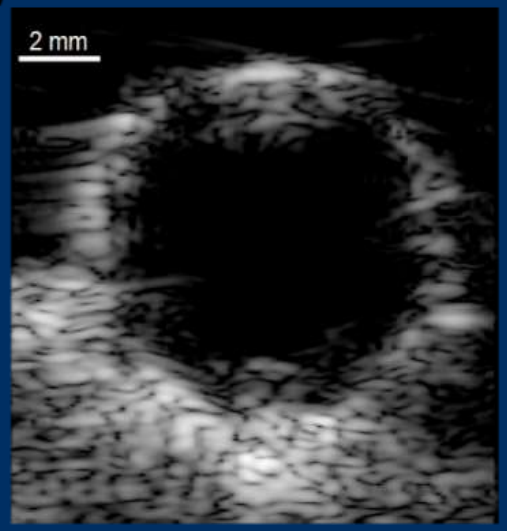




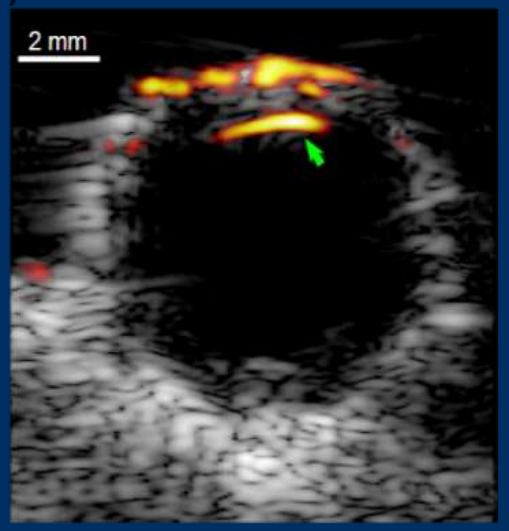
Arabul MU J Biomed Opt 2017;22:41010

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.



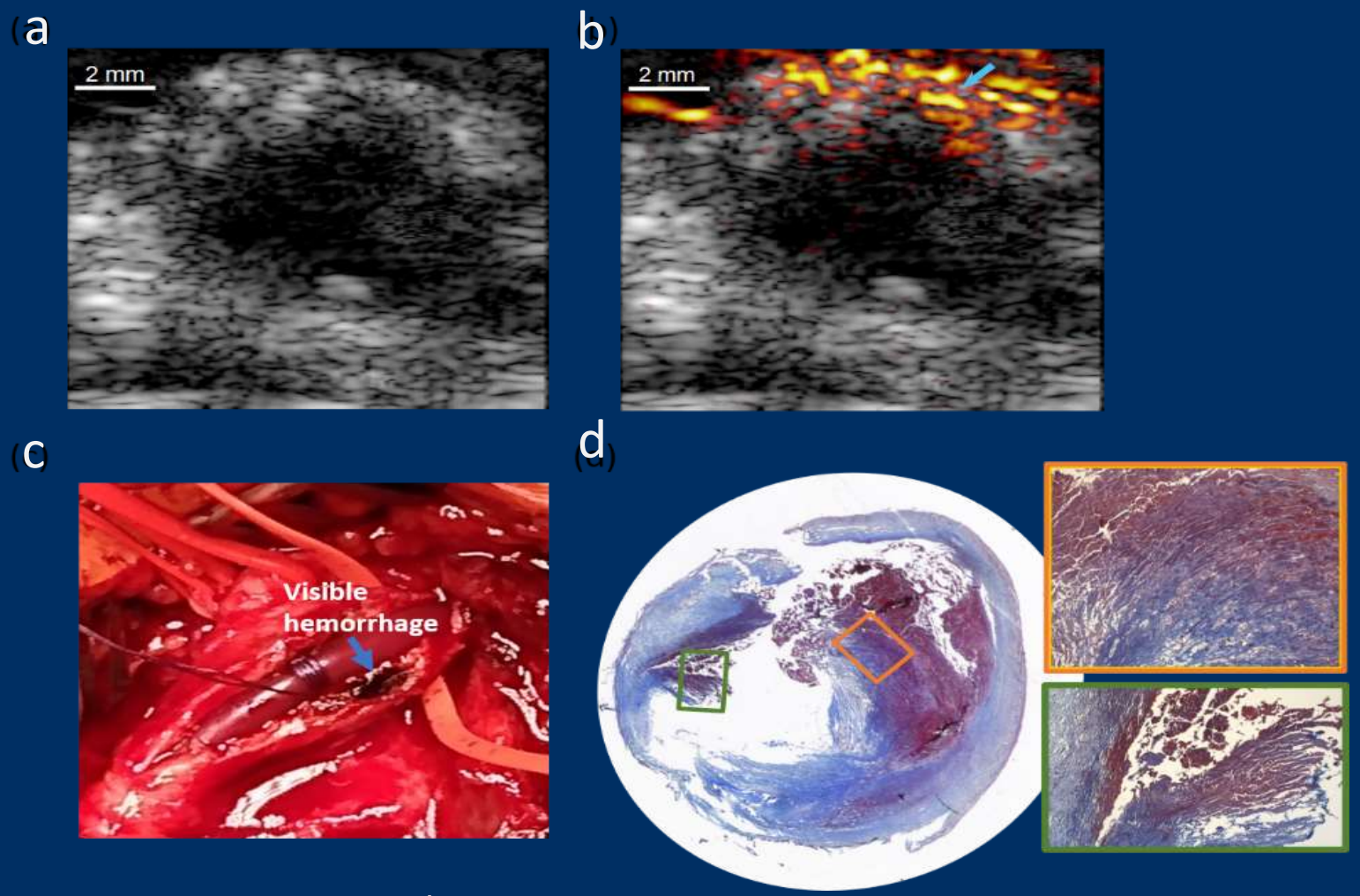
Ultrasound



Ultrasound + PAI

Histology

In vivo setting



(a) US image; (b) overlaid PA/US image (at 808 nm); (c) photo of the carotid plaque during the CEA surgery; (b) (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.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