A giant leap forward:
Novel diagnostic techniques for giant cell arteritis

On May 2, 2024, Magdalena Naumovska defended her thesis "Non-Invasive Diagnostic Approaches for Giant Cell Arteritis" at the Dept. of Ophthalmology, Clinical Sciences, Lund University. The main supervisor was Malin Malmsjö, M.D., Ph.D. Dept. of Clinical Sciences, Skåne University Hospital, Lund University, with co-supervisors Rafi Sheikh, M.D., Ph.D. and Björn Hammar, M.D., Ph.D. Dept. of Clinical Sciences, Skåne University Hospital, Lund University.

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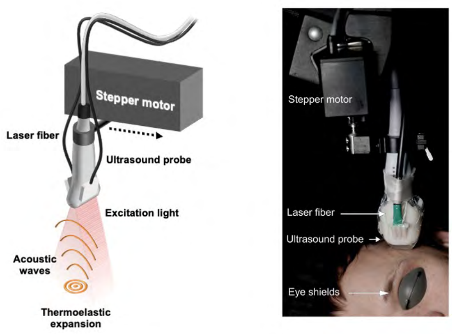
Giant cell arteritis (GCA) is an inflammatory vascular disease that primarily affects individuals over the age of 50. The exact cause of GCA is unknown, and while the disease is generally rare, it is more common in Scandinavia compared to other regions of the world, with an incidence of 15–20 cases per 100,000 in people aged 50 years or older. Despite its relatively low incidence, GCA is often suspected in healthcare settings due to the potential consequences of a missed diagnosis. If left untreated, GCA can lead to severe vascular complications, such as blindness or stroke, making it crucial to initiate treatment promptly. However, diagnosing GCA can be challenging, as there are no definitive diagnostic criteria and the symptoms are often initially diffuse.

Temporal artery biopsy has long been considered the gold standard for diagnosing GCA, but it has low diagnostic sensitivity and carries surgical risks. Therefore, a non-invasive diagnostic method would be highly beneficial. Previous attempts using methods such as ultrasound have shown variable results in terms of diagnostic accuracy. In recent years, several new imaging techniques have been developed with promising results for visualizing tissues and blood vessels. This thesis explored three novel methods for future GCA diagnosis: photoacoustic imaging (PAI), ultrasound center frequency shift (CFS), and tomographic 3D ultrasound.

Key points:

- PAI provides detailed spectral and spatial information and can be used to map the architecture of the temporal artery *ex vivo*. It has the potential to differentiate spectra of temporal arteries affected by GCA from those unaffected.
- Ultrasound CFS has the potential to differentiate temporal arteries with and without GCA *ex vivo*.
- Tomographic 3D ultrasound can be used to visualize the temporal artery and to measure geometric features of the vessel, such as the wall thickness, which may be altered in GCA.

Figure 1. Illustration of the photoacoustic imaging setup (left) and the image from an in vivo examination (right). The photoacoustic probe consists of an ultrasound transducer with laser fiberoptic bundles attached on each side, which is fixed to an adjustable arm with a linear stepper motor to scan the whole target. The tissue is irradiated with pulsed laser light, causing thermoelastic expansion, which generates acoustic waves that can be detected by the ultrasound transducer. The obtained spectral information can be used to analyze spectral signatures and to map the architecture of the temporal artery.



PAI is a biomedical technique that combines laser light and ultrasound to generate high-resolution images of biological tissues. PAI was performed in vivo on healthy temporal arteries and ex vivo on temporal arteries from subjects suspected of having GCA. The results showed that PAI is safe with regard to visual function and can provide detailed spectral information allowing the architecture of the temporal artery to be mapped. Spectral analysis revealed differences between temporal arteries affected by GCA and those without GCA, which reflected the molecular composition. Ultrasound CFS is a novel ultrasound technique that provides objective information about tissue microstructure. It was tested on temporal arteries ex vivo from patients suspected of having GCA. The results showed that the CFS value decreased less in arteries with GCA compared to those without, suggesting that ultrasound CFS has the potential to distinguish between vessels affected by GCA and those that are not. Tomographic 3D ultrasound was used to visualize the temporal artery in both healthy individuals and patients with suspected GCA. This technique allowed for 3D visualization of the temporal artery and enabled the calculation of vessel geometry, such as vessel wall thickness, which may be altered in GCA.

In conclusion, PAI, ultrasound CFS, and tomographic 3D ultrasound are promising non-invasive diagnostic tools for GCA. Timely and reliable diagnosis of GCA would enable the early initiation of treatment, thereby preventing the vascular complications associated with GCA, while simultaneously avoiding the unnecessary treatment of patients who do not have GCA.

Remaining questions:

- After technical development, large clinical trials are needed to assess the diagnostic performance of PAI, ultrasound CFS and tomographic 3D ultrasound in GCA.
- Follow-up studies to investigate if these techniques can be used to detect the subtle differences due to inflammation when treatment has been initiated.

References

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