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RESEARCH

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TAT/PAT: a new screening option?

Early diagnosis and treatment are key to surviving breast cancer. Over the past decade, advances in screening and treatment technologies have reduced the death rate from this disease by about 20%. But while mammography is used routinely as a mass screening tool for detecting breast cancers, it's not perfect: the technique struggles to image dense glandular tissue, early-stage tumours and those close to the chest wall or underarm.

Ultrasonography and MRI are increasingly being used as complementary modalities for breast-cancer diagnosis. Ultrasound specificity is limited, however, by the overlapping acoustic characteristics of benign and malignant solid lesions. MRI, meanwhile, offers excellent sensitivity but rather variable specificity. It's also the most expensive of the current breast imaging modalities.

Researchers at Washington University in St. Louis, MO, (WUSTL) have come up with another option: a scanner that integrates thermoacoustic and photoacoustic tomography (TAT/PAT) to achieve dual-contrast (microwave and light absorption) imaging. The non-ionizing, low-cost scanner can potentially provide high-resolution, dual modality 3D images of the breast (*Med. Phys.* **35** 2218).

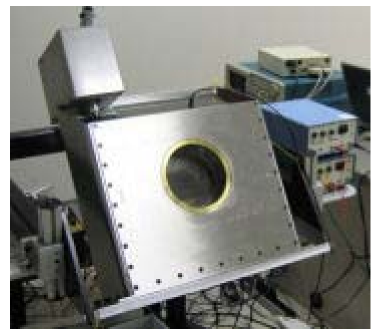
"Depending upon the clinical testing outcome, TAT/PAT could potentially replace X-ray mammography if its sensitivity and specificity are high enough," Lihong Wang, director of WUSTL's Optical Imaging Laboratory, told *medicalphysicsweb*. "Otherwise, it can serve as an adjunct."

Two-in-one

TAT works by irradiating tissue with microwave or RF pulses. When this energy is absorbed, it causes localized heating that results in a pressure wave. This wave is detected by ultrasound transducers at the tissue surface and can be used to generate an image.

The RF contrast between malignant tumour tissue and normal human breast tissue is about 4:1, with one recent study showing a contrast in dielectric properties between malignant and normal adipose-dominated breast tissues of up to 10:1. In comparison, X-ray contrast is typically only a few percent among soft tissues.

PAT exploits the same effect, except that the ultrasound is generated by irradiating the region of interest with pulsed near-infrared light. Here, the image contrast arises from the degree of vascularization within the tissue, with the optical absorption contrast of oxy- and deoxyhaemoglobin relative to the background as high as 10:1. Thus PAT is ideal for quantifying features such as angiogenesis and hypoxia, which are correlates of breast malignancy.



TAT/PAT

To create the dual-modality scanner, the WUSTL researchers integrated a 1064 nm Nd:YAG laser and a 3.0 GHz microwave source into a single device. The ultrasound signals are detected by transducers that revolve by 360 degrees around the sample. The breast is placed in a cylindrical aperture at the front of the scanner and compressed from the front, which potentially enables imaging near the chest wall. The system can instantaneously switch between microwave and laser illumination.

The researchers tested the TAT/PAT scanner using tissue phantoms made of porcine fat to mimic fatty breast tissue. Five water-based gel targets (of about 6 mm in diameter) were buried inside the phantom - two made of clear gel and three of black gel. TAT and PAT images were recorded using ultrasonic transducers with 13 and 6 mm-diameter active areas.

The RF absorption contrast between the gel and the background fatty tissue is about 4:1. As expected, TAT clearly imaged all five targets. The contrast, signal-to-noise ratio and resolution in the reconstructed TAT images were around 3.5:1, 34 and 1.2 mm, respectively, for the 13-mm transducer, and about 2.5:1, 20 and 0.7 mm for the 6-mm transducer.

The reconstructed PAT images only revealed the black targets, as the contrast in this case is dependent on light absorption. Here, the images exhibited contrast, signal-to-noise ratio and resolution of about 4.1:1, 64 and 0.7 mm, respectively, for the 13-mm transducer, and around 3.8:1, 27 and 0.7 mm for the 6-mm transducer.

The researchers conclude that "TAT and PAT together can provide additional functional information for the diagnosis of breast cancer." Integrating the two modalities into a single system also enables consecutive image acquisition without having to realign the patient - reducing both scanning time and system cost.

Wang points out that the techniques are highly compatible with pure ultrasonography, and notes that the team now plans to integrate ultrasound pulse-echo imaging into the scanner. Clinical testing is also in the pipeline, dependent upon the results of a pending grant application.

About the author

Tami Freeman is Editor of *medicalphysicsweb*.