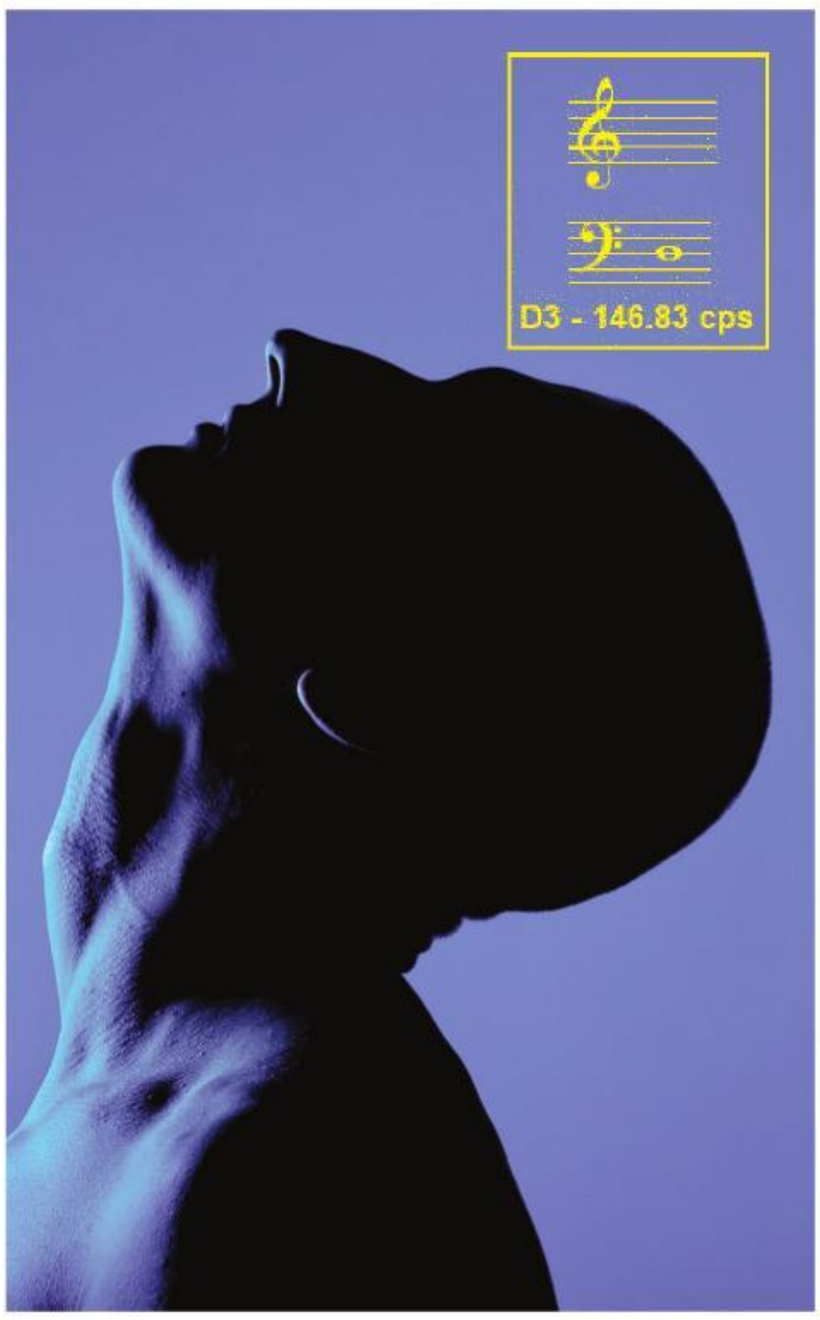
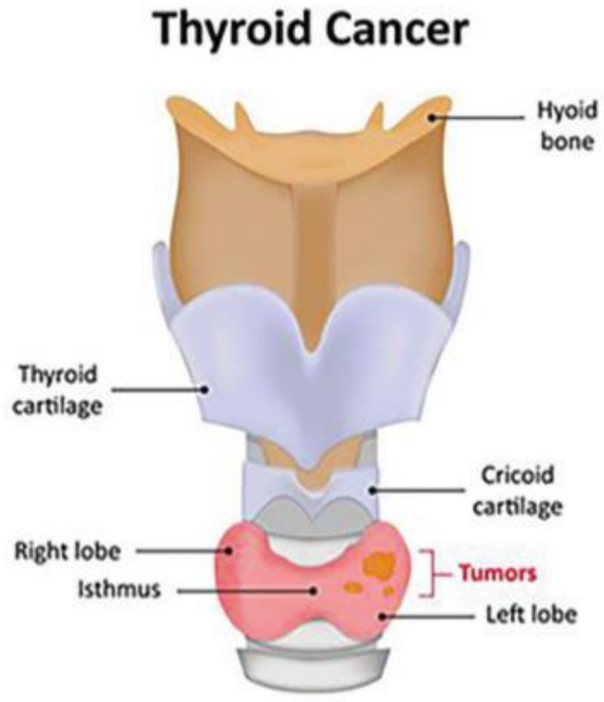
Tenor in the pathology lab

Voice can act as the tissue probe to detect cancer in the thyroid gland

S ANANTHANARAYANAN





A technique used to image Earth faults deep underground shows a way to peer into tissue of the human body.

The technique, which is described by Steve Beuve, Samuel Callé, Elise Khoury, Emmanuel Gilles Simon and Jean-Pierre Remenieras, from Université de Tours, Univerisité Bourgogne and the university hospital, Bourgogne, in France, in the journal, *Applied Physics Letters*, relates to the tissue of the thyroid gland. The thyroid gland can be affected by cancer. The current methods of detection of the cancer, however, do not locate the cancer precisely, and the detection of cancer can entail more discomfort than its treatment and cure. The new method, where the patient participates, leads to easier and more accurate detection.

The most common form of cancer of the thyroid gland, especially when detected early, is among the most treatable cancers. Detection is by physically feeling the area of the throat for the harder nodules that form, and with the help of ultrasound or x-rays. If a tumour is found, it must be followed by biopsy, or excision of a bit of the tumour, for lab tests, to see if the cells are malignant.

The excision is done by inserting a fine needle into the nodule and syringing out a sample. The procedure, known as fine needle aspiration, has often to be repeated, as it is only in some five per cent of the trials that the cancer is detected.

A reason for the poor results could be that the ultrasound, or even sophisticated x-ray methods, do not provide any supplementary information about the tissue in the places where they detect tumours. Ultrasound, for instance, does not create the contrast needed to make out live and dead tissue. The CAT scan, which uses x-rays to image an organ in several "slices" and puts together a 3D picture, is sensitive, but does not help make out malignancy.

The method now used to probe what is called soft tissue in the body, in different organs, is shear-wave elastography. Mechanical waves, like sound waves, that pass through media, are compression waves, or longitudinal waves, where the to-and-from motion of material is along the direction of the wave. In the ripples on the surface of a pond, or a violin string that is plucked, in contrast, the motion is at right angles to the direction of the wave. These are called transverse waves. Transverse waves can also arise when the surfaces of bulk materials are exposed to vibration. Here, planes within the material move relative to each other, and these are called shear waves.

The movement of longitudinal and transverse waves through the body of the Earth, and over its surface, is routinely used to make out seismic fault lines, presence of water, or minerals or ores, etc, within the depths of the Earth. In the case of tremors set off by movements in the Earth's crust, undersea volcanic action, etc, waves which travel, directly and after reflection at discontinuities within the Earth, get detected at observation centres, to locate and assess the severity of the tremor. Waves could also be generated on purpose, usually by explosives, and the timing of detection at different observation points leads to information about the nature of the material at different depths under the Earth's surface.

The use of elastography to probe body tissue is an extension of the same principle. As the movement of shear waves through the body of tissue brings about compression and bending of the material, a shear wave would scatter waves of ultrasound that are passed through the tissue at the same time. If there are spots where the material is of greater stiffness, the shear waves would move faster when they pass through those portions, and it would show up in the ultrasound scattering pattern. The method is then a sensitive way of discovering non-uniformities, and hence possible malignancy, in soft tissue.

A development of the technique is not to use an external source of vibration of the surface of the tissue, to create the shear wave, but to rely on the body's own physiological distortions, like the beating of the heart, expansion and contraction of blood vessels or respiration. The method is both non-invasive and sensitive, and by probing the tissue under study by ultrasound from different directions, an accurate map of the tissue distribution can be obtained. As there is no active source of vibration, the method is called *passive elastography*. The paper in *Applied Physics Letters* says that this technique has been applied to look for tumours in the thyroid, and the main arteries in the neck region are most suitable as sources of shear waves.

A factor that determines how effective this method can be is how strong the source of vibration is, in comparison with incidental disturbances, what is called the signal to noise ratio. In *passive elastography*, as the source of vibration is feeble, this could be a limitation. And then, the source of vibration is not what the investigator can control, and the investigation has to make the best of available sources.

The work reported in *Applied Physics Letters* moves forward, halfway in principle, but a lot in results, by harnessing the patient's own voice to work as the source of vibrations. The carotid artery, which is right next to the thyroid gland, the paper says, vibrates at the rate of less than ten beats a second. A higher frequency, which would create shear waves of shorter wavelength, would be more suitable. And a stronger source of waves would improve the signal to noise ratio too.

The paper reports that the vibrations of the vocal tract, when the patient vocalises a tone with a frequency of 150 cycles a second, produces robust shear waves that allow imaging of tissue with fine resolution. A tone at 150 cycles per second corresponds to something like D3, just to the left of the centre of the piano keyboard, an easy tone for a man or a woman to produce. And with this tone, using this method, which the authors call *vocal-passive elastography*, the authors could reach a resolution of 150 microns, or about a sixth of a millimetre. We can see that shear waves at 150 cps would be more than 15 times shorter than the waves at 0-10 cps, which come from sources like heartbeat or the carotid artery.

It is an innovative discovery of a higher frequency vibrator, right at the spot, at the thyroid gland, for accurate identification of where to aspirate. Reducing the discomfort of the patient, and involving her in the procedure, with a singing lesson, of holding a note, to boot!

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FOR RECHARGING GROUNDWATER

Permeability is an important property of soil investigation as an ongoing research project has found

MOHAMMAD KAFI

The excessive use and wastage of water in our country has landed us in a water-deficient zone. The scarcity is assuming such dimensions that more than 50 per cent of the population has no access to safe drinking water. Around 200,000 people die every year due to this reason. The present-day water crisis is the worst in history and India is considered at the centre of the global water calamity and sanitation.

Due to low rainfall and increasing pollution, surface sources are not dependable anymore. Thus, groundwater is the only option left to feed the demand of the population. According to Unesco, India is the largest extractor of groundwater. Fifty-four per cent wells in the country have gone dry and 21 major cities are going to be devoid of groundwater by the end of this year. Therefore, replenishment of groundwater sources by recharge of aquifers is the greatest need of the day.

Permeability is an important parameter of soil that governs seepage or infiltration -- it is the ease with which water travels in the soil through interconnecting voids. It warrants mention here that the seepage of rainwater not only takes place in a vertical direction but also horizontally. Thus, the determination of permeability in both directions becomes imperative.

Permeability plays a key role not only in groundwater recharge but also in estimation of seepage under hydraulic structures, such as dams and weirs. Seepage of water through the body of earthen dams has also been a cause of concern to hydraulic engineers. Many failures of dams have been reported in the past due to excessive seepage. Permeability is also a material property and differs from one material to another. The accurate estimation of soil permeability is of utmost importance for the selection of materials for the construction of hydraulic structures and their foundations.

The foundations of such structures are usually composed of porous media which allows the seepage of water into the foundation on the upstream side of the structure. This water, after entering the foundation, tries to escape on the downstream side. Thus, a pressure is created by the trapped water for its escape. This pressure is known as uplift pressure. Sometimes the uplift pressure escalates, and water escapes suddenly from the foundation with large amounts of bed material. This creates a blast-like situation and causes the failure of the structure. The phenomenon is known as "heave piping".

On the other hand, there is a slow process of movement of soil particles along with flowing water on the downstream side. Removal of soil particles from the foundation of the structure forms tube-like hollow spaces, which progresses in the backward direction with the dislodging of soil particles. This phenomenon is known as "backward erosion piping". If this piping reaches the upstream portion of the hydraulic structure, the structure as a whole is detached from the foundation and is washed away under the water pressure or may fail by subsidence.

Permeability was first determined by a French engineer called Henri Darcy in 1856. He conducted his experiments of flow of water on sand beds, which formed the basis of hydrogeology. Determination of permeability of soil in a vertical direction has been attempted by several researchers but its determination in a horizontal direction lags in comparison. For the determination of permeability in a vertical direction, standard procedures and equipment are available but that is not the case in the horizontal direction. This area needs the attention of scientists and researchers.

Moreover, the determination of permeability of layered soil carries great significance as soil in the Earth's crust is found mostly in layers. Thus, the determination of flow characteristics of water and permeability through layered soil, both in vertical and horizontal directions, are essential to effectively plan the schemes of groundwater recharge and seepage through and below hydraulic structures. The soil investigation of a certain area, with reference to permeability, could act as a basis for the determination of feasibility of the groundwater recharge scheme in that area.

With growing urbanisation and conversion of open land to built-up areas, the process of groundwater recharge is dwindling. The lowering of groundwater levels is taking place at such an alarming rate that in some districts of Rajasthan, people have left their dwellings and migrated to other areas. Studies have shown that the recharge of ground water is highly influenced by the permeability of the underlying soil. In case the soil is composed of stiff clays, with low permeability, rainwater is not able to find its way to the underground water strata. In such situations, the construction of recharge wells becomes important.

The Centre and state governments are keenly poised to implement groundwater recharge schemes for the survival of flora and fauna. Keeping in view the importance of the subject, the Council of Science and Technology Uttar Pradesh has sanctioned a project entitled "An Experimental Study on Permeability of Layered Soils Parallel to Bedding Plane" to the department of civil engineering at the Aligarh Muslim University, Aligarh. The amount sanctioned by UPCST is Rs 6.05 lakh for a span of two years. Work on the project started with effect from 1 February 2019 under the guidance of Professor Javed Alam, the principal investigator. The outcome is expected to be useful for farmers and scientists.

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PLUS POINTS

Metals in sharks

'Alarmingly high levels" of heavy metals have been found in sharks in the Bahamas, a new study has found. Researchers said human activities over the last century had "rapidly accelerated" the influx of metals entering the marine environment. The study found "alarmingly high levels" of a dozen heavy metals -- including mercury -- in large reef and tiger sharks throughout the Bahamas, where sharks live in a marine protected area.

Researchers from Beneath the Waves, a non-profit research institute, looked at muscle tissues of 36 sharks from six different species for the study, published in *Scientific Reports*. They said while the impacts on shark health were unknown, the concentrations of metals found exceeded levels that were considered toxic for human consumption.

The study concluded, "Our findings suggest that sharks residing within relatively pristine ecological environments may possess high levels of potentially harmful metals, which may have public health implications if they are consumed by local human populations."

Austin Gallagher, research co-author, said the study was "another piece of evidence to steer people away from consuming sharks". Sharks are not commonly eaten by people in the Bahamas, the researchers said.

Oliver Shipley, the study's lead author, said, "Understanding how sharks are affected by humans is critical for ongoing conservation efforts of these ecologically and economically important species."

The BTW research associate and postdoctoral researcher at the University of New Mexico said shark abundance was "relatively stable and healthy" in the Bahamas thanks to "effective long-term protection".

–THE INDEPENDENT

Next-gen antibiotics

The World Health Organisation has warned that the world is headed toward a post-antibiotic era if action is not taken to combat the issue of antibiotic resistance.

But one scientist is looking to prevent this by designing the "next generation of antibiotics". "The increasing appearance of multi drug-resistant strains of bacteria, together with the negligible number of new antibiotic drugs that are presently undergoing development, is becoming a colossal health threat," 81-year-old Israeli scientist Ada Yonath told *The Straits Times*. She said, "It seems that we will soon revert to the pre-antibiotic era, during which diseases caused by parasites or by simple or severe infections such as pneumonia or wounds were almost untreatable and resulted in frequent deaths."

Yonath won a Nobel Prize in Chemistry in 2009 for her work in studying the structure and functions of the ribosome – becoming the first woman in 45 years to win the coveted prize. The director of the Helen and Milton A Kimmelman Center for Biomolecular Structure and Assembly at the Weizmann Institute of Science said her team's concept for fighting antibiotic resistance is designing the next generation of antibiotics by zooming into ribosomal structures in bacteria.

The ribosome is a protein-making machine in almost all living cells, that strings together molecules called amino acids to form long chains that will eventually become proteins. Proteins in turn carry out many functions that are essential for life. Many antibiotics combat bacterial infections by preventing bacterial ribosomes from working.

But most antibiotics target ribosomes in a broad range of bacteria, which act on non-target bacteria along with the targeted bacteria and can lead to more antibiotic-resistant bacteria strains. Broad-range antibiotics can also cause disruption to native bacteria in the body – akin to throwing the baby out with the bathwater.

Yonath said such antibiotics rely on "traditional antibiotic binding sites" on bacterial ribosomes. So, to develop the next-generation antibiotics, it was key to map out the structure of ribosomes of disease-causing bacteria to identify new potential areas for antibiotics to target. This leads to the next step of designing compounds that match these targets, "thus blocking their function, and eventually killing the pathogen," said Yonath. These antibiotics targeting ribosomes specific to disease-causing bacteria species are called narrow-spectrum antibiotics.

–THE STRAITS TIMES/ANN