Duke engineers develop new 3-D cardiac imaging probe

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Biomedical engineers at Duke University's Pratt School of Engineering have created a new three-dimensional ultrasound cardiac imaging probe. Inserted inside the esophagus, the probe creates a picture of the whole heart in the time it takes for current ultrasound technology to image a single heart cross section.

The new probe has considerable potential not only for evaluating the condition of the heart, but also for use in guiding therapeutic treatment devices, the researchers said. The new Duke probe can also be used to image the esophagus, rectum, colon and prostate.

A peer-reviewed report on the work was published this month in volume 26 issue number 4 of the journal Ultrasonic Imaging. (Note: Because the journal's publication is backlogged, the issue date is 2004.)

The research is funded by the Heart, Lung and Blood Institute at the National Institutes of Health and by the National Science Foundation.

One form of ultrasound cardiac imaging, called transesophageal echocardiography (TEE), is conducted on hundreds of people each day in the United States. The technique entails inserting a probe down the patient's throat and behind the heart to capture ultrasound heart images. The images can reveal the condition of the heart chambers, valves, major blood vessels and heart tissue. TEE is a safe and fast diagnostic technique.

However, current TEE systems can quickly generate only two-dimensional cross-sectional images. This limitation makes it impractical for use in guiding therapeutic treatment devices such as ablation probes that burn off damaged cells that cause an irregular heart beat. Clinicians must repeatedly and painstakingly reposition the 2-D probe during treatments so, instead, they use fluoroscopy (X-ray movies) to guide the placement of the treatment devices. However, the use of X-ray imaging results in radiation exposure for patients and requires bulky lead-shielding garments for clinicians. In addition, such procedures take up to seven hours to complete.

Biomedical engineering professor Stephen Smith, who specializes in ultrasound imaging, said a move to three-dimensional imaging is the next logical step.

"Three-D ultrasound is already an established technology in many hospitals," Smith said. "With our new real-time 3-D transesophageal probe, we have all the benefits of the 2-D TEE probe and none of the drawbacks. We can generate sharp, high-contrast images of the whole heart and position heart catheters and ablation devices at the same time. We have already done so in laboratory tests on animals."

Smith and his team, including biomedical engineering graduate student Chris Pua, developed the probe specifically for use in hospitals and clinics. For example, they used the outer casing of a commercially available 2-D TEE probe to house their new 3-D model. The casing design already has been tested and approved for use.

The new Duke 3-D probe is tipped with a dime-sized array of 504 individual ultrasound sensors. Each sensor is as wide as a few human hairs. "It took a craftsman to create this probe," said Smith. "Not many graduate students could have done what Chris Pua has done."

"Maintaining the size of normal TE probes was a main factor in the design since 3-D imaging inherently requires significantly more sensors than 2-D imaging," said Pua. "The original casing held enough cabling for 64 transducer elements whereas our design successfully incorporates 8 times that number."

The probe generates ultrasound at 5 million vibrations per second, which, combined with the 504 sensors, provides great sensitivity and a sharp image, Smith said. And because the image is large enough to encompass the whole volume of the heart, fewer "pictures" need to be taken. This may shorten patient time in clinics, he said.

Source: Duke University