Georgia Tech

Research News

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MENDING BROKEN HEARTS:
BACK-TO-BASICS ENGINEERING PROVIDES
A TOOL FOR HEALING TROUBLED VALVES

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A new tool for assessing leaky heart valves may soon help doctors gauge problems non-invasively, without diagnostic surgery. Once perfected, the technique could bolster the battle against enlargement of the heart, certain types of high-blood pressure and other serious disorders caused by leaky valves that force the heart to work overtime.

Used in conjunction with conventional ultrasound Doppler imaging, the new technique is believed to be the first quantitative, non-invasive method for measuring the volume of blood leaking from human or artificial heart valves. Existing diagnostic techniques help characterize a leak based on physical measurements, but they offer little quantitative information about the severity of blood flow, explained Dr. Ajit P. Yoganathan, co-director of the Bioengineering Center at the Georgia Institute of Technology.

Yoganathan's findings were presented March 20 at the American College of Cardiology 1990 conference in New Orleans, La.

The Georgia Tech method employs basic engineering principles to calculate the volume of leakage, using a mathematical formula. Equations are based on physical characteristics of a particular leak, as characterized by ultrasound Doppler, an imaging technique for taking radar-like measurements or 'pictures' inside the body.

Yoganathan's unique blood-flow duplicator, a system of mechanical valves and pumps representing a human heart, provided preliminary information to validate the formula, graduate student Edward G. Cape reported. In both steady-state and pulsating-flow models, Yoganathan said, mathematical/Doppler predictions corresponded well with volume measurements of simulated blood flow.

Today, doctors can diagnose heart disorders with non-invasive ultrasound Doppler, or by performing angiography. There are drawbacks associated with both techniques, Cape said.

Angiography is a painful, time-consuming procedure that involves threading a catheter tube along a tortuous path through the body and into the heart. After dye is injected into the heart, an 'X-ray movie' allows the doctor to measure how fast the valve is leaking.

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Angiography can't be used repeatedly to monitor a patient's progress following surgery, Yoganathan said, and the technique only estimates the severity of leakage, rating the problem on a qualitative, one-to-four scale.

Unfortunately, there are problems with color Doppler mapping, too. The technique is highly susceptible to technical factors -- such as variations in instrument settings -- which can distort results. What's more, Yoganathan said, color Doppler images sometimes aren't consistent with the results of angiography.

In a healthy human heart, blood pumps constantly through four chambers: the left and right atrium, and the left and right ventricle. Each chamber is equipped with a valve which opens and closes in a precise sequence. In a single heartbeat, oxygen-rich blood flows from the lungs into the left atrium, then into the left ventricle before dispersing throughout the body. At the same time, used, oxygen-deficient blood enters the right atrium and the right ventricle before entering the lungs, where it is revitalized.

When a valve leaks, however, a 'jet' of blood backs up into one of the chambers, requiring the heart to pump more forcefully. A number of health problems may result, including heart enlargement and cardiac failure. Georgia Tech scientists parlayed their knowledge of jets into a better understanding of blood jets leaking from faulty heart valves. Cape believes this back-to-basics engineering approach will continue to provide new perspectives on medical problems.

"Turbulent jets have been studied for years, but researchers have largely ignored this extensive engineering theory as it applies to medical problems," Cape said.

In laboratory experiments, either saline or a 40 percent glycerin solution (simulating the same flow rate as blood) were channeled through the duplicator. During preliminary studies, the system was set up to mimic a classic jet, unobstructed by chamber walls. Linked to an electromagnetic flow meter and other measuring instruments, the duplicator provided the physical data Cape needed to calculate the jet's volume. Later, conventional spectral Doppler imaging produced similar information, Yoganathan said.

Ongoing research is addressing more complicated leaks, which may encounter physical obstructions that alter flow patterns. Building on their work with conventional spectral images, the researchers also hope to incorporate color coded Doppler mapping. Further, Yoganathan believes it might be possible to incorporate the formula into an automated computer program, thus making it more feasible in a real-world, clinical setting.

Georgia Tech is working in collaboration with Dr. Robert A. Levine, a cardiologist with the Cardiac Ultrasound Laboratory at Massachusetts General Hospital in Boston. Findings were published in Circulation, the research journal of the American Heart Association.

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