Ultrasensitive detector pinpoints big problem in tiny fetal heart

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At the University of Wisconsin-Madison, one of the most powerful magnetic detectors in the world is helping screen high-risk pregnant patients for rare but very serious fetal heart rhythm problems. Thanks to a collaboration with The Medical College of Wisconsin, Milwaukee; Children's Hospital of Wisconsin, Milwaukee; and Hope Children's Hospital, Chicago, the ultrasensitive detector measures magnetic signals coming from the tiny beating hearts of fetuses.

The translational research program allows pediatric cardiologists and obstetricians from around the country to gather additional data and offer their patients the best treatment options.

"It's the only place in the country dedicated to evaluating rare and very serious fetal heart rhythm problems using biomagnetism," says Dr. Ron Wakai, the professor of medical physics at the UW School of Medicine and Public Health who created the lab. "In a typical year, we see between 50 and 70 patients, the vast majority around their 25th week of pregnancy."

Janette Strasburger, a pediatric cardiologist at Children's Hospital of Wisconsin and a professor of pediatrics at The Medical College of Wisconsin (both in Milwaukee), supervises each patient during the procedure along with her obstetrical research nurse, Gretchen Eckstein.

Strasburger and Wakai teamed up eight years ago to study how biomagnetism could be used to diagnose fetal heart problems. They were

soon joined by Bettina Cuneo, a pediatric cardiologist from Hope Children's Hospital in Chicago, who also specializes in fetal cases. With a solid scientific foundation now under their belts, the team has almost single-handedly created the emerging field of fetal cardiac arrhythmia care.

The result, says Strasburger, "is the closest thing there is to a cardiac intensive care unit for fetuses, with continuous monitoring while the mother and fetus are with us at the lab."

The hearts of the fetuses referred for evaluation may skip beats, race or beat too slowly. Structural abnormalities may also affect cardiac performance. Doctors must know exactly what's happening so they can treat accordingly. Results of the recordings, in conjunction with data obtained from current technologies such as ultrasound, allow physicians to offer appropriate treatment options—from cautiously waiting and seeing, to prescribing medications, to delivering the fetus as soon as possible.

"We may determine that the fetus has a potentially fatal arrhythmia that must be treated immediately," says Strasburger. "While rare, this treatment might include medications that the mother takes, or direct shots of medication given by a pregnancy specialist, similar to an immunization injection."

The passive detector, mounted on a track above a table upon which the patient lies, is positioned over the pregnant woman's belly, where it picks up the faintest magnetic signals and sends the information back to a computer in an adjacent room. The safe, non-invasive test takes about an hour.

Unlike MRI, which produces a magnetic field, this magnetic recorder does not. It listens for naturally-occurring magnetic fields.

"Currents flowing through the heart and brain generate these magnetic signals," explains Wakai. "They're the same currents that generate electrical signals detected by EKGs and EEGs."

The EKG is the standard test for adults with heart rhythm problems, but it doesn't work on fetuses, adds Wakai.

"A slimy protective layer on the fetal skin, called the vernix, prevents electrical signals from being conducted to the surface of the expectant mother's body, where they could be measured," he says. "Magnetic signals, which don't require electrical conductivity, aren't affected by the vernix."

The only detector sensitive enough to measure these signals is a superconducting quantum interference device, or SQUID, which was invented by physicists and has been used for submarine detection and oil exploration in addition to its medical usage. Only a handful of hospitals now have SQUIDs, using them almost exclusively for adult brain mapping studies.

Another big advantage of the SQUID detector, says Wakai, is that it makes hour-long, continuous recordings, while ultrasounds, by far the most common technology used today in measuring fetal heart rhythms, capture only a small window of activity.

"While ultrasound measures the pumping action of the heart, this new magnetic recording device measures the rhythm signals that cause the heart to pump," he says.

The Wisconsin team has used the detector to analyze heartbeat irregularities in more than 300 patients so far, but they see it as just the tip of the iceberg.

"So many miscarriages and stillbirths are unexplained, and we think cardiac conditions often may be the explanation," says Strasburger. "We can use this technology to identify fetuses with many of those conditions."

There is hope for those fetuses, Strasburger adds.

"Many of the diseases fetuses are dying of in utero are preventable and treatable," she says.

Right now the testing is confined to patients who come to Madison. But Wakai and Strasburger plan to provide scientific and technical support for a project that will take the show on the road--with a mobile unit currently under construction.

"This is a big project involving many players, including a company based in rural Wisconsin, Shared Medical Technologies," Wakai says. "We will need a smaller SQUID sensor, a special shield that blocks magnetic interference from the environment and a truck large enough to carry it all."

He expects the first mobile unit to be ready for testing in about one year.

Strasburger, who practices primarily in the small town of Neenah, is committed to making connections with Badger State communities.

"One of my goals in practicing as an outreach physician with the Herma Heart Center at Children's Hospital of Wisconsin has been to integrate research into the community," she says.

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