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Researchers examine bio-magnetic sensors

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Doctors in the future might be able to diagnose breast and ovarian cancer or Alzheimer's disease using magnetism and microscopic particles of iron oxide bound to the type of cells being traced.

A team led by Dr. Richard Larson of the University of New Mexico Cancer Research and Treatment Center and Ed Flynn of Senior Scientific LLC is investigating the potential of bio-magnetic sensors for early detection of disease or organ rejection.

The super-sensitive sensors can detect cancer cells in far smaller concentrations than current technology can — meaning earlier detection and treatment, they say.

"My bottom line is it's much more sensitive, (spotting) fewer cells at a much earlier stage of the disease," Larson said. "You could detect cancer or Alzheimer's noninvasively. We can't do that right now."

Early detection is key, said Flynn, who decided to explore biomagnetism for diagnosis after his wife got breast cancer.

Flynn, who specializes in measuring weak magnetic fields, and Larson, who has expertise in building the kind of particles needed, formed a collaboration.

The researchers said similar techniques are used in heart and brain imaging, but they're the only ones adapting it to detect disease.

Their studies focus on noninvasive detection of breast and ovarian cancer and Alzheimer's, spotting kidney transplant rejection early and doing better bone marrow biopsies for leukemia. All of the research centers around superconducting quantum interference devices, called SQUIDs, and their ability to use magnetic nanoparticles targeting small clusters of cells.

Specific antibodies for cells to be tracked attach to nanoparticles so tiny that researchers can attach 10,000 or more nanoparticles to a single cell.

"What we do is take a nanoparticle, a very small particle in part made of iron that's smaller than you could see with the naked eye, and coat it with antibodies or peptides," Larson said. "We're coating it with an agent that specifically binds to what you want to image."

If you want to detect breast cancer, for example, you bind it to breast cancer antibodies. In the case of ovarian cancer, that's CA125, a marker used in blood tests for women to diagnose ovarian cancer.

Nanoparticles would be injected into patients, then the SQUID would "detect that the nanoparticles have bound to the tumor or the disease," Larson said.

By measuring the magnetic fields of particles attached to the cells, researchers can determine the number of diseased cells and their location.

The technique can target as few as 50,000 cancer cells, they said. Traditional X-ray or ultrasound imaging techniques need 100 million cells to detect cancer or organ rejection.

"You set it about the person and measure the magnetic fields coming out of the person," Flynn said. "If you want to check for breast cancer, you locate it over the breast. In the case of Alzheimer's, you place over the head."

It involves no radiation, and the magnetism used is a billion times less than the Earth's magnetic field, he said.

A diagnosis arrives much more quickly. Except for their bone marrow biopsy technique, results are available in about 10 minutes, they said.

Harvard radiology Professor Bruce Rosen said that while he was not familiar with the specifics of the UNM-Senior Scientific research, it was credible and took "a very interesting angle."

While SQUID detectors are "exquisitively sensitive," the picture clarity is coarser than than that from widely used MRIs, Rosen said. On the other hand, he said, MRIs are not very sensitive to such particles, although researchers are trying to improve that.

"At the end of the day, it's a little bit of a horse race as to who's going to solve their problems first. ... They (Larson and Flynn) are absolutely right that it has more sensitivity than MRIs" and if they solve picture resolution problems, their technique will have the advantage, said Rosen, who works on how imaging tools can be applied to biological and clinical problems.

The New Mexico research is in various stages. Flynn and Larson began working on a "smart' bone biopsy needle several years ago and on breast cancer about two years ago; they got funding for Alzheimer's research in January.

The bone marrow biopsy is in clinical trials using animals or extracted human cells. That has to be completed before trials on patients.

Current bone marrow sampling for leukemia involve a needle inserted in the pelvic area, a painful procedure.

"The problem is, it's random and might miss the tumor or the leukemia if it's somewhere else," Larson said.

They would inject nanoparticles and antibodies to target only leukemia cells, then insert their patented needle with a magnet into the marrow. It attracts and collects leukemia cells because of the magnetic characteristics of the attached iron-oxide particles.

"With the smart bone marrow biopsy needle, you attract the leukemia cells to the needle. It's much more able to detect cancer if it's there," Larson said.

The idea is to find residual leukemia in smaller clusters than currently possible.

"We can give the patient additional treatment so they will be cured rather than relapse in the future," Larson said.

The researchers also hope someday to use nanoparticles' magnetic properties to concentrate anti-cancer drugs. They envision external magnets whose fields would be focused where the cancer is located. That would reduce the side effects from chemotherapy, which normally infuses the whole body.

In addition, they're developing the SQUID so it won't require heavy magnetically shielded rooms, cutting costs to hospitals. Flynn estimates the instrument would cost $150,000 to $250,000 depending on the number of sensors. By contrast, MRI machines run $1.5 million, he said.