Nuclear Magnetic Resonance Imaging to Visualize Fetal Abnormalities

Nuclear magnetic resonance imaging (MRI) is a technique to create a three-dimensional image of a fetus. Doctors often use MRIs to image a fetuses after an ultrasound has detected an, or has been inconclusive about an, abnormality. In 1983 researchers in Scotland first used MRI to visualize a fetus. MRIs showed a greater level of fetal detail than ultrasound images, and researchers recognized the relevance of this technique as a means to gather information about fetal development and growth. Researchers later used the technology to take measurements of the uterus, placenta, amniotic fluid, and fetus during the first trimester of pregnancy. MRI provided doctors with a non-invasive method to diagnose and treat fetal abnormalities and maternal conditions such as pre-eclampsia.

Magnetic resonance imaging uses a magnetic field and pulses of radio waves to visualize the inside of a human body. Magnetism causes water molecules in the body to spin in specific directions, which causes the emission of radio waves. In an MRI machine, an antenna detects the radio waves that spinning water molecules release. A computer then picks up the data from the antenna, and computer software creates images from the radio sequences of the human body using the signals that bounce back and create an image. The image is a representation of all of the water molecules that the antenna detected.

Isidor Rabi at Columbia University in New York City, New York, developed the nuclear magnetic resonance technology in 1938. He did so to measure magnetic field strength frequencies to obtain chemical and structural information about particular molecules. Rabi received the Nobel Prize in Physics for his work in 1944. Felix Bloch and Edward Purcell in the US expanded this technique in 1946 to study the composition of atoms in liquids and solids. Bloch and Purcell received the Nobel Prize in Physics in 1952 for their work. In 1971, Raymond Damadian at Brooklyns Downstate Medical Center in Brooklyn, New York, used a magnetic resonance machine to differentiate cancerous tissue from healthy tissue, and he found that cancerous tissues contain more water than healthy tissue. His work prompted other scientists to use magnetic resonance to study diseases. Over the decades, scientists refined and enhanced the magnetic resonance technique.

MRI became a diagnostic technology for human ailments. In 1973, Peter Lauterbur at the State University of New York in Stony Brook, New York, produced the first MRI image. This image was of a test tube. In 1977, Peter Mansfield at Nottingham University in Nottingham, UK, developed a rapid imaging technique called echo-planar imaging for use on T2 weighted images. This imaging technique enabled researchers to collect images faster than previously possible. With their work, Lauterbur and Mansfield spurred the use of MRI as a diagnostic tool, especially in medecine. Lauterbur and Mansfield received the Nobel Prize in Physiology or Medicine in 2003 for their contributions to the application of magnetic resonance in medical imaging. An early clinically relevant image created by MRI was taken in 1980, and it revealed a tumor in a patient's chest, an abnormal liver, and cancer in the patient's bones. Initial clinical uses of MRI showed no evidence of harmful effects on patients from the use of MRI, and researchers increasingly used MRI in other areas.

In 1983, Francis W. Smith and his team at the University of Aberdeen in Aberdeen, Scotland, performed one of the earliest experiments involving the MRI to visualize a human fetus. In the study, the research subjects consisted of six patients between the ages of sixteen to twenty-one years-old. The patients were pregnant and sought to terminate their pregnancies between twelve and twenty weeks of gestation. They gave Smith's team informed consent for a pelvic examination by ultrasound and for MRI. Before its application to imaging the fetus, clinical use of MRI had shown no short-term or medium-term side effects for adults. The study occurred for imaging purposes, and

MRIs didn't cause terminated pregnancies. The unknown safety of fetal imaging prompted the team to image fetuses that were to be terminated.

The team compared the measurements they had taken of the fetus by MRI to those they had obtained through ultrasound to determine imaging detail. The fetal detail obtained by MRI was greater than that observed through ultrasound, and the researchers concluded that MRI could be a new method to observe fetal tissues, development, and growth. The difference in proton density between tissues and amniotic fluid enabled researchers to view the uterine cavity, fetus, amniotic fluid, and placenta. Imaging restrictions due to a two-dimensional view rendered circumference measurements a shortcoming in early imaging. Smith and his team stated that the measurements of tissue water they made by MRI provided promising application of MRI to study pre-eclampsia. Pre-eclampsia affects the flow of blood to the placenta, leading to lack of oxygen and nutrients to the fetus, and it results in poor fetal growth or death of the fetus.

By the early twenty-first century, use of the MRI involved a preliminary fetal screening through ultrasound. Ultrasound operates similar to sonar, and it creates images from sound waves that bounce back to a computer software. An ultrasound cannot create images through bone or air, whereas an MRI can. MRI and ultrasound became complimentary examinations, and researchers sometimes performed MRI for further visualization and diagnosis if ultrasound showed fetal abnormalities.

To visualize a fetus, an MRI required a pregnant woman to lie on her back or on her left side while the table on which she lays moved in and out of the MRI machine. While an individual received an MRI, she had to lie as still as possible, and the examination usually took between thirty to forty-five minutes, depending on fetal motion. Doctors discouraged patients from eating food with high sugar content or caffeine, as those substances increased fetal movement. Technicians gave the patient ear protection to protect her from the loud noises emitted from the MRI machine. Individuals with permanent objects containing metal, such as a pacemaker, couldn't undergo MRI due to safety reasons. For others, all metal was removed from an individual before the examination. To create the final three-dimensional image, the machine takes many two-dimensional images, in a slice-like fashion, and a computer combines the images into a single three-dimensional image.

Early MRI machines struggled to constructing clear images of fetuses that had moved during the imaging process. For that reason, researchers often sedated the fetus by injecting muscle relaxants into its umbilical vein. In the early twenty-first century, MRI technologies had improved in such a way that enabled clear images even when the fetus had moved during the imaging process. Doctors in the US began to avoid sedating fetuses during MRI, but many doctors in Europe continued to do so.

By 2015, researchers hadn't substantiated any risks to fetuses that undergo MRI. However, some argue that the impact of MRI on a fetus were inconclusive, and that it should be performed only when essential. Many doctors deemed that MRI was essential when there was an abnormality in the fetus, or when the MRI results will affect the management of the pregnancy. Doctors often prescribed MRI to study fetal abnormalities in lung development or central nervous system, maternal tumors, and conjoined twins.

Doctors also used MRI to image the pregnant woman's pelvis in relation to the birth of a baby. MRI of the pelvis helped doctors and their pregnant patients decide whether or not a vaginal birth is possible, or if cesarean section was advisable. Researchers often advised practitioners to wait until twenty weeks of gestation before using MRI to image a fetus.

Sources

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