Protocols for pregnant patients increase safety

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The answer depends on the clinical indication and a determination of whether the test's benefits outweigh the very small potential risks of prenatal ionizing radiation exposure. Childhood cancer is one such risk. The most sensitive period for imaging during pregnancy is the first trimester. In this particular example, CT revealed a ruptured appendix following an inconclusive ultrasound and was clearly of great benefit, according to Cynthia McCollough, Ph.D., an associate professor of radiologic physics at the Mayo Clinic in Rochester, Minnesota, during a presentation at Stanford University's 2006 Symposium on Multi-Detector Row CT.

Of the various modalities, CT rings the most alarm bells when it comes to imaging pregnant women, just as it does in the general population. Nonionizing imaging alternatives are thought to be safer, although potential risks from ultrasound waves to the fetus have recently come to light.

Use of CT as a first-line imaging study has increased as multislice scanners have become widely available, and the threshold for performing CT has become lower across all patient groups, said Dr. Donald Frush, director of pediatric radiology at Duke University Medical Center.

"Nobody used to get CT for suspected appendicitis or renal stones. Now, CT has become the first-line imaging study. It's often considered first even in the pregnant patient," Frush said.

Nonurgent cases can be put on hold, but in the emergency room setting, a decision about appropriate workup needs to be made on the spot. Common indications for imaging pregnant women include the need to rule out pulmonary embolism and assessment of suspected appendicitis. Gynecologic conditions often mimic appendicitis, and risks of performing unnecessary surgery are higher in pregnant patients. Ultrasound may be inconclusive.

"Obviously, fetal health is dependent on maternal health. We have to protect maternal health to sustain a pregnancy. A missed appendicitis is potentially devastating to both maternal and fetal health," said Dr. Tracy Jaffe, an assistant professor of radiology in Duke's abdominal imaging section.

As with other patient groups, a balance must be struck between perceived risks and benefits of imaging during pregnancy. Heightened concern about radiation exposure could make some patients miss necessary treatment.

In a study published in April in Radiology, for example, researchers at the University of Texas M.D. Anderson Medical Center warned women not to dismiss symptoms of breast cancer during pregnancy and to seek assessment with diagnostic imaging techniques. The study found that ultrasound identified all cancers, and it highlighted the benefits of ultrasound in combination with mammography in pregnant patients. Postdiagnosis, women with advanced stages of cancers were treated with a safer form of chemotherapy in the second and third trimesters of pregnancy.

HOW HIGH THE RISK?

Radiation dose is a measurement of the energy absorbed by tissue from a beam of radiation. The amount of energy that is absorbed is dependent on the material being irradiated. Terminology for measuring exposure and risk varies. Absorbed doses to the fetus are measured by gray (gy), which has replaced the older term rad (one gray is equivalent to 100 rads). Another measurement unit, the rem, takes into consideration the fact that some forms of radiation are more effective than others. Neutrons may be two to 20 times more effective than x-rays in killing cancer cells, for example. In recent years, the term rem has been replaced by the Sievert (Sv).

Data about the risks of fetal exposure to radiation are drawn mainly from studies of female survivors of the U.S. atomic bomb attacks on Japan. Based on this research, possible harmful effects of medical imaging include prenatal death, retardation, physical defects, and childhood cancer.
The National Council on Radiation Protection and Measurements and other organizations consider a dose to the human conceptus below 50 mGy as an acceptable risk in a trade-off with the potential medical benefit of the examination to the patient. In practice, diagnostic examinations, including fluoroscopy, rarely result in a dose to the conceptus as high as 50 mGy.

The American College of Obstetricians and Gynecologists has noted that, based on available data, an absorbed dose of less than 50 mGy has not been shown to increase fetal anomalies or pregnancy loss. Less is known about the risk of developing childhood cancer, however. There may be a slightly increased association with cancer for an absorbed dose as low as 10 mGy (1 rad).

Methods of measuring dose and equipment technology have changed in recent years, and concern has arisen that the data available do not reflect experience with newer MSCT scanners. Duke University researchers performed one of the first studies of MSCT and prenatal exposure, using the latest methodology for dose measurement and 16-slice scanners. Results were published in *Roentgenology* in March 2006.

The researchers used an anthropomorphic phantom to simulate a pregnant woman and placed detectors at various locations of the uterus to measure exposure in early stages of pregnancy (zero to three months) for three protocols commonly performed during pregnancy: pulmonary embolus, appendicitis, and renal colic. Means of reducing dose with MSCT, such as adjustment of current settings, were used where possible.

The study findings were reassuring for all three protocols. "The doses were below those thought likely to cause neurologic damage, such as reduced IQ and microcephaly," said lead author Dr. Lynn Hurwitz Koweek, an assistant professor of radiology in Duke's thoracic imaging division.

Risk of childhood cancer for these protocols ranged from zero to extremely low.

REASSURING PATIENTS

Counseling women who know they are pregnant prior to CT exams or those who have undergone CT and discovered subsequently that they were pregnant at the time of imaging requires care and skill. Rather than telling women about an increase in risk, it is useful to advise them of the likelihood that no harm will result, McCollough said (see table).

"That is a very different way of communicating the exact same data. Patients realize it is not as scary as they thought," she said.

Mayo staff have assessed the fetal radiation dose for a range of studies performed in their own radiology department and found negligible dose levels. Even though many studies involve a negligible dose, however, practitioners should not be cavalier about ordering exams, McCollough said. It's important to set protocols for appropriate use to ensure consistent care and to help residents and fellows manage trauma cases in the middle of the night.

CT is not infrequently performed in pregnant women to look for renal stones, and a routine protocol delivers a dose of 25 mGy. The Mayo Clinic has developed a new protocol that calls for a dose as low as 5 mGy, because stones are bright and easy to pick up, she said.

ALTERNATIVES TO CT

In a new study conducted at Beth Israel Deaconess Medical Center in Boston, researchers found MR to be very effective in evaluating acute appendicitis in pregnant women. The retrospective study examined experience with 51 consecutive patients imaged from 1999 to 2004. After an inconclusive ultrasound, patients were referred for noncontrast MRI and CT only if necessary.

There were four cases of appendicitis, and MRI was positive in all four. MR's sensitivity was 100% and its specificity was 93.6%. After adjustment for prevalence, negative predictive value was 100%. The researchers concluded that MRI has great value in excluding appendicitis, and the medical center's protocols have been changed to reflect the new research.

As of September 2006, researchers had worked with a total of 115 pregnant patients, including the 51 reported cases. Ten patients had acute appendicitis, and all of them were accurately diagnosed with MRI. The negative predictive value of MR, adjusted for prevalence, remained at 100%. Abdominal pain in pregnancy is extremely common, while appendicitis is uncommon, accounting for less than 1% of cases of abdominal pain in pregnancy, said lead author Dr. Ivan Pedrosa, an assistant professor of radiology at Harvard Medical School.

"We don't believe CT is appropriate for pregnant patients with suspected appendicitis. Most don't have appendicitis, and if you use CT to evaluate all of these patients, you are giving a lot of unnecessary radiation," Pedrosa said. "At our institution, CT is now reserved for those rare cases where MR is inconclusive and there is a strong clinical concern for appendicitis."
At Duke University, protocols call for ultrasound first for suspected appendicitis in pregnant women. If ultrasound is inconclusive, examiners perform MRI without contrast. If MR is inconclusive, CT is indicated.

**PE RULEOUT**

CT to rule out pulmonary embolism is another study that causes concern. But the radiation risk to the fetus is negligible, and CT is more effective than the alternative ventilation/perfusion scintigraphic scanning, according to McCollough. That conclusion does not excuse overutilization. Oregon Health and Science University researchers analyzed appropriateness in a retrospective study with a particular focus on the use of CT angiography in women aged 35 years or younger. The positive rate was low generally and particularly low in women under 35. The researchers found that the established clinical Wells criteria were not being followed for CTA of PE across the study group and CT scans were commonly performed on patients who had a low probability of PE.

The new Duke study found the fetal dose for this study with MSCT to be higher by a factor of 16 at zero months and a factor of 10 at three months, compared with reports in the literature in which single-slice scanners were used. Even with an MSCT examination, however, the uterus is far enough away from the exposure that fetal dose remains well below the threshold for biological effects.

MSCT had been thought to yield a lower fetal dose compared with V/Q, but the Duke study found that in the early months of gestation, the dose is about the same. In the third month, it was twice as high for MSCT compared with V/Q.

Compared with imaging of the appendix, the dose to the fetus from PE studies is much lower, and it is slightly lower with renal calculi MSCT performed according to Duke protocols. But CT for PE exposes the breast to a much higher radiation dose than does V/Q. Consequently, V/Q is the first-line imaging study at Duke for ruling out PE in all women under 40 with a normal chest x-ray. For the same reason, OHSU now advises that all women under 40 with suspected PE, a normal chest x-ray, and no underlying pulmonary conditions have a V/Q scan first instead of CT.

Beyond protocols, examiners sometimes find it useful to consider the appropriateness of imaging pregnant women. "The way we approach it is to ask, 'If it were me or my wife, what would I do?'" Jaffe said. *Ms. Hayes is feature editor of Diagnostic Imaging.*

**Disclosures:**

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