The Pregnant Patient: Alternatives to CT and Dose-Saving Modifications to CT Technique

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Overview

Four key points should be remembered about performing CT in pregnant patients:

- The primary risk to the irradiated fetus is carcinogenesis (i.e., increased risk of childhood cancer) and not teratogenesis. The radiation dose from a single diagnostic CT is highly unlikely to exceed the estimated threshold dose of 100 mGy for the induction of malformations.
- The relative risk of childhood cancer may be as much as doubled in an irradiated fetus, but this should be offset by the risks of failing to diagnose serious disease in the mother and by realizing the absolute risk remains very small.
- Iodinated contrast (unlike gadolinium) appears safe to use in pregnancy, and arguably it is better to administer any potentially useful contrast (intravenous, oral, or rectal) prior to scanning rather than having to rescan because such contrast was not administered from the start.
- The fetus is exposed to a significant dose during a CT exam only when the fetus is within the primary beam. The scattered dose to the fetus from a chest or head CT for example is usually negligible, unless the lower cuts of a chest CT include the fetus in the primary beam (which might occur in late gestation).

Dose calculation and risk

The radiation dose to the fetus from a typical CT study of the maternal pelvis is variable and depends on the gestational age and scanning parameters, but typically ranges from about 10 to 50 mGy (1-3).

The fetal dose for an average-size patient can be estimated from the technique used to scan the pregnant uterus using dose conversion factor of 10.8 mGy/100 effective mAs, for 120 kV abdominal exams (4). (Effective mAs is defined as tube current in mA multiplied by rotation time in seconds divided by pitch.) For example, an effective mAs 222 for a CT scan of the pelvis would result in a fetal dose of 24 mGy (10.8 x 2.22). The baseline risk of childhood cancer is about 1.0 to 2.5 per 1000 (5). Estimates for the extra risk of childhood cancer from a fetal radiation dose of 1000 mGy range from 0.022 (Oxford Survey Childhood Cancer) through 0.028 (Life Span Study of atomic bomb survivors) to 0.060 (expert statistical review) (4, 6). After classifying these risk values as low, intermediate, and high, the excess risk of cancer for a variety of fetal doses would then be as follows:

Table 1

Dose (mGy)	Low risk model	Intermediate risk model	High risk model
10	1 in 4545	1 in 3571	1 in 1667
20	1 in 2272	1 in 1786	1 in 834
30	1 in 1515	1 in 1190	1 in 556
40	1 in 1136	1 in 892	1 in 417
50	1 in 909	1 in 714	1 in 334

The lowest achievable dose is zero! That is, non-ionizing options are always preferable to any test with ionizing radiation in pregnant patients. In particular, most pregnant patients with pelvic pain should initially be scanned with ultrasound. When the diagnosis with ultrasound is not clear, imaging can be performed with MRI, in particular when appendicitis is suspected (7). Other strategies for CT dose reduction, which are equally applicable to CT in pregnant patients, have been described elsewhere (8) and are summarized in Table 2. More information can be obtained by referring to the ACR Practice guideline for imaging pregnant patients (9), which lists ultrasound as the initial imaging modality of choice for right lower quadrant pain in pregnancy, left lower quadrant pain in women of reproductive years, flank pain in pregnancy, and acute pelvic pain in the reproductive age group.

Table 2: Potential strategies and measures to reduce CT radiation dose and to address patient concerns regarding radiation risk.

Category	Measure
General	Provide patient information material Review CT protocols and indications
Before the test	Promote alternative non-ionizing studies (ultrasound and MRI) Decision support software
During the test	Automatic tube current modulation Empower technologists to adjust protocol Improve reconstruction algorithms
After the test	Calculate radiation dose Report radiation dose

References

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Useful links and resources

Chen M.M., Coakley F.V., Kaimal A., Laros R.K. Jr. "Guidelines for computed tomography and magnetic resonance imaging use during pregnancy and lactation," *Obstetrics & Gynecology*, August 2008; 112(2 Pt 1): 333-40.