

# The Use of Magnetic Resonance Imaging in the Obstetric Patient

This clinical practice guideline has been prepared by the Diagnostic Imaging Committee, reviewed by the Family Physician Advisory Committee, and approved by the Executive and Council of the Society of Obstetricians and Gynaecologists of Canada.

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## Abstract

**Objective:** To review the biological effects and safety of magnetic resonance imaging (MRI) in the obstetric patient and to review procedural issues, indications, and contraindications for obstetrical MRI.

**Outcomes:** This guideline is intended to reassure patients and clinicians of the safety of MRI in pregnancy and to provide a framework for its use.

**Keywords:** MRI, safety, prenatal diagnosis, indication

**Evidence:** Published literature was retrieved through searches of PubMed or Medline in 2013 using controlled vocabulary and key words (e.g., MRI, safety, pregnancy). Results were restricted to systematic reviews, randomized control trials/controlled clinical trials, and observational studies published in English and in French. There were no date restrictions. Searches were updated on a regular basis and incorporated in the guideline to July 2013. Grey (unpublished) literature was identified through searching the websites of health technology assessment and health technology-related agencies, clinical practice guideline collections, clinical trial registries, and national and international medical specialty societies.

**Values:** The quality of evidence in this document was rated using the criteria described in the Report of the Canadian Task Force on Preventive Health Care (Table).

**Benefits, harms, and costs:** This article is intended to reassure obstetric care providers that if used in an appropriate manner without the use of contrast agents, MRI in the obstetrical patient is safe for mother and fetus in the second and third trimesters. Because obstetrical MRI is expensive and has limited availability in Canada, this clinical guideline is intended to encourage the judicious use of this resource.

## Summary Statements

1. Fetal magnetic resonance imaging is safe at 3.0 tesla or less during the second and third trimesters. (II-2)
2. It is safe to continue breastfeeding after receiving a gadolinium contrast agent. (III)

## Recommendations

1. Use of magnetic resonance imaging during the first trimester of pregnancy should be restricted to maternal indications for which the information is considered clinically imperative. Inadvertent exposure to magnetic resonance imaging during the first trimester has not been associated with any long-term sequelae and should not raise clinical concern. (III-C)
2. Gadolinium contrast may be used in pregnant women when the benefits outweigh the potential risks. (III-C)

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## Key to evidence statements and grading of recommendations, using the ranking of the Canadian Task Force on Preventive Health Care

Quality of evidence assessment*	Classification of recommendations†
I: Evidence obtained from at least one properly randomized controlled trial	A. There is good evidence to recommend the clinical preventive action
II-1: Evidence from well-designed controlled trials without randomization	B. There is fair evidence to recommend the clinical preventive action
II-2: Evidence from well-designed cohort (prospective or retrospective) or case-control studies, preferably from more than one centre or research group	C. The existing evidence is conflicting and does not allow to make a recommendation for or against use of the clinical preventive action; however, other factors may influence decision-making
II-3: Evidence obtained from comparisons between times or places with or without the intervention. Dramatic results in uncontrolled experiments (such as the results of treatment with penicillin in the 1940s) could also be included in this category	D. There is fair evidence to recommend against the clinical preventive action
III: Opinions of respected authorities, based on clinical experience, descriptive studies, or reports of expert committees	E. There is good evidence to recommend against the clinical preventive action
	L. There is insufficient evidence (in quantity or quality) to make a recommendation; however, other factors may influence decision-making

\*The quality of evidence reported in these guidelines has been adapted from The Evaluation of Evidence criteria described in the Canadian Task Force on Preventive Health Care.<sup>38</sup>

†Recommendations included in these guidelines have been adapted from the Classification of Recommendations criteria described in the Canadian Task Force on Preventive Health Care.<sup>38</sup>

## INTRODUCTION

Ultrasound is currently the standard approach for the initial evaluation of fetal anatomy. It is an imaging modality that is widely available, is cost-effective, and allows real-time examination of the fetus.<sup>1</sup> US has the advantage of providing better spatial resolution than many other imaging techniques including MRI. However, for a variety of reasons, US may not allow adequate assessment of a complex case or provide critical information for antenatal clinical management. MRI can provide additional information resulting in better counselling, management, and perinatal outcomes.<sup>2</sup> This guideline has been developed to discuss safety, pre-procedure counselling, procedural considerations, and indications in the use of obstetrical MRI.

## SAFETY OF MRI IN THE OBSTETRICAL PATIENT

### Maternal Risks

Maternal risks associated with the use of MRI are the same as for non-pregnant patients.<sup>3,4</sup> One safety consideration for the obstetrical patient is prolonged supine positioning.

## ABBREVIATIONS

MRI	magnetic resonance imaging
RF	radiofrequency
SAR	specific absorption rate
US	ultrasound

A gravid uterus of significant size can lead to hypotension due to compression of the inferior vena cava. This can be avoided by placing the patient in a lateral oblique or lateral decubitus position.

### Fetal/Neonatal Risks

Theoretical fetal concerns include teratogenic and biological effects. It is known that MRI may cause effects at the cellular level from the induction of local electric fields, currents from static and time-varying magnetic fields, and tissue and cellular heating from RF fields. Most of the biological effects associated with exposure to RF fields are related to thermogenesis. The term “specific absorption rate” refers to the dosimetric absorption of RF power. During an MRI procedure, the SAR is influenced by many complex factors and variables including the strength of the static magnetic field, the type of RF pulse used, the repetition time, the type of transmitting RF coil used and volume of tissue contained within, and the anatomical region exposed, among other factors.<sup>5</sup>

Other physiological, physical, and environmental factors include exposure length, the rate of energy deposition, physiological thermoregulatory response, concomitant illness, and local environmental conditions.<sup>5</sup> Limits are determined for SAR for each pulse sequence to ensure that the increase in body temperature is less than 0.5°C. Maternal and fetal temperatures remain within the specified limits even when sequences with higher SAR values are used, including when SAR increases significantly when using higher magnetic fields.

### First trimester

Static field exposure has been the subject of animal research. Some animal studies have documented effects on the early fetus in terms of growth, miscarriages, and eye malformations.<sup>6-8</sup> The applicability of these animal models to humans has been questioned.<sup>9</sup> The National Radiological Protection Board in the United Kingdom stipulates in its principles for the protection of patients and volunteers during MRI that it “might be prudent to exclude pregnant woman during the first three months of pregnancy,”<sup>10</sup> whereas the latest American College of Radiology guideline for safe MRI practices does not differentiate among the pregnancy trimesters, and states that all pregnant patients could undergo MRI as long as the benefits outweigh the risks.<sup>11</sup> From a practical standpoint, MRI done during first trimester is usually performed for maternal indications and not for prenatal diagnosis. There are limited case reports of unplanned exposure to MRI in the first trimester of pregnancy. To date there is insufficient evidence to understand the true risks of first trimester exposure to the developing fetus.<sup>8,12</sup> Until these theoretical concerns can be appropriately addressed, we advocate a cautious approach to using obstetrical MRI in the first trimester.

### Second and third trimesters

The high level of acoustic noise generated in an MRI system may be of concern for both mother and fetus. The attenuation of sound within the abdomen of a pregnant mother, and its effect on the fetus, is currently under investigation.<sup>9</sup> There are no reports of significant acoustic impairment resulting from exposure to prenatal MRI. Fetal MRI is typically performed at 1.5 T. The higher field strength of 3 T is also considered to be safe.<sup>3</sup> Artifacts may be more pronounced in the second and third trimesters due to the large amount of amniotic fluid and increased abdominal girth.<sup>13</sup> There are no published studies of the long-term effects in human children who have had prenatal exposure at magnetic field strengths of 3 T or more.<sup>14</sup>

#### Summary Statement

1. Fetal magnetic resonance imaging is safe at 3.0 tesla or less during the second and third trimesters. (II-2)

#### Recommendation

1. Use of magnetic resonance imaging during the first trimester of pregnancy should be restricted to maternal indications for which the information is considered clinically imperative. Inadvertent exposure to magnetic resonance imaging during the first trimester has not been associated with any long-term sequelae and should not raise clinical concern. (III-C)

### Use of contrast agents in obstetrical MRI

Gadolinium is classified as a category C drug by the United States Food and Drug Administration. Intravenous gadolinium is teratogenic in animals at high and repeated doses.<sup>14</sup> Gadolinium crosses the placenta and is excreted by the fetal kidneys into the amniotic fluid, where it remains, exposing the developing fetus, particularly the lungs and gastrointestinal tract, for an extended period of time.<sup>15</sup> The 2010 American College of Radiology guideline for safe MRI practices recommends that intravenous gadolinium be avoided during pregnancy and used only if it is judged absolutely essential. One example of appropriate use could be in an examination for placenta percreta when planned delivery is imminent and fetal exposure to gadolinium is thus limited.<sup>16</sup> The risks and benefits of gadolinium use must be discussed with the pregnant patient and referring clinician.<sup>11</sup> Despite animal data and concerns about the use of gadolinium in pregnancy, there have been no reported adverse human fetal effects.<sup>17</sup> However, many authors remain cautious about the use of gadolinium at any time in pregnancy.<sup>13,18,19</sup>

#### Recommendation

2. Gadolinium contrast may be used in pregnant women when the benefits outweigh the potential risks. (III-C)

### Risks of oral contrast media administration during lactation

In the postnatal period, it may be necessary to perform an MRI for maternal indications and contrast may be used in the lactating mother. A minimal amount of gadolinium is excreted in the breast milk: 99.2% of orally administered Magnevist (a Gadolinium contrast) is fecally excreted; only 0.1% of the maternal intravenous dose is found in the breast milk, and only 1% of this is subsequently absorbed by the infant.<sup>14</sup> In fact, the 2012 edition of the American College of Radiology manual on contrast media states that “the available data suggest that it is safe for the mother and infant to continue breast-feeding after receiving such an agent.”<sup>14</sup> A similar conclusion was reached by the Contrast Media Safety Committee of the European Society of Urogenital Radiology in 2005.<sup>20</sup>

#### Summary Statement

2. It is safe to continue breastfeeding after receiving a gadolinium contrast agent. (III)

### PROCEDURAL CONSIDERATIONS

Obstetrical MRI can be technically challenging to perform and interpret given the movement of the fetus and its variable lie and presentation.

## Technical Requirements

The imaging team should consist of:

1. a technologist who fulfills the competency profile of the Canadian Association of Medical Radiation Technologists and has experience in fetal MRI, with specific training in MRI principles, sequences, and safety, and ideally
2. a radiologist who is either trained or highly experienced in fetal MRI.

Standards for credentialing MRI physicians vary from province to province. In British Columbia, subspecialty MRI accreditation (such as fetal MRI), requires 3 months of full-time training. Selection of optimal sequences and interpretation of resulting images requires knowledge of fetal anatomy, pathology, development, and maturation, as well as experience in discriminating between artifacts and true pathology. Fetal MRI is operator-dependent and requires appropriate sequences tailored to the organ system and suspected pathology. The imaging protocol must be altered when the fetus moves or if new anomalies are detected in the course of the scan. In addition to investigating the anomaly in question, the operator should examine the entire fetus and intrauterine structures whenever possible.

Ideally, three orthogonal planes should be obtained through the fetal head and body in each sequence. The MRI protocol primarily includes T2-weighted sequences. T1-weighted, diffusion-weighted, and additional sequences may be added if indicated, and ideally should provide documentation of the entire fetus as well as the placenta, uterus, and surrounding maternal structures. Repeated sequences may be required if the fetus moves. The field of view should be as small as possible without causing foldover artifacts. Slice thickness between 2.5 and 5 mm is used in examining most fetal structures. Thinner slices are possible but have adverse effects on signal-to-noise ratio. At present, the minimum voxel size that may be obtained with fetal MRI is  $0.8 \times 0.8 \times 2.5$  mm, with slice thickness and fetal–maternal movement the major limiting factors. These factors decrease resolution and may obscure structures smaller than 1 mm and create difficulties in accurately measuring small or thin structures.

## Pre-procedure Counselling

Pre-procedure counselling and education is important prior to obstetrical MRI as it may help alleviate maternal anxiety.<sup>21</sup> Counselling should include discussions of the working diagnosis and the indications for the MRI as well as procedural details, such as the duration of the scan

and the noise involved. A communication plan should be formulated to relay information to the patient from the interpreting physician via the primary caregiver as soon as reasonably possible. However, both patient and referring physician should understand that in view of the number of images acquired and the complexity of anatomical data, formulation of an opinion can take many hours and therefore the expectation of a prompt verbal report is in most cases unrealistic.

## Maternal and/or Fetal Sedation

Patients may find the claustrophobic environment distressing, particularly if the exam is prolonged by fetal movement and repetitive sequences. In the past, maternal and or fetal sedation was frequently used in obstetrical MRI. With the development of ultrafast sequences, maternal and fetal sedation is no longer required except in extraordinary circumstances.

## Technical Considerations

There are limitations in performing fetal MRI in obese patients. With increased body wall thickness, the signal-receiving elements of the coil are not close to the intrauterine regions of interest, and a larger field of view is required; therefore, signal and image resolution are not optimal. A large mother may not fit inside the MRI unit, particularly when placed in decubitus position. Maximum values for body size and weight vary among manufacturers; however, a body circumference of more than 140 cm and/or a weight of more than 140 kg may be problematic.

MRI resolution can also be suboptimal if there are excessive fetal movements. Polyhydramnios can allow increased fetal movement, so should a decompression amniocentesis be performed for other clinical indications, a clinically indicated fetal MRI should be done as soon as reasonably possible following the decompression.

## INDICATIONS FOR OBSTETRICAL MRI

US remains the primary diagnostic tool for the fetus, and MRI is an expensive and limited resource in Canada. However, in certain cases MRI may provide additional relevant clinical information that will facilitate perinatal counselling and management decisions.<sup>22</sup>

The indications for fetal MRI cannot be easily defined as they depend on a number of factors including regional differences in perinatal management, experience of technicians and physicians, availability of obstetrical MRI, and access to in-utero fetal surgery. Indications for fetal MRI and technological advances are evolving rapidly and

vary depending on the available expertise and the individual maternal–fetal pathology under investigation.

### Central Nervous System

The fetal brain is well-observed on T2-weighted sequences because of the contrast between cerebrospinal fluid and brain tissue. After 17 weeks, the advantages of MRI in diagnoses of both developmental and acquired intracranial abnormalities have been well established<sup>23–25</sup>; however, diagnosis of some abnormalities may not be possible until after 24 weeks. Additional sequences such as T1-weighted and diffusion-weighted imaging provide information about brain development, cell density, myelination, hemorrhage, and ischemic lesions. It should be noted that calcifications are not demonstrated on routine MRI sequences, and consultation with the radiologist is recommended if confirmation of sonographically suspected calcifications is required.

### Fetal Oropharynx and Face

MRI can be used to assess oropharyngeal anatomy in conditions where airway patency may be compromised by masses or mandibular or other facial malformations. MRI is useful to confirm or diagnose an isolated cleft of the posterior palate. MRI may also be helpful in clarifying anatomy in other anomalies, such as atypical facial clefts, retrognathia, micrognathia, craniosynostosis, cephaloceles, vascular anomalies, tumours, microphthalmia, and other ocular and orbital abnormalities.<sup>26</sup>

### Neck

The position of neck masses relative to the fetal airway can be assessed using MRI, which can assist in managing delivery when an EXIT (ex-utero intrapartum treatment) procedure is being considered. Fetal goiter and thyroid position relative to neck masses can also be imaged on T1- and T2-weighted views.

### Thoracic Anomalies

Sonography is the primary screening method for the detection of thoracic anomalies, mediastinal shift, and the presence of fluid in the pleural space. For malformations such as bronchopulmonary sequestration or congenital pulmonary adenomatoid malformation, MRI should be performed if fetal US cannot provide the information necessary for counselling or management.<sup>27</sup> In congenital diaphragmatic hernia, MRI can be used to evaluate lung volume and the presence of liver and intra-abdominal organs in the thorax.<sup>28–30</sup> Pulmonary hypoplasia can be a significant contributor to neonatal mortality and morbidity, and so the antenatal assessment of lung growth and development maybe useful in predicting survival and may aid in perinatal management.

### Evaluation of the Fetal Heart

Although sequences are being developed to evaluate cardiac structures and function, fetal echocardiography remains the method of choice for screening and prenatal diagnosis of cardiovascular anomalies.

### Intra-abdominal Anomalies

MRI should be reserved for circumstances when fetal US cannot provide the information necessary for counselling or management. After 20 weeks, high signal from meconium on T1-weighted sequences forms the basis for an MRI colonography. This technique can confirm the presence of bowel within the thorax in congenital diaphragmatic hernia, and it can confirm suspected bowel obstruction and anorectal malformations. Calcifications in meconium peritonitis may be depicted sonographically but not on MRI.<sup>31,32</sup>

### Urogenital Tract

Urogenital tract structures are readily visualized on US unless severe oligohydramnios or anhydramnios, fetal position, or other condition precludes adequate visualization of anatomy. MRI may be helpful in providing anatomical information in these situations.<sup>33</sup>

### Extremities and Bone

US is the primary method of evaluating skeletal biometry and observing findings involving distal appendages. However, sequences have been developed to image musculoskeletal structures with MRI.<sup>34</sup>

### Spine

US is the imaging modality of choice to screen for open neural tube defects. MRI can be used to confirm suspected anomalies of the spinal cord.<sup>35</sup>

### Maternal Conditions

MRI provides images of maternal anatomy in 3 orthogonal planes without interference from bowel gas. Upper abdominal organs, bowel, kidneys, bladder, ovarian and adnexal masses, uterine anatomy, placental position, and cervical anatomy are visible, and additional targeted sequences can be obtained if necessary. MRI may be particularly useful when appendicitis is suspected clinically and US examination is negative.<sup>36</sup>

### Placental Adhesion Disorders

The diagnosis of placental percreta can be made with either US or MRI. However, MRI is the imaging method of choice when there is a risk of posterior placenta increta or percreta.<sup>37</sup>

## SUMMARY

Fetal MRI is an expensive and limited resource in Canada. Questions arise over its utility, indications, and safety in

the obstetrical patient. Ultrasound remains the primary diagnostic tool for fetal imaging. Although MRI may provide additional relevant clinical information, fetal movement can create artifacts leading to non-diagnostic images. MRI in the obstetric patient should only be done if the ultrasound assessment is inadequate for antenatal clinical management and the desired information is required in the fetal period; on occasion it may replace neonatal MRI requiring general anaesthesia. MRI should only be performed and interpreted in centres with sufficient expertise following a careful review of all imaging and clinical information. During the first trimester of pregnancy, MRI should be used only as a clinically necessary precaution in the case of theoretical risks. Gadolinium contrast can be used during pregnancy when it can provide critical information for the health of the mother and fetus. Although no documented adverse effects to the human fetus have been documented, gadolinium crosses the placenta and has teratogenic effects in animals. It is safe to breastfeed after receiving a gadolinium contrast agent.

While screening for fetal anomalies and prenatal diagnostic imaging relies primarily on US, fetal MRI tailored to gestational age and suspected pathology has a complementary role in prenatal and perinatal management.

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