Evan Siegelman, MD
MRI of endometriosis

SAM Questions

1. Which MR pulse sequence would best differentiate a T1 hyperintense mature cystic teratoma from a T1 hyperintense endometrioma?
   A. Contrast enhanced T1-weighted
   B. Diffusion weighted imaging
   C. Fat suppressed T1-weighted
   D. Short Tau Inversion Recovery (STIR)
   E. T2-weighted fast spin echo

The correct answer is C.

Reference:

Mature cystic teratomas (MCT) will lose signal intensity on a fat suppressed T1-weighted image while endometriomas and hemorrhagic functional cysts will remain hyperintense. While conceivably a solid portion of a MCT could enhance, gadolinium enhanced imaging has not been advocated in differentiating between the two lesions. Both endometriomas and portions of MTCs can show restricted diffusion. Both MTC and endometriomas can show low signal intensity on fat suppressed T2-weighted images. Low signal intensity on STIR imaging is not specific for fat; endometriomas can also have low signal intensity on STIR imaging because of the T1-shortening effects of the intra-cystic blood products. While endometriomas have lower signal intensity than simple fluid on T2-weighted imaging (“shading”), the relative difference in T2 signal intensity is not as accurate as fat suppressed T1-weighted images in differentiating between the two lesions.

2. Which imaging finding increases the specificity for a diagnosis of endometriosis?
   A. Brenner Tumor
   B. Pelvic free fluid
   C. Polycystic ovaries
D. Serous cystadenoma  
E. Solid fibrotic masses  

ANSWER: E  

References:  

The two major imaging findings of pelvic endometriosis are endometriomas and deeply infiltrative endometriosis. The latter presents as solid fibrotic masses. Brenner tumor can be associated with other ovarian neoplasms but is not associated with endometriosis. Free pelvic fluid is seen in normal women and does not increase the likelihood of endometriosis. Pelvic inclusion cysts, which are composed of loculated fluid that surround one or both ovaries may be present more often in women with endometriosis because of scar and adhesion formation. Neither polycystic ovaries nor serous cystadenomas are associated with endometriosis.  

3. Which of the following is the most common location for solid endometrial implants?  
   A. Broad ligament  
   B. Cesarean section scar  
   C. Rectosigmoid Colon  
   D. Round ligament  
   E. Uterosacral ligament  

ANSWER: E  

Reference:  
Bazot M, Gasner A, Ballester M, Darai E. Value of thin-section oblique axial T2-weighted magnetic resonance images to assess uterosacral ligament endometriosis. Hum Reprod 2011; 26:346-353  

The most common location for solid endometriosis is the uterosacral ligaments. In one study of 100 symptomatic women, uterosacral ligament solid endometriosis was present in over 80% of women as surgery(4). The other sites listed are less common. Solid endometriosis within Cesarean section scars is often do to direct implantation of endometrial tissue at the time of surgery.
Susan Ascher, MD  
MRI of Gynecologic Malignancy  
SAM Questions

1. Which two uterine cancer histologies are associated with a worse prognosis?
   A. Endometrioid Adenocarcinoma and Adenocarcinoma with Squamous Differentiation
   B. Adenocarcinoma with Squamous Differentiation and Pure Squamous Carcinoma
   C. Pure Squamous Carcinoma and Clear Cell Carcinoma
   D. Clear Cell Carcinoma and Papillary Serous Carcinoma
   E. Papillary Serous Carcinoma and Endometrioid Adenocarcinoma

   ANSWER: D

   Clear Cell Carinoma and Papillary Serous Carcinoma are aggressive tumors with a 50% pretest probability of advanced disease. It is critical to know the tumor histology (and grade) to optimize MRI protocol and interpretation.

   References:


2. In endometrial cancer patients, which MRI parameter correlates best with lymph node metastases and overall prognosis?
   A. Vaginal invasion
   B. Cervical mucosal invasion
   C. Myometrial invasion
   D. Rectal invasion
   E. Bladder invasion

   ANSWER: C

   MRI is robust as a local staging tool because it provides accurate assessment of the depth of myometrial invasion which correlates with the likelihood of lymph node metastases and overall patient survival. Patients with deep myometrial invasion have a 50% chance of lymph node involvement.

   References:


3. What is the MRI size cutoff value for stage IB and IIA cervix cancers that preclude surgery as a primary treatment option?
   A. > 1cm
   B. > 2cm
   C. > 3cm
   D. > 4cm
   E. > 5 cm
   ANSWER: D

   Early cervical cancers that are > 4cm include Stages IB2 and IIA2. These bulky tumors have a worse prognosis--patients forfeit surgery as primary treatment and undergo chemo- and radiation therapy similar to patients with locally advanced disease.

   References:

1. History: An 18 year old undergoes single phase contrast-enhanced CT for an incidentally discovered hemangioma seen as a nonspecific liver lesion on ultrasound. The patient denied any possibility of pregnancy prior to the scan. You are reporting the CT scan. The lowermost image from the CT study is shown below:

![CT scan image]

Question: What is the most appropriate next step?

A. Consider termination because of the risk of teratogenesis
B. Consider termination because of the risk of childhood cancer
C. Consider termination because of the administration of contrast in pregnancy
D. Inform referring physician of findings and seek input from medical physicist
E. Seek legal counsel because failure to perform a pregnancy test constitutes malpractice

Answer: The correct answer is D. Inform referring physician of findings and seek input from medical physicist.

Imaging findings: The contrast enhanced CT images demonstrates fetal structures with visible bony ossification within the uterus, consistent with a second trimester pregnancy.

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DISCUSSION – Incidental second trimester pregnancy

Pregnancy is occasionally discovered at imaging performed for another reason. This situation creates the greatest radiological concern when the fetus has been exposed to ionizing radiation, particularly when the fetus has been in the primary beam of a CT scanner.
Answer options

A. Consider termination because of the risk of teratogenesis. It is unlikely that the fetal dose was sufficient to cross the estimated fetal threshold dose for teratogenesis of approximately 10 rad [1-3], and so consideration of termination is not appropriate.

B. Consider termination because of the risk of childhood cancer. While the relative risk of fatal childhood cancer is likely appreciably increased by fetal radiation exposure, the absolute risk remains very low and insufficient to justify termination [4-5].

C. Consider termination because of the administration of contrast in pregnancy. Iodinated contrast is categorized as a class B agent by the FDA with respect to use in pregnancy [6]. That is, use in pregnancy considered probably safe because, while there are no controlled human studies, animal studies show no risks. For example, acetaminophen is also a class B agent.

D. Inform referring physician of findings and seek input from medical physicist. This is the appropriate course of action. The referring physician carries responsibility for the results of the test, including the unexpected finding of pregnancy, and is likely the best person to inform the patient of this finding. Involvement of a medical physicist to assist in calculation of fetal dose is also advisable.

E. Seek legal counsel because failure to perform a pregnancy test constitutes malpractice. There is no regulatory requirement or standard of care that requires performance of a pregnancy test in women of child-bearing age prior to exposure to ionizing radiation, if they have stated they are not pregnant. Patients must be asked if they are pregnant [7, 8], which was done in this case.

References

8. DHSS publication no. HHS/FDA-86-8254.
2. History: A 26 year old who is 36 weeks pregnant has symptoms of appendicitis, and presents to the Emergency Department of a large academic medical center.

Question: The attending physician in the Emergency Department calls for your advice on the best imaging algorithm in this scenario. The most appropriate approach is:

A. Ultrasound first, then CT if ultrasound inconclusive
B. Ultrasound first, then MRI if ultrasound inconclusive
C. Ultrasound only, CT and MRI are contra-indicated
D. CT only, with oral, rectal, and intravenous contrast
E. MRI only

Answer: The correct answer is B. Ultrasound first, then MRI if ultrasound inconclusive.

DISCUSSION – Imaging suspected appendicitis in pregnancy

Appendicitis in pregnancy can be a challenging diagnosis, both clinically and radiologically, particularly in later gestation when the appendix can be difficult to identify by any modality because it is compressed by the gravid uterus and may be obscured by large para-uterine veins.

Answer options

A. Ultrasound first, then CT if ultrasound inconclusive. This approach would have been considered the standard of care up until recent years, but now a substantial body of literature has emerged that has established the utility and accuracy of MRI for the diagnosis of suspected appendicitis in pregnancy [1-3]. MRI has the advantage of not exposing the fetus to ionizing radiation.

B. Ultrasound first, then MRI if ultrasound inconclusive. This is most reasonable approach, especially in a large academic center where MRI and experienced readers should be readily available. This approach has been endorsed by both radiological and clinical publications [3-5].

C. Ultrasound only, CT and MRI are contra-indicated. This is incorrect, both CT and MRI can be performed in pregnancy if the clinical benefits are considered to outweigh the risks.

D. CT only, with oral, rectal, and intravenous contrast. This is incorrect; ultrasound followed by MRI if ultrasound is inconclusive is currently regarded as the most appropriate strategy [4].

E. MRI only. While ultrasound is frequently unhelpful in the diagnosis of appendicitis in pregnancy [6], it is relatively cheap and available, and can be helpful if positive for appendicitis or to indicate another cause of abdominal pain.

References


3. History: A 40 year old woman who is 11 weeks pregnant has symptoms of pulmonary embolism. A chest radiograph shows a nonspecific 4 cm opacity in the left mid-lung.

Question: What is the best imaging algorithm in this patient?

A. CT pulmonary angiography
B. Transbrachial conventional pulmonary angiography
C. Ventilation/perfusion scintigraphy
D. All the above are contra-indicated; perform bilateral lower extremity ultrasound instead
E. Gadolinium-enhanced MR pulmonary angiography

Answer: The correct answer is A. CT pulmonary angiography.

DISCUSSION – Pulmonary embolism in pregnancy

Answer options

A. CT pulmonary angiography. CT pulmonary angiography is readily available, accurate, non-invasive, and likely to be diagnostic. Recent society guidelines indicate CT is the test of choice for pregnant women with suspected pulmonary embolism who have an abnormal chest-radiograph [1, 2].

B. Transbrachial conventional pulmonary angiography. While transbrachial conventional pulmonary angiography is accurate and carries a lower fetal dose than transfemoral conventional pulmonary angiography, it is invasive and still has a higher fetal dose than CT [3].

C. Ventilation/perfusion scintigraphy. The relative role of ventilation/perfusion scintigraphy and CT for pulmonary embolism diagnosis during pregnancy is contentious. Lung scintigraphy and CT angiography have comparable performances for pulmonary embolism diagnosis during pregnancy. Interobserver agreement is better for CT angiography, which also enables alternative diagnosis of unsuspected disease but delivers higher maternal radiation dose [4]. That said, recent society guidelines favor CT when an initial chest radiograph is abnormal and ventilation/perfusion scintigraphy when an initial chest radiograph is normal [1, 2].

D. All the above are contra-indicated; perform bilateral lower extremity ultrasound instead. While bilateral lower extremity ultrasound may be helpful, particularly in the setting of lower extremity symptoms, it is not true that the other studies are contra-indicated.

E. Gadolinium-enhanced MR pulmonary angiography. This technique is not yet widely available or validated as an appropriate test for the diagnosis of pulmonary embolism in pregnancy. In addition, the use of gadolinium during pregnancy is relatively contra-indicated.

References


4. History: A 24 year old woman who is 8 weeks pregnant presents with nonfebrile acute pelvic pain. An enhanced MRI shows a crenulated thick-walled briskly rim-enhancing 2 cm structure in the left ovary and a separate low T2 and high T1 signal 2.5 cm solid left para-uterine mass.

Question: Which of the following is TRUE?

A. Tubo-ovarian abscess is the leading diagnosis
B. The use of gadolinium was appropriate
C. Red degeneration of a fibroid is the leading diagnosis
D. The ovarian finding merits serial ultrasound follow-up
E. The pregnancy should be terminated

Answer: The correct answer is C. Red degeneration of a fibroid is the leading diagnosis.

Imaging findings: The T1-weighted pre-contrast image shows a centrally T1-bright 2.5 cm solid left para-uterine mass that appears to arise exophytically from the left side of the uterus. The T2-weighted image shows this mass is of low T2 signal. In conjunction, these findings favor a diagnosis of red degeneration of an exophytic uterine fibroid. The gadolinium-enhanced T1-weighted images shows a typical corpus luteum cyst in the left ovary. This is an expected physiological finding in the first trimester that should not be mistaken for a necrotic tumor of for an abscess.

DISCUSSION – Red degeneration of fibroid

Answer options
A. Tubo-ovarian abscess is the leading diagnosis. Incorrect. The finding of a typical corpus luteum cyst in the left ovary is an expected physiological finding in the first trimester that should not be mistaken for an abscess.

B. The use of gadolinium was appropriate. Incorrect. Gadolinium is teratogenic in animal studies and is relatively contra-indicated in pregnancy (FDA class C agent). In addition, this patient is only 11 weeks pregnant so the concern regarding the administration of a potentially teratogenic agent during ongoing organogenesis is heightened. Finally, the diagnosis of red degeneration of a fibroid can be made in this case without the contrast-enhanced images.

C. Red degeneration of a fibroid is the leading diagnosis. Correct, this diagnosis is strongly favored by the non-contrast T1 and the T2 signal characteristics of the exophytic uterine mass.

D. The ovarian finding merits serial ultrasound follow-up. No additional follow-up is required for a typical corpus luteum cyst.

E. The pregnancy should be terminated. While gadolinium should not have been administered because it is teratogenic in animal studies when given in high and repeated doses, limited human studies have not shown deleterious effects of gadolinium given during pregnancy [5, 6] and termination would not appear advised based on the administration of gadolinium alone.

References
5. History: A 29 year old with known longstanding Crohn’s disease who is 11 weeks pregnant with a desired pregnancy presents to the Emergency Department with increasingly severe abdominal pain, hypotension, fever, and leukocytosis. Her gastroenterologist considers her “deathly ill” and is concerned the patient may have an intra-abdominal abscess. He calls you for advice on imaging.

Question: Which of the following statements is TRUE?

A. Contrast-enhanced CT is contra-indicated because of the risk of neonatal hypothyroidism
B. The primary risk of CT during the first trimester is teratogenesis
C. Doing a CT or MRI is too dangerous and cannot be justified in this setting
D. Injected gadolinium will enter and persist in the amniotic fluid, posing a potential risk
E. Contrast-enhanced MRI is contra-indicated because gadolinium is teratogenic in animal studies

Answer: The correct answer is E. Contrast-enhanced MRI is contra-indicated because gadolinium is teratogenic in animal studies.

DISCUSSION – CT and MRI safety in pregnancy

CT and MRI carry different concerns when performed in the first trimester of pregnancy. The primary concern with CT is the carcinogenic effect of exposure to ionizing radiation in utero. Diagnostic CT studies are unlikely to expose the developing fetus to a teratogenic dose of radiation, so this is rarely a real risk. The primary concern with MRI is the possibility of teratogenesis associated with the administration of gadolinium. There is also a general concern that exposure to strong magnetic fields and radiofrequency pulses might be somehow harmful to the fetus, but no specific adverse effects have been linked to in utero exposure to MRI.

Answer options

A. Contrast-enhanced CT is contra-indicated because of the risk of neonatal hypothyroidism. The iodine content of contrast media has the theoretical potential to produce neonatal hypothyroidism. For example, neonatal hypothyroidism has been observed after the direct instillation of ionic contrast into the amniotic cavity during amniofetography [1]. Conversely, the intravascular use of non-ionic contrast media has been reported to have no effect on neonatal thyroid function [2] and no cases of neonatal hypothyroidism were observed in a study of 23 children who were exposed to intravenously administered iodinated contrast in utero [3]. Given these data and given that it is standard pediatric practice to screen all neonates for hypothyroidism, the theoretical risk of neonatal hypothyroidism is not a contra-indication to the use of iodinated contrast in pregnant women.

B. The primary risk of CT during the first trimester is teratogenesis. Diagnostic CT studies are unlikely to expose the developing fetus to a teratogenic dose of radiation, so this is rarely a real risk [4].

C. Doing a CT or MRI is too dangerous and cannot be justified in this setting. Both CT and MRI can be used in pregnancy, provided the benefits are considered to outweigh the risks.
D. Injected gadolinium will enter and persist in the amniotic fluid, posing a potential risk. Studies in pregnant mice indicate that gadolinium is cleared rapidly from amniotic fluid, so that persistence is likely not a concern [5].

F. Contrast-enhanced MRI is contra-indicated because gadolinium is teratogenic in animal studies. When given at a dose of 0.5 mmol/kg/day over 13 days to pregnant rabbits, gadodiamide is associated with the development of skeletal malformations. Given this teratogenic potential, gadolinium is contra-indicated during pregnancy, especially during the period of organogenesis.

References
6. Omniscan package insert, Nycomed, Princeton, NJ.
1. When performing CT urography, the rationale for administering IV furosemide in addition to IV contrast material includes...

A. IV furosemide improves both opacification and distension of the collecting systems, ureters, and bladder.
B. IV furosemide shortens examination time.
C. IV furosemide improves 3D image quality.
D. Upper tract urinary neoplasms are common.
E. IV Furosemide improves the detection of bladder neoplasms.

Answer ‘A’ – Data supporting the use of IV furosemide are clear and based on anatomy depiction. CTU supplemented with IV furosemide has not been shown to detect more cancers but it may. Upper tract neoplasms are uncommon. Although other signs may aid in their detection, visualizing the collecting systems and ureters probably increases their detection. IV Furosemide increases urinary flow rate, but has not been shown to shorten examination time, nor is this the rationale for using it. IV Furosemide may or may not improve 3D image quality; it can increase the number of visualized segments but dilutional effects can also reduce image quality. IV Furosemide may improve the detection of bladder cancers but this has not been shown.

References:


2. CT urography (including scans before and IV contrast material) is indicated in...

A. 32 year-old man with flank pain
B. 45 year-old woman with a suspicious renal mass
C. 50 year-old with a suspected urinary leak after radical prostatectomy
D. 70 year-old woman with gross hematuria, otherwise normal urinalysis

Answer ‘D’ – Hematuria detected in patients with an otherwise normal urinalysis is not likely to be infectious or caused by glomerular or tubulo-interstitial disorders. Hence CTU is indicated to search for a neoplasm. A young patient with flank pain should undergo a stone protocol unenhanced CT, not CTU. A suspicious renal mass is best evaluated with a renal mass protocol CT. Post—operative leaks can be evaluated with excretory phase images alone.
3. According to guidelines of the American Urological Association published in 2012, CT urography is indicated…

A. only if 2 of 3 urinalyses demonstrate hematuria
B. in patients in whom infection, ‘medical renal disease’, trauma, menses and other benign causes are excluded
C. if cystoscopy is negative
D. after one year if the initial CT urogram is negative
E. if cytology is negative

Answer ‘B’ – The AUA guidelines apply to all patients in whom an initial evaluation for infection, ‘medical renal disease’, trauma, menses, and other benign causes are excluded. Unlike the 2001 AUA guidelines, according to the new, 2012 AUA guidelines, only one positive urinary sediment with hematuria is needed to trigger an evaluation that includes both CT urography and cystoscopy. If the evaluation is negative, repeat CTU is unlikely to reveal a new abnormality. Therefore, if the hematuria persists and remains unexplained, CT urography is not recommended for 3-5 years. CT urography can be performed earlier if the clinical scenario changes.

