Radiology and Pregnancy. Risks and reality

Poster No.: C-0923
Congress: ECR 2013
Type: Educational Exhibit
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Keywords: Obstetrics (Pregnancy / birth / postnatal period), Foetus, Medico-legal issues, Decision analysis, Obstetrics
DOI: 10.1594/ecr2013/C-0923

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Learning objectives

To make known the **effects of ionizing radiation in the embryo-fetus** according to gestational age and given dose.

To make known the **importance of the role of the radiologist** and his/her responsibility in the election of the imaging technique to use in the imaging study of the pregnant woman.

To make known the **most recommended radiological diagnostic algorithm** in the more frequent medical-surgical pathologies in the pregnant woman.
Background

The pregnant woman is potentially a sick human being that requires occasionally radiological procedures (ultrasound, radiography, CT and MRI).

The diagnostic radiation and the use of intravenous contrast media in CT and MRI studies is disturbing because of the possible effects on the fetus, that can originate inadequate suggestions as to delay or consider inappropriate performing radiological studies, or even, to recommend the interruption of the pregnancy.

The effect of the ionizing radiation in the embryo and fetus is variable according to the gestational age and the absorbed doses.

According to gestational age, ionizing radiation can induce:

1. In the first two weeks of pregnancy: abortion.
2. Between the 3rd and 8th weeks: skeletal and ocular anomalies, and growth retardation.
3. Between 9th and 25 weeks: ranging from a decrease in the intellectual coefficient to severe mental retardation.
4. In the rest: increase of child’s cancer risk, according to received doses.

Plain radiography studies, fluoroscopy and CT of parts of the body that doesn’t include abdomen and pelvis imply a fetal radiation lower than 1mSv.

The studies that include those parts, could represent a moderate dose for the fetus, even reaching doses higher than 50 mSv if the procedure is not correctly optimize.

In the case that a CT scan including the pelvis or abdomen is necessary, it is necessary to optimize the acquisition parameters (thickness and pitch) so if they are used adequately, rarely they exceed the 25 mSv dose, so the absolute risk of noxious effects in the fetus is insignificant in a dose lower than 50 mGy.

As a general attitude, in any given study that implies the use of ionizing radiation, it is reasonable to consider as a pregnant woman every woman in child bearing age, especially if there is a reasonable doubt and/or the menstruation is absent or retarded. Fig. 1 on page 5
Generally speaking all the diagnostic imaging algorithms of non obstetrical pathologies that pregnant women have more frequently are based on **two principles**:

1. To start using procedures that do not use ionizing radiation (ultrasound and MR).
2. If they are not conclusive, or we can not use them (emergency studies and MR), and we need more imaging studies to orientate the diagnosis, we can use ionizing radiation techniques (usually CT) after an individualized evaluation if the risk benefit relationship and optimizing the procedure so the received fetal dose is the lowest possible.

As it is said by the **84 publication of the international commission of radiological protection (ICRP)**, the fetal dose estimation is only necessary in radiological studies that use higher doses in which the fetus is in the direct radiation beam but it would be advisable its calculation if it is possible.

The **Real Decreto (RD 815/2001)** about the justification of the ionizing radiations for the radiological protection of people because of the medical exposure in its **5 article**, establish the need to give a special care to the justification of executing imaging studies with ionizing radiation in child bearing age in which we can not rule out a pregnancy, specially in studies that include the pelvis or the abdomen.

In these cases, they recommend to evaluate the procedure, the urgency of it, and the **optimization of the technique**, paying attention to the exposure of the expectant mother and specially the fetus.

In the **6th article** of the same RD it says that the radiologist is responsible for the evaluation of a correct indication of the radiological procedure and of defining alternatives to it that imply less or none radiological risk.
**Fig. 1:** AP radiography of the abdomen in a supine decubitus in a 17 years old patient that came to the emergency department because of abdominal pain and fever. We performed a study with a simple radiography without optimization of the technique for the reduction of the dose. In the emergent ultrasound we identified a gestational sac in relation with an ongoing pregnancy (at the moment of the examination it was a 8 weeks old pregnancy). The estimated fetal dose from the technical data of the study (81 kV and 5.34 mAs) and the tube performance was 0.27 Gy.)

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Implications of different imaging techniques and contrasts in the pregnant women:

1. Ultrasound and pregnancy:

To the date we do not know any fetal adverse effects related to this imaging technique, although it is recommended a wise use of Doppler, shortening the times and diminishing the acoustic output as it is reasonable possible.

2. Pregnancy and MR:

The security committee of image by magnetic resonance society in their recommendations establishes that MR is an imaging technique that can be used in the pregnant woman when other non ionizing imaging techniques are not adequate or after a correct evaluation of the risk benefit in each particular case.

To the date we do not now any noxious fetal effects because of its use, but a wide experience that we have today is related to studies performed with equipments with magnetic field intensity not higher than 1'5T.

Generally speaking it is not advisable to use equipments with magnetic fields greater than 2'5T because we have less experience.

Although there is no evidence of fetal risk, some international organizations recommend a wise use in the first trimester of pregnancy.

So it is a procedure that can be used in pregnant women beyond the first trimester although its use in emergency studies is limited because it is not always available, it needs longer study time, and frequently is incompatible with some life support devices that have metallic material.

3. Plain radiography and CT in pregnant women:

The exposure to estimated radiation is low if the fetus is out of the region of interest and the technique is performed adequately.
Cranial, cervical and thoracic spine and extremities studies, (excluding pelvis and hips) could be performed in a pregnant woman if they are essential for the diagnosis and not be delayed in time. Fig. 2 on page 11 Fig. 3 on page 11

In some clinical situations it could be necessary to perform studies that include the abdomino-pelvic region, as in the case of emergent acute abdominal pathology with a no conclusive ultrasound study. These studies would be performed after a correct evaluation in each case of the risk benefits minimizing in what is possible the fetal dose. Fig. 4 on page 12

4. Use of iodinated contrast media during pregnancy:

It is known that the fetus is exposed to this kind of contrasts because it goes through the placental barrier.

The Food and Drug Administration (FDA) classifies iodinated contrast media with a B level of security for pregnant women, that means that in experimental studies with animals they could not demonstrate noxious effects in the fetus.

Anyhow there are not studies with pregnant women and they admit their use only if it is necessary for a definitive diagnosis.

A potential noxious effect known is the depression of the thyroid fetal function.

5. Paramagnetic intravenous contrasts (gadolinium) and pregnancy:

There had been studies with animal fetuses with doses 2 to 7 times higher to the normally used in human studies with the result of growth retardation and congenital anomalies.

However, to the date there are not known adverse effects in human fetuses with the regular used dose so it would be possible to use them in normal dose with a certain margin of security in not delayed studies, after a correct evaluation of risk-benefit in each case.

Imaging Studies in main non-obstetrical pathologies during pregnancy:

1. Imaging studies in a pregnant woman with the clinical suspicion of pulmonary thromboembolism (PTE):
PTE is 5 times more frequent in pregnant women because of the hypercoagulability state of pregnancy and the venous ectasia associated. Fig. 5 on page 13

D-dimer can not be employed as a screening method during pregnancy because it progressively rises all the way through it and it loses its specificity when normal parameters (not for pregnant women) are used.

Actually it is being studied the possibility to establish normal values for each pregnancy trimester that allow the interpretation of this determination in pregnant women blood tests.

When we suspect a PTE clinically it could be useful to perform a venous ultrasound of the lower limbs, because if it confirms the existence of deep vein thrombosis, it will initiate anticoagulant therapy (the same treatment for PTE) avoiding performing an angioCT of the thorax. Fig. 6 on page 13

If it is necessary to perform this last study for the definitive diagnosis of PTE in a pregnant woman, it would be necessary to give the possible lowest fetal dose, so it will be recommended the following modifications of the techniques that must be performed trying to obtain the best possible image quality Fig. 7 on page 14:

- Inferior limit of the study immediately below the xyphoid process (excluding the abdomen).
- Increase of pitch.
- Collimation excluding the lateral regions.
- Increase of kilovoltage and decrease of the miliamperage.
- Utilization of a lead apron with protection of the abdomen: although it does not avoid scatter radiation generated within the human body or the patient but at least it gives protection to the abdomen.

2. Acute appendicitis:

It is the non obstetrical surgical pathology more frequent in pregnant women.

The delay in the diagnosis associates a higher risk of perforation than in non pregnant women.

In the clinical suspicion of appendicitis we recommend to start the imaging studies with ultrasound (it helps a lateral left decubitus position), taking in to account that in pregnant women there is a rotation and superior migration of the appendix.
If the study is not conclusive and the clinical symptoms are suggestive we could opt to confirm the clinical suspicion by performing a CT Fig. 8 on page 15 or MR Fig. 9 on page 15, always after a correct evaluation of the risk-benefit relationship.

3. Urolithiasis:

It is the **most frequent non obstetrical pain** and it is the first cause of admission for non obstetrical pathology in a pregnant woman.

It is important to **differentiate true obstructive hydronephrosis from physiologic hydronephrosis** secondary to changes of pregnancy.

The presence of fluid surrounding the kidney and the increase of the kidney size are suggestive of obstructive hydronephrosis Fig. 10 on page 16 while in physiologic pregnancy hydronephrosis usually is predominant on the right side and is suggestive of it the selective obstruction at the medium third of the ureter because of the extrinsic compression by the augmented uterus.

In the suspicion of urolithiasis, our imaging studies should start performing a **trans abdominal ultrasound**.

A **Doppler ultrasound study** could also add information about the intrarenal resistivity index (that confirms the presence of obstructive hydronephrosis when it increases above 0'70) and helps to visualize the ureteral jet.

For the latter it is recommended to position the patient in the contralateral lateral decubitus, to rule out false positives because of the compression of the urinary tract by the fetus.

**Trans vaginal ultrasound** could be useful to visualize urolithiasis located in the distal region of the ureter when abdominopelvic ultrasound is normal or non conclusive, and the symptomatology is very suggestive.

If ultrasound is not useful for a definitive diagnosis, we could confirm the clinical suspicion performing an abdominopelvic CT without contrast after the correct and individualized evaluation of the risk benefit relationship. Fig. 11 on page 16

4. Trauma in pregnant women:
It is the **first cause of non obstetrical maternal death.**

Physiologic pregnancy changes can conceal the injuries.

Fetal death could be because of trivial or severe trauma. For that reason, if a pregnant woman has had a severe abdominal trauma it is necessary to perform urgent imaging techniques on her so the possible received fetal radiation could not stop or delay the execution of them.

As usually it is recommended to start the study with an **abdominal ultrasound**, that is considered positive if we see abdominal free fluid (in pregnant women it accumulates in the superior lateral quadrants and pelvis) or a visceral lesion (solid organ injury).

At present there are not studies that recommend the execution of an **abdominal CT** in pregnant women with direct trauma if the ultrasound is normal, but it is well known that the CT examination is more sensitive to visualize intraperitoneal free fluid or solid organ injuries.

**MR** could be theoretically an alternative to CT but as we previously said, it is not usually available, it needs longer examination time and it is not compatible with life support devices that have metallic parts, so usually it is not helpful in the most emergent cases.
**Fig. 2:** Simple chest PA radiography in a 30 years old woman with a pregnancy of 33 weeks. The study was performed with 125 kV and 1.52 mAs. We protected the abdominal region with a lead apron. Study performed with anti scatter grid. The effective fetal dose (EFD) calculated for this study is lower than 0.01 mSv, that implies a very low fetal risk.

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**Fig. 3:** Simple AP radiography of the left foot of a 26 years old woman with a pregnancy of 20 weeks. The study was performed with 50 kV and 3mAs. We protected the abdominal region with a lead apron. Study performed without an anti scatter grid. The effective fetal dose (EFD) was very low.

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**Fig. 4:** Simple radiography with two projections of the pelvic region in a 38 weeks pregnant woman. Study for a possible cephalo-pelvic disproportion. We removed the anti scatter grid and it was collimated to the maximum.

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**Fig. 5:** Angio CT of the chest in a 25 years old 14 weeks pregnant woman that was referred for chest pain and hemoptysis. Left: repletion defect in the left inferior posterior segmentary artery in relation to acute thrombosis (white arrow). Right: peripheral consolidation suggesting a pulmonary infarction (black arrow).

**Fig. 6:** Color Doppler ultrasound in a 34 years old 30 weeks pregnant woman who consulted to the emergency department for pain and increase of the lower limb diameter. We performed a study that showed deep vein thrombosis from the common femoral vein (left) to the popliteal vein (right). The treatment for the deep vein thrombosis consists of anticoagulation therapy as it is for the pulmonary embolism (PE), so if we have the clinical suspicion of PE, it can be useful to perform the Doppler ultrasound of lower limbs examination because if, we see DVT, the patient could be treated with anticoagulation therapy without the need to have a ionizing radiation examination and iodinated contrast material (chest angio CT).

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**Fig. 7:** Chest angio CAT, axial images. In the right we visualize the study of a healthy non pregnant woman performed with the usual protocol. In the left we can see a similar study performed in an pregnant woman with a reduction of the dose protocol. We cannot see great variations in the quality of the image obtained.

Fig. 8: Axial CT abdominal image with IVC and oral contrast in a 21 years old 23 weeks pregnant woman. Appendix increased in size, with thickened wall with the presence of an appendicolith (white arrow) and inflammatory periappendicular changes. The patient had surgery with the result of acute perforated appendicitis.

**Fig. 9:** MR study with T2 weighted sequences with axial and coronal images in a pregnant woman with abdominal pain located in the right iliac fossa. Increased in size appendix, with thickened walls with inflammatory changes of the surrounding fat (white arrows).


**Fig. 10:** Echographic study of the urinary tract in a 37 years old woman on her third trimester of pregnancy that consulted because right flank pain. Left: Sagital image of the right kidney with moderate hydronephrosis. Center: Echographic image of the bladder with a stone located in the distal part of the right ureter. Right: Left ureteral jet visualized with Doppler ultrasound.

**Fig. 11:** Abdominal CAT without IVC, axial images, in a patient with left flank pain in the third trimester of pregnancy and with the clinical suspicion of left urolithiasis. Left: Moderate right hydronephrosis. Right: Small stone in the right vesicoureteral junction.

Conclusion

The execution of many imaging examinations with ionizing radiations in pregnant women needs a correct individualized justification about its indication. In the case of that it is necessary its execution the procedure should be optimized to minimize the fetal dose.

Prenatal doses accounting for the execution of imaging examinations using ionizing radiation (if they are correctly performed and they do not affect the abdominopelvic region) are not associated with a substantial increase of death, malformation or mental deterioration of the fetus.

In those examinations that affect the pelvic or abdominal areas they should be justified with more detail the indication of them, evaluating the possibility of performing other tests that do not use ionizing radiation as the first option.

In any case, after a previous individualized justification, we can assume that almost always the risk for the mother if we do not execute the diagnostic procedure, is greater than the potential risk for the fetus.

However, for obvious reasons, in a pregnant woman the imaging study should start with imaging techniques that do not use ionizing radiation, as ultrasound or MR, keeping those which use them for when the first ones are not conclusive available, and trying, in any case that the received fetal dose is the minimum possible.

Form a legal point of view, the radiologist is responsible for the evaluation of the correct indication of the radiological procedure, and also to define those alternatives that imply less radiological risk for the fetus.

The radiologist should inform the expectant mother about the real risks and the potential benefits of the procedure, that will help diminishing the expectant mother anxiety and also gives the pregnant woman the necessary information to agree or not in the execution of the procedure with full knowledge of the possible consequences derived from her decision.
References

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- International Commission on Radiological Protection (ICRP), n° 103.