Making decisions about radiological imaging in pregnancy

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Globally ultrasound has been used in pregnancy for decades. The use of other imaging modalities such as plain radiography, Computed Tomography (CT), and Magnetic Resonance Imaging (MRI)—is increasing1. Imaging plays an important role in the investigation of many conditions in pregnancy, but there is also the potential to cause harm. Concerns about fetal and maternal harm can make decisions to image difficult for patients and clinicians. However, risk is often lower than expected and, especially in many acute situations, is outweighed by the benefit.

How will this paper help clinicians and their patients make these decisions?

This paper will discuss the risk different commonly used imaging modalities pose to the fetus. Commonly encountered emergency clinical scenarios will be explored, along with what imaging could be used in these situations, with the aim of enabling the reader to understand the benefits and risks of imaging so that they can make informed decisions with their patients. We also describe how to approach discussion of risk with patients.

We will not cover elective scenarios which could potentially wait until post pregnancy; however, the principles we discuss behind choosing imaging modality can be applied to all pregnant patients.

As this paper is aimed at clinicians referring patients for imaging we will not discuss issues that are primarily the role of the radiology department e.g. dose modification techniques and prevention/management of inadvertent fetal imaging (e.g. when patients are unaware they are pregnant).

We will also not cover imaging in the post-partum period and in women who are breastfeeding.

What imaging modalities will be covered?

* Ultrasound—uses high frequency sound to produce images
* Ionising radiation— uses high energy electromagnetic radiation to produce images. X-rays and gamma rays are the most commonly used forms of ionising radiation in medical imaging
* MRI (magnetic resonance imaging) – uses strong magnetic fields and radio waves to produce images

What is the evidence like?

The evidence base for the risks of imaging in pregnancy that will be discussed in this paper includes experimental animal studies, observational epidemiological studies on human subjects and, in the case of ionising radiation, studies from Japanese atomic bomb survivors2-6. The majority of human studies are retrospective.

What potential risk does imaging in pregnancy pose to the fetus?

Different imaging modalities have different effects on human tissues and as such pose different risks (and levels of risk) to the fetus. See table 1. High dose ionising radiation such as CT (computed tomography) is generally of more concern than ultrasound, MRI and low dose ionising radiation such as plain radiography.

**Table 1: fetal risks associated with, and guidelines for the use of, specific imaging modalities in pregnancy**

|  |  |  |
| --- | --- | --- |
| **Modality** | **Consideration** |  |
| **Ultrasound** | **Common indications in the pregnant patient** | Obstetric imaging  Suspected acute abdominal/pelvic pathology  Heart imaging (echocardiography) |
| **Evidence based summary of risk** | No evidence of adverse maternal, fetal, perinatal, or childhood outcome 2\*  There are theoretical risk from heating and movementeffects7 8 but adverse outcomes as a result of this have not been found in human studies. |
| **IV contrast use** | Microbubbles  Only used rarely in clinical practice (echocardiography, characterisation of liver and renal lesions) and as such will rarely be considered in pregnancy.  Microbubbles bursting can cause cavitation in tissues. Microbubbles enter the placenta and the risk of damage to the placenta has not been well investigated9. |
| **Recommendations** | Whilst ultrasound is generally safe, the principles of As Low As Reasonably Achievable (ALARA) principle should be followed:7 8  - only use ultrasound if clinically indicated  - limit scanning time,  - limit Doppler imaging (uses higher energy than 2D imaging)  - use machine configured for obstetric use  IV contrast  Ultrasound contrast should be generally avoided (only used where benefits clearly outweigh the risks)10. |
| **Ionising Radiation** | **Common indications in the pregnant patient** | X-rays:  Plain radiographs e.g. chest and extremities  CT e.g. head imaging in suspected intracranial haemorrhage, CT pulmonary angiography in suspected pulmonary embolism and abdominal imaging in trauma  Gamma-rays:  ventilation/perfusion (VQ) scans  bone scans (rarely considered in pregnancy)  PET-CT uses both gamma rays and X-ray (rarely considered in pregnancy). |
| **Evidence based summary of risk** | Fetal malformation, growth restriction, intellectual disability and death, should not occur as a result of the levels of radiation used in diagnostic imaging. UK guidelines suggest this threshold is 100mGy11 whilst USA guidelines suggest 50mGy7.  Cancer induction can theoretically occur with any dose of ionising radiation and as such there is no threshold below which this cannot occur. Risk is dependent on dose and body part imaged.See table 2 for childhood cancer risk with ionising radiation. |
| **IV contrast use** | Iodinate contrastUsed in most body imaging including CTPA and CT abdomen studies.Not routinely used in brain imaging unless vascular assessment required – such as in CT venogram and angiogram studies.Contrast does cross the blood-placental barrier but there is no evidence that IV CT contrast administered at any time in pregnancy causes harm to the fetus10.There is a theoretical risk of neonatal hypothyroidism12 |
| **Recommendations** | See table 2 for information about fetal dose  Low fetal dose procedures (e.g. X-ray and CT above the diaphragm or below the knees)   * risk to the fetus is extremely small (< 1 in 10,000-100,000 risk of childhood cancer induction (compared to a background risk of 1 in 500). * If the procedure is clinically indicated they pose minimal risk to the fetus and can be justified.   Higher fetal dose procedures (e.g. CT which covers the pelvis and PETCT)   * risk to the fetus higher, though still low in absolute terms e.g. up to 1 in 200 * should only be considered if there is no way this information could be obtained without ionising radiation and not performing the procedure could be at serious detriment to the woman’s health * if performed, fetal dose should not exceed 50-100mGy.   In all cases involving ionising radiation the dose should be kept as low as low as reasonable achievable. IV contrast-can be used if clinically indicateddue to theoretical risk of neonatal hypothyroidism, screen baby in first week of life10 13 \*\* |
| **MRI** | **Common indications in the pregnant patient** | Brain imaging (apart from suspected intracranial haemorrhage)  Fetal imaging  Acute abdominal pain |
| **Evidence based summary of risk** | No conclusive evidence that MRI use in pregnancy causes harm to the human fetus7 14 15.  Theoretical risks of fetal hyperthermia5 and inner ear damage6 can be mitigated by scanner modifications15 |
| **IV contrast use** | Gadolinium based contrast  Contrast crosses the blood-placental barrier. There is limited evidence that MRI contrast use in pregnancy is associated with “a broad set of [neonatal] rheumatological, inflammatory, or infiltrative skin conditions” and of stillbirth or neonatal death16. |
| **Recommendations** | MRI can be considered safe in pregnancy.  Some bodies, such as the UK Government’s Medicines and Healthcare Products Regulatory Agency, advise caution in scanning in the first trimester (though it is advised this can be done when the benefits outweigh the risks)15. Others, such as the American College of Radiologists, suggest that patients in the first trimester of pregnancy should not be treated differently to those in later stages of pregnancy14.  Scan modification techniques should also be performed by the radiology team performing the study  IV contrast  Avoid IV gadolinium unless it will change management during pregnancy or there is no other way to get the information10 17. |

\* The metanalysis cited found a weak association between ultrasound exposure and non‐right handedness in boys, though not when boys and girls were analysed together.

\*\* Already offered to all newborns in Europe, Australia, New Zealand and North America to assess for congenital hypothyroidism

Table 2: Typical fetal doses and risks of childhood cancer for some common diagnostic ionising radiation modalities used in early pregnancy when the fetus is small. Based on data summarised by the UK’s Health Protection Agency, The Royal College of Radiologists and The Royal College of Radiographers11

Risk of childhood cancer has been rounded up to 1 in 10,000 per mGy.

For comparison, the natural childhood cancer risk is ~1 in 500.

|  |  |  |
| --- | --- | --- |
| **Examination** | **Typical fetal dose (mGy) from a single scan\*** | **Risk of childhood cancer per examination** |
| **Radiography**  Teeth  Neck  Chest  Extremity  **Mammography**  **CT**  Head  Neck | 0.001-0.01 | <1 in 1,000,000 |
| **CT**  Chest  Pulmonary angiogram | 0.01-0.1 | 1 in 1,000,000  to  1 in 100,000 |
| **Radiography**  Abdomen  Pelvis  Hip  **CT**  Chest and liver  **Nuclear medicine**  Ventilation/perfusion scan (VQ scan)\* | 0.1-1.0 | 1 in 100,000  to  1 in 10,000 |
| **Radiography**  Lumbar spine  **CT**  Lumbar spine  Abdomen (not pelvis) | 1.0-10.0 | 1 in 10,000  to  1 in 1,000 |
| **CT**  Abdomen and pelvis  **PETCT**  Whole body | 10.0-50.0 | 1 in 1,000  to   1. in 200 |

\*Dose can be reduced by performing perfusion scan first and, if normal, ventilation part of the scan need not be performed

Is there a role for abdominal shielding?

Abdominal lead shielding was historically used for ionising radiation that does not directly expose the fetus (examples include chest X-ray and CTPA). However, as the majority of the dose to the fetus in these studies is from internal (rather than external) scatter there is not likely to be any benefit to abdominal shielding. Additionally, if the shield is inadvertently partially in the field of view during the scan, automatic exposure control can inadvertently lead to increased dose18.

Guidelines from the American Association of Physicists in Medicine12 and the British Institute of Radiology13 suggest avoiding the routine use of shielding for the above reasons. Both do suggest, however, to consider shielding on a case by case basis if patients would feel calmer and more reassured with lead shielding in place, providing the patient is adequately counselled about the potential risk of increased dose to the fetus and all care is taken that the shielding does not interfere with the image.

Does imaging pose a risk to the pregnant woman?

Ultrasound –

A meta-analysis performed on behalf of the World Health Organization found no evidence of adverse maternal outcome following ultrasound used in pregnancy2. Ultrasound can be considered safe to the pregnant patient.

Ionising radiation -

Breast tissue is particularly susceptible to the effects of ionising radiation. A meta-analysis of studies of women exposed to different types of ionising radiation, including imaging, therapeutic radiation and atomic bomb survivors, showed that women whose breasts have been exposed are at increased risk of breast cancer19. Theoretically a 20 year old non-pregnant woman undergoing a CTPA study, giving a dose of 10mGy, has an excess breast cancer risk of 429 in 100,00020. Pregnant and breastfeeding women are theoretically at increased risk of radiation effects because the breast are larger and are actively undergoing glandular proliferation20

Despite these theoretical risks, a recent study21 did not show an increased risk of breast cancer in patients exposed to CT chest or VQ scanning in pregnancy or the early post-partum period for a short follow up time period (<12 years).

Overall, the exact risk of breast cancer induction in pregnant women exposed to ionising radiation is not known, but, as with all imaging, the theoretical risks needs to be weighed against the benefit that the imaging will provide and doses kept as low as reasonably achievable.

MRI –

As well as usual MRI safety considerations for all patients (the discussion of which are beyond the scope of this article), pregnant patients may find the relatively long scan times (most studies take at least 20 minutes to perform, some up to 1 hour) and claustrophobia difficult, particularly in late pregnancy. Scan technique may need to be adjusted to account for this which may include reducing scan times and considering alternative positioning within the scanner, for example anterior oblique positioning.

Are there any other risks of imaging pregnant patients?

The risk of detecting incidental findings (“incidentalomas”), which may lead to further investigations and increase unnecessary patient anxiety, needs to be considered along with other risks of imaging22.

Additionally, the possibility of false negative and false positive findings is of particular concern in pregnancy because anatomy and physiology is altered compared to the non-pregnant patient. Examples of this include haemodynamic circulation causing difficulties in pulmonary artery opacification on CTPA23 and in suspected acute abdominal pathology when the gravid uterus can displace or compress structures, making them difficult to visualise on ultrasound24.

How can I involve pregnant patients in decision making for techniques involving higher risk?

For ultrasound, MRI and low dose ionising radiation (see tables 1 and 2) discussions with the patient may be relatively straightforward. For techniques which involve higher fetal or breast doses (e.g. some X-ray and CT examinations) the discussion may be more challenging.

Discussion of risk in pregnancy can be particularly difficult as patients have to consider not only the risk to themselves but also need to make decisions on behalf of their unborn child.

The Royal College of Obstetricians and Gynaecologists offer advice to healthcare professionals and to patients about the discussion of risk in healthcare25 26. Some of the points from these sources that apply to imaging in pregnancy include:

* Explain why the imaging is being suggested and how it will change management for the patient (and, if appropriate, the fetus). Explain what may happen if no imaging is done e.g. the risk of missing serious pathology, acknowledging that this may be difficult to quantify
* Give information in different ways.
  + Give estimated numerical risk of harm (table 2)
  + Give this in relative terms e.g. compared to background risk of childhood cancer of approximately 1 in 500 so an additional risk of 1 in 500 doubles the risk the baby will later develop childhood cancer
  + Provide context e.g. exposure to the fetus from background radiation is approximately 1 mGy whilst the radiation exposure from a transatlantic flight is 0.01 mGy27
* Offer patient information leaflets if available (see “Information resources for patients” box below).

Should I obtain written consent?

The process for obtaining consent for imaging is variable. The ACR suggest that consent can be obtained in both verbal and written forms but in either case should be documented. They offer a sample patient consent form in their guidelines28.

What are some common clinical scenarios?

Trauma

*A 27-year-old woman is brought to the Emergency Department by ambulance following a high speed road traffic collision. She is 30 weeks pregnant.*

*GCS: 15. Heart rate: 125bpm. Blood pressure: 120/70. Respiratory rate: 25bpm.*

*She has left lower chest wall and left flank pain, guarding, and left flank bruising. She states her baby is moving normally and the obstetric team do not believe there is immediate fetal concern. The surgical team is called and imaging is considered. The patient wants to know about risks to her baby from CT scanning.*

Trauma is the leading non-obstetric cause of maternal mortality and can also cause fetal loss so early identification of injury is important29. Consider radiology when the risk from trauma is likely to be higher than the risk from imaging.

Chest radiography and Focussed Assessment with Sonography in Trauma (FAST) may help to rule in some injuries (for example pneumothorax and large volume haemoperitoneum respectively) and expose the fetus to minimal or no radiation. However, these modalities may not rule out potentially life threatening injury which could put the patient and fetus at risk, such as active bleeding, organ injury or fractures.

When potentially life threatening thoracic or abdominal injury is suspected, CT scan is the imaging modality of choice.

To communicate the risk of CT, explain to the patient

* The risk of missing life threatening pathology vs
* The risk to the fetus from radiation. For example, using an estimated fetal dose of 20mGy for a single CT abdomen and pelvis (table 2) the risk of childhood cancer induction is approximately 1 in 500. Using baseline risk of childhood cancer of 1 in 500, the risk would approximately double the baseline risk of childhood cancer. This could be communicated by saying, *for every 500 times this scan is done in pregnancy, theoretically, one child would develop a cancer that they would not have developed otherwise*.

Note, doses and risk in table 2 are for single scans but trauma protocols can involve dual phase scanning30.

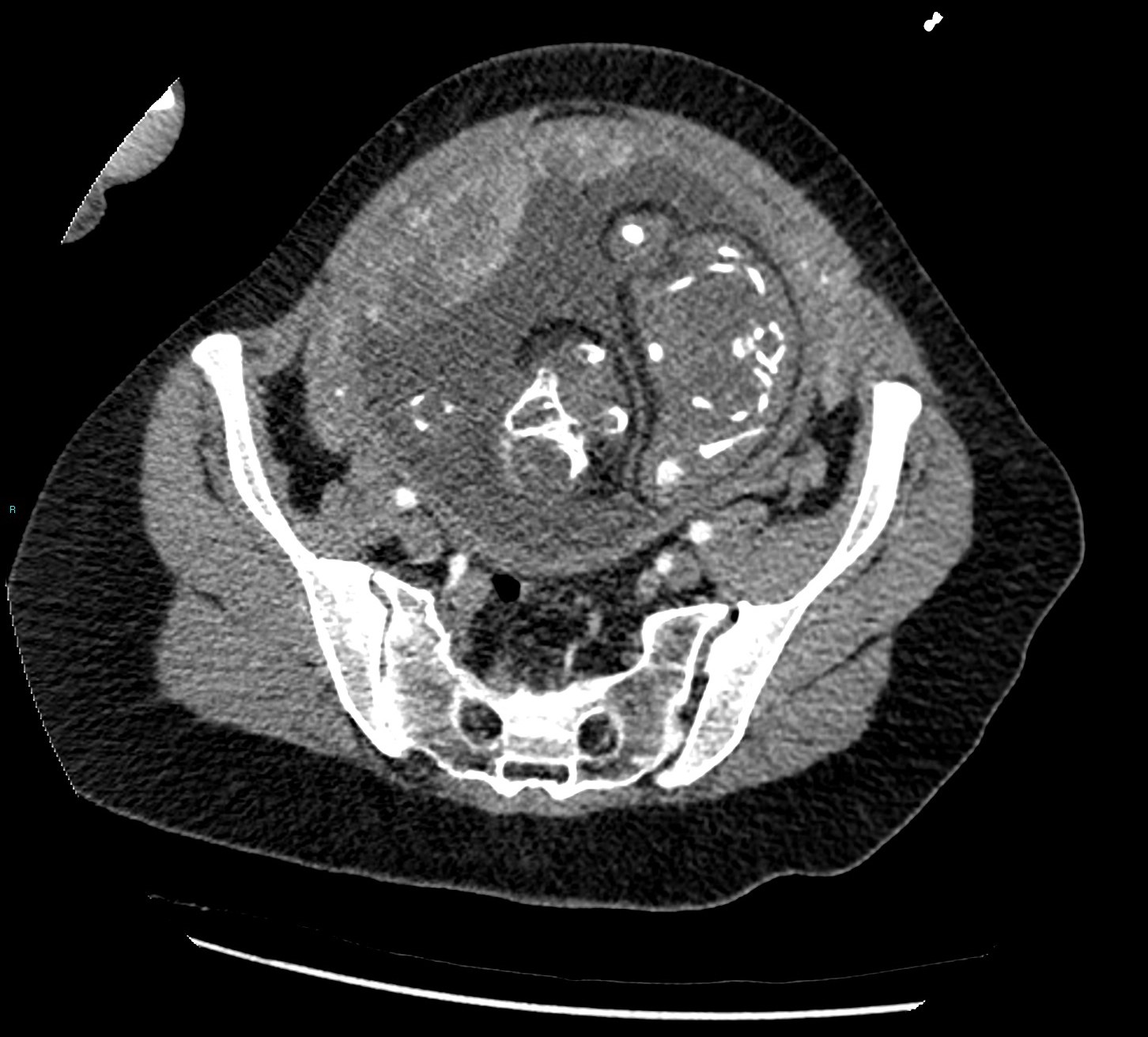
CT in trauma usually requires the use if IV contrast. Explain to the patient that there is no definite risk to the fetus from IV contrast administration. Due to the theoretical risk of hypothyroidism, neonatal heel prick is advised (this is already offered to all newborns in many countries). See table 1.

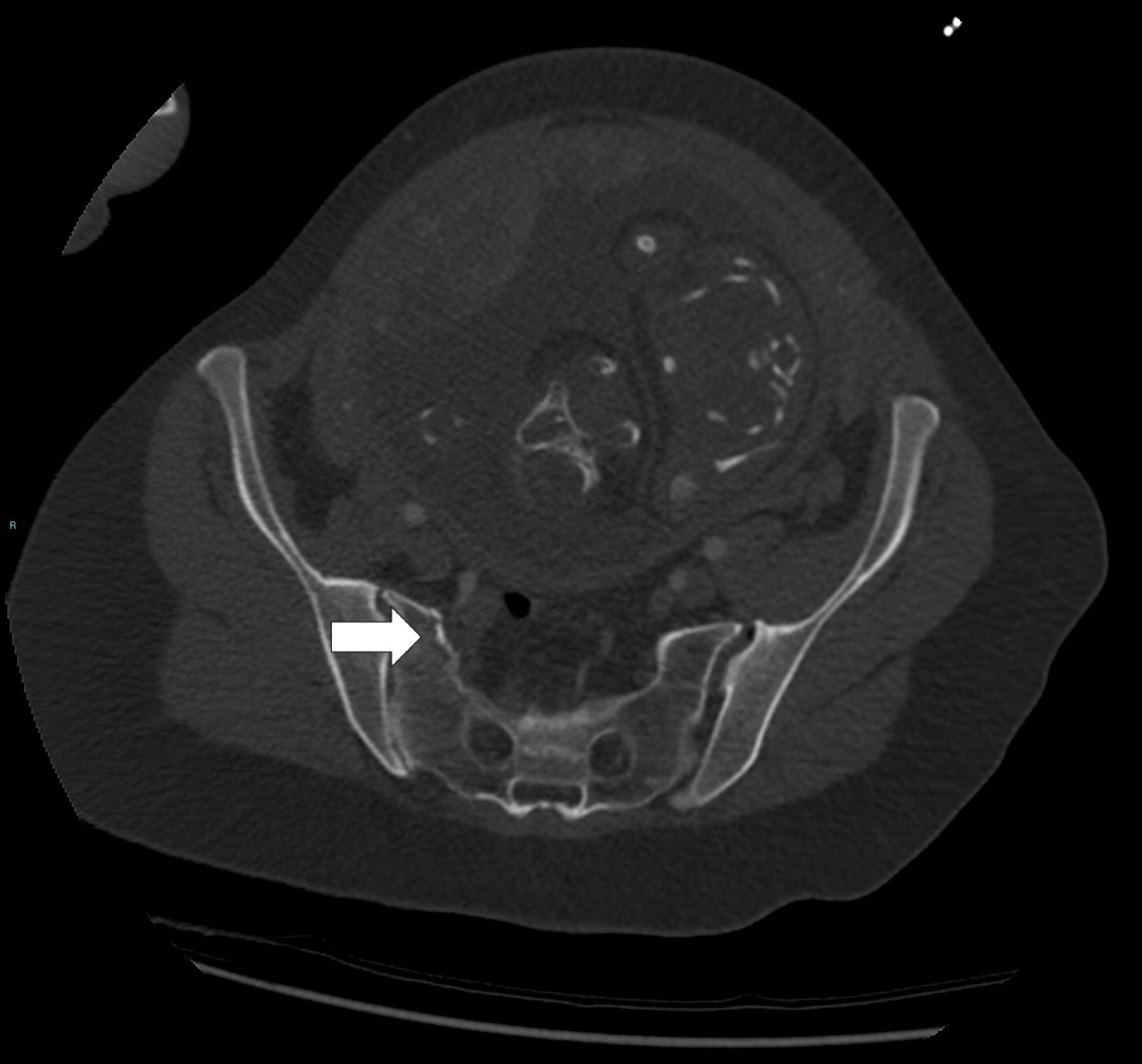
Once life threatening injury to the patient is excluded, consider obstetric ultrasound to look for fetal, placental, and uterine injury29.

Figure 1a-d Imaging of a pregnant patient following major trauma

1a-c CT scan of the abdomen and pelvis with IV contrast in a pregnant patient involved in a high speed road traffic accident. Figure 1a (axial image, soft tissue windowing) demonstrates the gravid uterus and anterior placenta. Figures 1b (axial image, bone windowing) and 1c (coronal image, bone windowing) demonstrate a right sacral fracture (arrows).

1d ultrasound scan of the placenta and fetus performed the following day demonstrated no evidence of fetal or placental injury.









Headache

*A 35-year-old woman attends an out of hours GP service with headache and vomiting that started suddenly, 24 hours earlier. She is 17 weeks pregnant and has no headache history. She has diplopia but no fever or meningism. All vital observations and urine dipstick are unremarkable. The GP recommends urgent assessment in the Emergency Department and advises the patient this will likely include imaging. The patient wishes to discuss imaging options.*

Headache in pregnancy is common and usually due to primary headache disorders such as tension headache or migraine.

Preeclampsia is also a common cause of headache after 20 weeks of gestation and associated with hypertension with or without proteinuria31.

Features which warrant further urgent evaluation to exclude underlying pathology include acute onset, new headache, diplopia and vomiting. Potential diagnoses in pregnancy include subarachnoid haemorrhage and venous sinus thrombosis.

CT is quick, readily available, can readily detect acute haemorrhage and post contrast iodinated imaging is possible. MRI is more sensitive than CT for detecting most intracranial pathology; however, it is slower, less readily available, more prone to artefact, and post contrast gadolinium imaging generally not recommended in pregnancy10 17 (table 1).

Advise the patient that the radiation dose to the fetus from CT scanning of the head is negligible (Table 2)11. CT head should not be delayed if clinically indicated and MRI should not be considered first line purely on the basis of risk to the fetus if CT would be the usual first choice in the non-pregnant patient. If CT is negative further investigation with MRI, post contrast CT or lumbar puncture may be required depending on the suspected diagnosis.

Dyspnoea and chest pain

*A 32-year-old woman attends the Emergency Department following sudden onset chest pain and dyspnoea 6 hours ago. She is 25 weeks pregnant. She has no relevant past medical history. She has had no fever, cough, or alteration in her sense of taste or smell.*

*Heart rate: 105bpm. Respiratory rate: 18bpm. Other observations, examination, ECG, routine blood, and chest radiograph are normal. Wells score is calculated as 7.5 (high risk of pulmonary embolism). The need for imaging is discussed. The patient is concerned about implications for her baby. She asks, “What difference will a scan make if I have a blood clot in my lungs?”*

Venous thromboembolism (VTE) includes deep vein thrombosis (DVT) and pulmonary embolism (PE). The risk of missing VTE or of anticoagulating a patient without VTE puts the patient, and therefore also her fetus, at risk of illness or even death.

Wells score indicates high risk for pulmonary embolism and imaging investigations are recommended32. D dimer is not recommended in pregnancy or if Well’s score indicates high risk (>4) 33 34.

Lower limb vein ultrasound should be performed if there are clinical signs of DVT35 36 . Because the management of DVT and PE are the same, the diagnosis can therefore be made without the need for ionising radiation and there is no known risk to the fetus with ultrasound (Table 1).

In the absence of signs of DVT, guidelines for imaging of suspected PE are conflicting37. Some suggest pregnant patients with suspected PE should undergo lower limb vein ultrasound to avoid ionising radiation. Others advise this is only done if the patient has clinical signs of DVT.

Direct imaging of PE is most commonly performed with CT pulmonary angiography (CTPA) or lung scintigraphy (ventilation/perfusion or VQ scanning). The choice between these studies is controversial because there are relative risks and benefits for each modality (table 3).

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Modality | Fetal dose11\* | Maternal breast dose38\* | Availability | Use in presence of other lung pathology38 | Likelihood of non-diagnostic result39 | Other considerations |
| CTPA | Low. May be lower than VQ.  0.01-0.1 mGy (1 in 1,000,000 to 1 in 100,000 risk of childhood cancer) | May be higher than VQ  10-60 mGy | Good – common test performed widely | Advised | 12% (95% CI 8- 17) | IV contrast used (see table 1) |
| VQ | Low. May be higher than CTPA  0.1-1mGy (1 in 100,000 to 1 in 10,000 risk of childhood cancer) | May be lower than CTPA  0.98-1.07 mGy | May be limited, especially out of hours | Not advised | 14% (95% CI 10-18) | Perfusion scan can be performed first. If normal, ventilation scan is not needed |

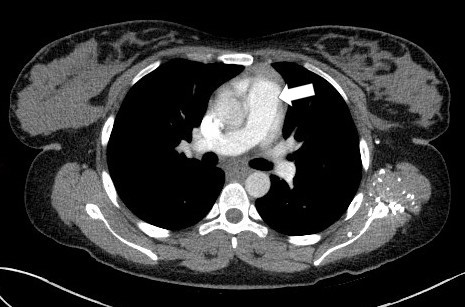
\* recent Cochrane review40 and further recent meta-analysis39 pooled data regarding maternal and fetal doses for CTPA and VQ and advised caution in interpreting results of studies due to lack of high quality data.

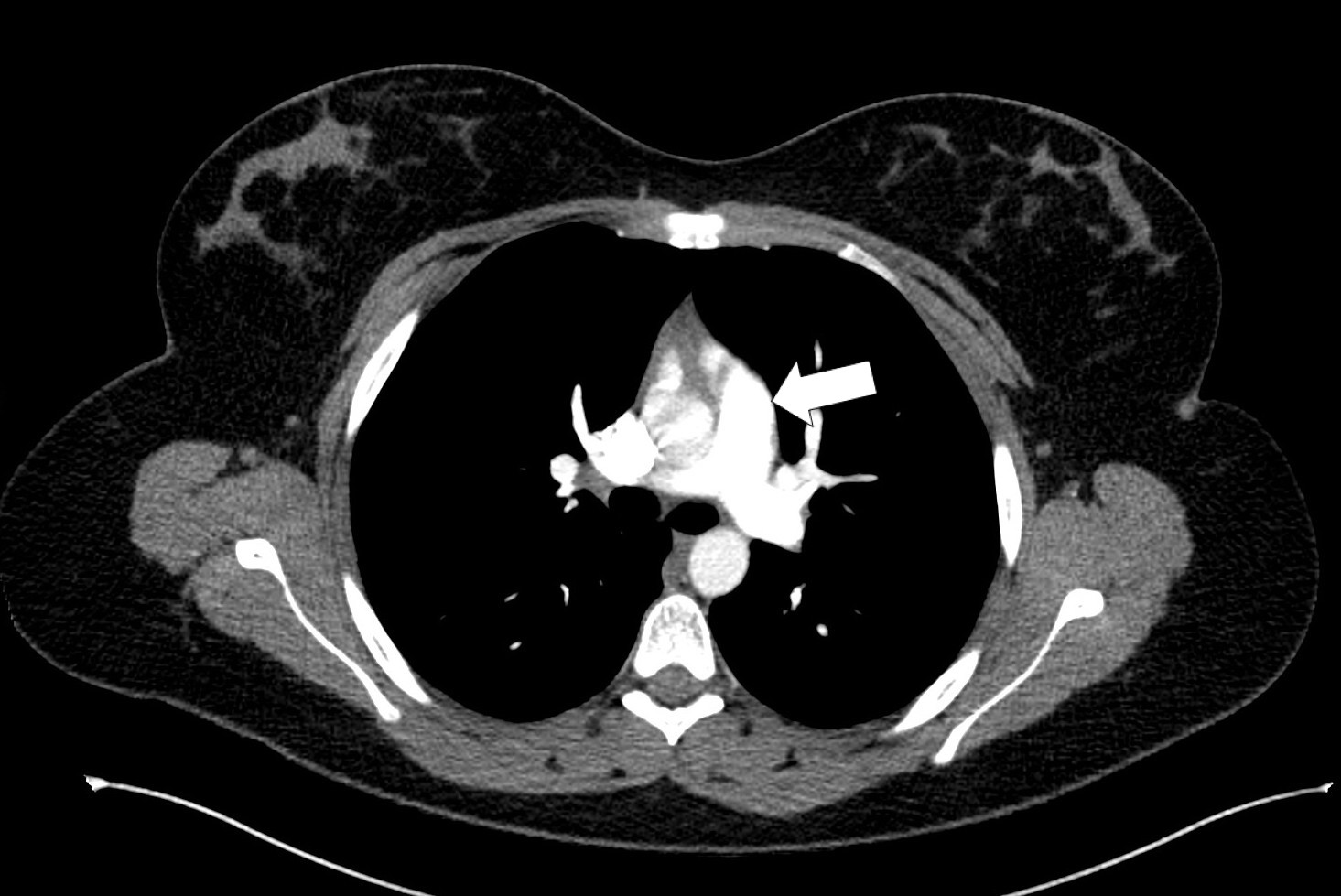
Choice of CTPA and VQ scan in practice depends on a combination the factors in table 3 as well as local practices. The patient should be reassured that whichever modality is chosen the risk of missing PE is likely to be more than the risk to the fetus or the pregnant patient.

References to example patient information leaflets can be seen in the Information resources for patients section below.

Figure 2a CTPA in a patient in third trimester of pregnancy demonstrates dense glandular breast tissue, at increased risk from ionising radiation. Also demonstrating suboptimal opacification of the pulmonary trunk (arrow) measured at 191 Hounsefield units (optimal >210) which may be seen due to haemodynamic effects of pregnancy. 12% of CTPA studies may be non-diagnostic in pregnancy39.

Figure 2b CTPA in a non-pregnant patient of the same age demonstrates less dense breast tissue and better opacification of the pulmonary trunk measured at 350 Hounsefield units (arrow)





Acute abdominal pain

*A 30-year-old woman attends the Emergency Department with right iliac fossa pain which started in the mid abdomen. She is 30 weeks pregnant. On examination she has tenderness and is guarding in the right iliac fossa. Blood tests reveal elevated white cell count and CRP. Urine dipstick is normal. Acute appendicitis and adnexal torsion considered the most likely differential diagnoses. The patient asks, “Do I need an MRI? Isn’t ultrasound good enough?”*

Early diagnosis of acute abdominal or pelvic pathology can prevent maternal and fetal harm. The risk of not treating some conditions, for example acute appendicitis or adnexal torsion, whilst difficult to exactly quantify, is likely to be higher than the risk of imaging.

Ultrasound is safe in pregnancy and is often the first imaging modality used for abdominal and pelvic pain in a non-emergency situation. However, it is operator dependent and views of deep structures can be poor in pregnancy when anatomy becomes displaced. Ultrasound for acute appendicitis has 50-100 % sensitivity and 33- 92 % specificity41.

MRI is more accurate in the diagnosis of other suspected acute abdominal or adnexal pathology in pregnancy41. For example sensitivity and specificity for diagnosing appendicitis was 92% and 98% in a recent meta analysis42. MRI is, however, more time consuming and not as readily available at ultrasound, particularly out of hours.

If MRI is being considered, advise patients that MRI is not known to cause harm to the fetus (Table 1) but that scan times are at least 20 minutes (potentially longer) and that the scanner is small which may be uncomfortable. Also avoid IV contrast (Table 1).

If MRI is not available, CT is potentially an alternative but, as pelvic irradiation will be required, should only be considered if there is no other alternative. The risks will be similar to those discussed in the “Trauma” section above.

Figure 3a and b. MRI in a pregnant patient demonstrates right adnexal torsion. Coronal balanced fast field echo images show a right adnexal mass (large arrow in 3a) and intrauterine pregnancy (small arrow in 3a) which had been detected on ultrasound. Additional finding on MRI, not detected on ultrasound, was the twisted adnexal pedicle (arrow in 3b) confirmed the diagnosis of adnexal torsion for which surgery in pregnancy was required.



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**What you need to know**

Ultrasound and MRI pose no known risk to the fetus in pregnancy. Nevertheless there are theoretical risks and as such patients should only undergo these studies if clinically indicated.

In radiography and CT, the fetal dose is dependent on whether the fetus is directly irradiated. Radiography and CT that does not cover the pelvis poses very low risk to the fetus.

IV contrast used in CT is not known to cause harm to the fetus (though due to theoretical risk of hypothyroidism, it is advised that thyroid function is tested in the child after birth via heel prick). IV contrast used in MRI and ultrasound should generally be avoided in pregnancy.

**Education into practice**

Questions about practice:

Do you always ask premenopausal women whether they could be pregnant before requesting imaging investigations?

Are you aware of any specific protocols or pathways in your institution for imaging pregnant patients? For example, is there a pathway for imaging suspected pulmonary embolism in pregnancy based on local availability of radiological services? If not, would this be helpful to your practice?

Reflective question:

Think about a time you have requested imaging for a pregnant or possibly pregnant patient. How did you communicate the risk to the patient? What alternatives to imaging did you offer?

**How patients were involved in the creation of this article**

EB is a patient representative in the Liverpool Babies Patient and Public Involvement and Engagement Group. She provided a patient perspective on imaging in pregnancy. This included the discussion surrounding how to discuss risk with patients and the use of straightforward, terminology without being patronising. She produced the “Information for Patients” section of the article.

The paper was also reviewed by an external patient representative. As a result of this the language was worded to ensure clear information to the reader, acknowledging that the reader (be they medical professional or patient) may not be familiar with some radiological and other technical terms.

**How this article was created**

The authors searched for UK and International guidelines (from both Radiological and Obstetric and Gynaecological societies and faculties) regarding imaging the pregnant patient with ultrasound, ionising radiation and MRI. Guidelines for imaging in specific conditions were also reviewed.

A literature search was also performed of patient information leaflets discussing the subjects relevant to the study – imaging in pregnancy and the investigation of specific conditions in pregnancy.

**Information resources for patients**

To be supplied separately

**Contributorship and the guarantor**

RW conceived the article.

RW and AS are guarantors

EB and RW wrote the Information resources for patients section

RW, AS and BH wrote the rest of the article

**Conflicts of Interest**

AC has received payment from Roche for giving an invited talk about the role of blood biomarkers sFlt-1/PlGF in predicting fetal growth restriction at a lunchtime symposium at an international conference in 2019. He received travel and accommodation expenses and an honorarium for his lecture.

RW, BH and EB - Competing Interest: None declared

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