Imaging the pregnant patient with acute abdominal pain

Introduction
Pregnant patients frequently present with non-specific abdominal pain requiring medical attention. It is important to identify those with an ‘acute abdomen’ requiring surgical intervention and equally not expose mother and baby to the risks of surgery if this is not indicated. Clinical assessment is difficult in pregnant females due to a number of factors related to a normal pregnancy including vague symptoms such as nausea and vomiting, heartburn and constipation, non-specific leukocytosis that can mimic or mask an inflammatory response and, perhaps most importantly, displacement of abdominal and pelvic structures from their normal location by the increasing size of the gravid uterus. The latter not only confounds the clinical presentation, as the displaced structures can result in pain in ‘atypical’ sites, but also limits physical examination – particularly at the later stages of pregnancy.

Imaging therefore plays a particularly important role in determining the aetiology of acute pelvic pain in pregnant patients.

Causes of abdominal pain in pregnancy
Aetiology of acute abdominal pain in pregnant patients includes obstetric, gynaecological, genitourinary, gastrointestinal, vascular and other non-specific causes (figure 1). Selected causes will be discussed below, including illustrative cases and the salient imaging findings (please refer to figure 2 for examples).

It is important to consider pregnancy, or obstetric-related complications, as a cause of acute pelvic pain in any female of reproductive age. The patient may not know she is pregnant at the time of presentation or a patient who has had a positive pregnancy test may present with acute pelvic pain early in the first trimester, which represents early miscarriage or ruptured ectopic pregnancy. It is therefore important to inquire regarding the stage of the patient’s menstrual cycle and whether the patient is sexually active to ascertain the likelihood of pregnancy (if not already confirmed), utilising urinary beta-HCG to confirm pregnancy where appropriate. This information is also useful to know when planning appropriate imaging (see imaging strategy below).

Gynaecological causes of pelvic pain can present during pregnancy as the risk of complications may be increased by the hormonal changes that occur. For example, high oestrogen levels can promote growth of benign ovarian neoplasms and uterine fibroids, which increase the risk of ovarian torsion or haemorrhagic fibroid infarction. High progesterone levels also cause ligamentous laxity which can result in non-specific or musculoskeletal pelvic pain.

It is important to distinguish physiological, pregnancy-related hydronephrosis from obstructive causes; the former demonstrating a smooth tapering to the level of the sacral promontory and an absence of a filling defect, renal enlargement or perinephric oedema.

Appendicitis is the most common non-obstetric cause of acute abdominal pain requiring surgery in the pregnant population. As mentioned above, due to displacement by the growing uterus, appendicitis may present as right flank or right upper quadrant pain, but as long as this is borne in mind then the differential can be considered and scanning technique and/or image interpretation adapted to confirm this. Ultrasound may be utilised to identify an inflamed, distended blind-ending structure, however locating the abnormality on ultrasound can be challenging; particularly true in the later stages of pregnancy as the enlarged uterus further limits the use of ultrasound. MRI becomes a useful imaging tool in these circumstances as, like ultrasound, it does not utilise ionising radiation but it is less impaired by the presence of the gravid uterus and has the ability to detect alternative causes of abdominal pain.

Imaging strategy
Ultrasound
Ultrasound is recommended as the first-line investigation, given its ability to identify many causes of acute abdominal pain in pregnancy without the use of ionising radiation. It can also be used to confirm intrauterine pregnancy and assess the viability of the fetus. Its main limitations are related to user dependence, based on previous experience, and its inability to image pathology which is deep to the gravid uterus.

MRI
MRI is utilised as a second-line method for imaging the pregnant abdomen, which again avoids exposing the mother and fetus to ionising radiation. The innate soft tissue contrast and ability to image the whole abdomen increases the detection of a range of causes for the acute abdomen. MRI can also be useful to differentiate blood from other fluid collections. Masselli et al, on behalf of the European Society of Urogenital Radiology, describe their comprehensive multiplanar MRI protocol for imaging the pregnant abdomen (please see article for further details on scanning parameters). While there are no known risks related to 1.5T MRI, the safety of MRI during pregnancy is difficult to establish and current guidance recommends avoidance of MRI in the first trimester where possible; the risks of 3.0T MRI are not known and its use in pregnancy is not recommended.

There is possible increased risk of stillbirth and rheumatological, inflammatory and skin conditions related to gadolinium-based contrast agents crossing the placenta, therefore these agents should only be used when the diagnosis cannot be made on a non-contrast MR study.

CT
CT is mainly reserved for emergency situations due to its widespread availability and speed of scanning; it may also be indicated if ultrasound and MRI remain inconclusive and the patient remains unstable with cause unknown. The main disadvantage is the exposure of mother (particularly maternal breast tissue) and fetus to ionising radiation, therefore it is important to check female patients’ pregnancy status...
Figures of abdominal and pelvic pain in pregnant females.

Before undertaking procedures involving ionising radiation, the Royal College of Radiologists (RCR) and College of Radiographers guidance makes recommendations based on the radiation dose to the developing embryo, which should present “no risk of causing fetal death, malformation, growth retardation or impairment of mental development”. They recommend a higher dose threshold of 100mGy for fetal exposure.\(^7\) These deterministic effects are not dose dependent, so risks in practice, as the fetal dose associated with diagnostic imaging procedures utilising ionising radiation do not exceed the 100mGy threshold deemed enough to cause the tissue damage that is thought to result in the aforementioned effects (\textit{figure 3}).

The main stochastic risk of clinical relevance, the increased risk of childhood cancer, is not so clearly predictable but the risk is felt to increase with increased dose. For examinations with a dose <1mGy there is a less than one in 10,000 risk of childhood cancer, which does not much increase the natural risk of one in 500.\(^7\) The risks of exposure to higher dose procedures, for example indications such as possible active intra-abdominal haemorrhage or trauma (\textit{figure 4}), may result in up to a doubling of the risk of childhood cancer when compared to the background natural risk.\(^7\) Higher dose exposures should therefore be avoided if there are alternative non-radiation-based means of imaging the patient or if the examination is not justified.

The risks are however still low in absolute terms (less than one in 200, mostly less than one in 1,000; \textit{figure 3}) therefore termination of pregnancy is not justified based on the risk to the fetus alone; such as in cases of inadvertent exposure in a female not known to be pregnant. The Care Quality Commission should be informed if there is significant accidental or unintentional calculated fetal dose exposure >1mGy.\(^7\) If Ionising Radiation (Medical Exposure) Regulations (IR(ME)R) guidelines are followed to justify studies and medical exposure is optimised (by altering scan parameters) to minimise the dose to the unborn fetus then CT may be used safely for the benefit of pregnant patients and their unborn offspring. This is particularly important to remember in cases of trauma or life-threatening circumstances, when CT provides the quickest and optimal study to identify any injuries or life-threatening pathology requiring immediate surgical intervention – when the clinical benefits clearly outweigh the potential risks – and it is important that radiology staff recognise and expedite these studies without unnecessary delays.

The RCR endorses the Royal Australian and New Zealand College of Radiologists guidance on the use of iodinate contrast agents during pregnancy.\(^7\) Specifically, no definite increased risk of fetal injury, malformation or adverse effects has been demonstrated therefore IV contrast can be used in CT where clinically indicated. The main precaution is to check for hypothyroidism during the neonatal period, when the clinical benefit clearly outweighs the potential risks.

Figures

\textbf{Figure 1}
Causes of abdominal and pelvic pain in pregnant females.

\textbf{Figure 2}
Images demonstrating potential causes of acute pelvic pain that can be identified on different modalities. (A) Ruptured ectopic pregnancy on axial contrast-enhanced CT. High attenuation (average 68HU) free fluid within the pelvis in keeping with haemoperitoneum; the cystic structure seen within the right hemipelvis, within the blood, represents the extra-uterine gestation sac, (B) Torsion of a benign right ovarian cystic neoplasm on coronal T2-weighted MRI image. Large simple fluid density (high T2 signal) cystic structure represents the cystic ovarian neoplasm, with ‘whirling’ of the adjacent tube and vessels indicates torsion (red arrow). (C) ‘Red degeneration’ of a large uterine fibroid on axial T1-weighted fat saturated MRI. High signal on the T1 fat saturated image represents haemorrhage within the uterine fibroid, in keeping with haemorrhagic infarction (also known as ‘red degeneration’). (D) Acute appendicitis identified on coronal T2-weighted MR image in a pregnant female. The approximately 26 week gestation fetus is seen within the gravid uterus, which arises from the pelvis, displacing bowel superiorly and laterally. A dilated, fluid-filled, thick-walled tubular structure is identified in the expected location of the appendix (within the right iliac fossa; arrowhead) with evidence of adjacent peri-appendiceal free fluid and fat stranding indicative of acute inflammation.
Figure 4
The images illustrate the appearance of an intrauterine pregnancy of approximately 17 weeks’ gestation on triple phase CT, which may be performed for indications such as trauma or suspected active gastrointestinal bleeding. The axial unenhanced, arterial and portal venous phase images demonstrate the fluid-filled amniotic sac within the uterine cavity and an eccentric enhancing thickening of the myometrium representing the developing placenta (red arrows). Such studies may result in inadvertent exposure of the fetus to ionising radiation as well as iodinated contrast if pregnancy status is not sought prior to imaging.

References