Resistance is futile

Studies of surgical procedures and devices don’t have a great reputation. This study’s findings that a new device aimed at improving healing after surgery for rotator cuff tears is not effective—and may even be harmful—aren’t going to change clinical practice, but the study itself may set a new benchmark for surgical trials. The randomised control trial of the InSpace balloon was independently funded, recruited from the target population, blinded patients (who all underwent debridement), and randomised them during the procedure. It was also designed with pre-defined boundaries for futility, which meant that it could be halted early and the findings published before the device became widely used in clinical practice. Now that we know that high quality trials for surgical devices can be carried out in a timely manner, will this become the norm?

Boost for boosters

What type of evidence do we need when it comes to further booster vaccinations for covid-19? Will endpoints in studies continue to move away from deaths and hospital admissions to cases and laboratory markers of immunity? Will observational data do, or do we need to keep conducting costly randomised controlled trials? A lot of observational data on covid vaccines come from Israel, where they’ve tended to roll out vaccines early and quickly. The latest such study, of over 60s eligible for a fourth dose, concludes that: “rates of confirmed SARS-CoV-2 infection and severe covid-19 were lower after a fourth dose of BNT162b2 vaccine than after only three doses.” This supports the case for fourth doses in this age group, but residual confounding is hard to exclude in these studies, particularly given there may be important differences in care seeking behaviours and cautiousness between those who come forward quickly for boosters and those who don’t.

Judgement day for syncope score

It often feels as though clinical risk scores exist to compete with clinical judgment, but here’s a clinical risk score that incorporates clinical judgement and is almost entirely driven by it. The Canadian Syncope Risk Score (CSRS) comprises nine predictors of outcomes after a syncopal episode, including blood pressure, ECG findings, and the clinician’s classification of syncope at discharge from the emergency department (cardiac, vasovagal, or other). It’s designed to be used at the point of discharge from the emergency department to identify those who can be safely discharged—particularly older patients, who are more likely to have cardiac syncpe and less likely to be discharged after a syncopal episode. A prospective, international, multicentre study sought to externally validate the CSRS, and found that it performed well on a composite primary endpoint of serious clinical plus procedural events at 30 days—but that was mostly driven by the clinical judgment part of the score.

Dementia race

Studies consistently find large differences in dementia risk between ethnic groups, and it appears again in this retrospective cohort study of 1 869 090 veterans in the US. The researchers found that Hispanic and Black participants were far more likely to be diagnosed with dementia during the mean follow-up period of 10.1 years. Compared with White participants, unadjusted hazard ratios were 1.99 for Hispanic participants and 1.55 for Black participants.
Recognising acute coronary syndrome

Ralf E Harskamp,1 Alexander C Fanaroff,2 Sinead Wang Zhen,3 Hendry R Sawe,4 Ellen J Weber5

1Department of general practice, Amsterdam UMC, University of Amsterdam
2Division of Cardiology, Perelman School of Medicine, University of Pennsylvania
3Duke-NUS family medicine, SingHealth Polyclinics, Singapore
4Emergency Medicine Department, Muhimbili University of Health and Allied Science, Dar es Salaam, Tanzania
5Department of Emergency Medicine, University of California, San Francisco

Correspondence to: R E Harskamp r.e.harskamp@amsterdamumc.nl

This is one of a series of occasional articles highlighting conditions that may be more common than many doctors realise or may be missed at first presentation. To suggest a topic for this series, please email us at practice@bmj.com.

A 72 year old woman with hypertension and diabetes was evaluated by her general practitioner for shortness of breath that developed over the course of several hours and increased on exertion. On presentation, she denied chest pain, but she did mention tiredness and shoulder pain that started in the preceding weeks. She had contacted the general practice the previous week, and during the telephone consultation, her symptoms were interpreted as the aftereffects of covid-19, which kept her under the weather for the past three weeks. Her vitals at presentation were breathing rate of 22 breaths/min, SpO2 94%, blood pressure of 165/95 mm Hg, regular pulse of 130 bpm, blood glucose of 16 mmol/L, and temperature 36.7°C. She had basal crackles on pulmonary auscultation, normal heart sounds, and peripheral oedema. Her GP suspected acute heart failure and requested an ambulance transfer to a nearby hospital. Subsequent diagnostic work-up revealed that a blocked proximal left anterior descending coronary artery had led to myocardial infarction and now acute heart failure.

What is acute coronary syndrome?

Acute coronary syndrome (ACS) encompasses a range of conditions that result from a sudden reduction in blood flow to the heart muscle and includes unstable angina, non-ST segment elevation myocardial infarction (NSTEMI), and ST segment elevation myocardial infarction (STEMI), which are differentiated based on findings from an electrocardiogram (ECG) and troponin testing.1,2 The overall mechanism is a rapid development of inadequate blood flow to meet the myocardium’s metabolic demand. This is predominantly caused by atherothrombosis (due to plaque rupture, erosions, and calcified nodules) resulting in diminished flow within a major coronary artery; however, other coronary (dissection, spasm), myocardial, or non-cardiac conditions are also in play.1,2

Why is acute coronary syndrome missed?

Patient, physician, and institutional factors contribute to why ACS is missed. While there is geographical variation, roughly half of patients with ACS do not directly call emergency services.3 The main reason for failing to seek immediate care is that patients do not perceive their symptoms to be related to an important health problem; this form of patient delay is more common in women, those of older age, and those with a large burden of chronic disease.3–5 Classically, ACS presents as a sense of pressure radiating across the chest and down the left arm. However, it is less known that ACS can also present as dyspnoea, isolated jaw or arm pain, bilateral arm pain and back pain, or nausea and vomiting without any pain.6–9 This can lead both patients and physicians to fail to recognise ACS. Misinterpretation of an ECG and overreliance on a normal ECG have also been reported as causes of misdiagnosis by physicians.8

Among patients undergoing emergency evaluation, up to a third of ACS cases are misclassified during initial triage; fortunately, this drops to ~1% after full clinical assessment and observation.7,9 These initially missed cases are often detected as a result of changes in ECG results or troponin concentration, or clinical deterioration.9 In low income countries, the dual burden of communicable and non-communicable diseases poses an additional challenge, since ACS may be misdiagnosed as a communicable disease, such as pulmonary tuberculosis.7 In rural and low-income countries, resources are another barrier, as misdiagnosis is common in environments without direct access to (a facility with) tests critical for diagnosing ACS, such as ECG and serum troponin testing.9,9

WHAT YOU NEED TO KNOW

- Consider the possibility of acute coronary syndrome in any patient with new onset or worsening chest discomfort (pain, pressure, tightness), dyspnoea, or localised symptoms outside the chest (such as arm, throat, or jaw), occurring while at rest and have a low threshold for emergency department referral of patients with ongoing symptoms
- Delay in seeking medical attention is common, and more often reported in women, older adults, and those with high chronic disease burden
- Administer aspirin (acetylsalicylic acid) in patients suspected of acute coronary syndrome and arrange immediate transfer by ambulance. Glyceryl trinitrate can be given for pain relief but should be used with caution if there is hypotension
- A prehospital electrocardiogram should be used to identify ST segment elevation, which requires immediate coronary reperfusion in a cardiac catheterisation laboratory, whereas those without ST segment elevation should undergo rapid evaluation and risk stratification at the emergency department
Why does this matter?

Patients in whom ACS is missed, and who are not cared for in a suitable facility, will not benefit from initial treatments aimed at minimising myocardial damage. This results in irreparable myocardial damage, which increases the risk for complications, including heart failure and arrhythmias. These patients are more likely to develop ventricular arrhythmias, cardiogenic shock, and mechanical complications (papillary muscle, ventricular septal, and ventricular free wall rupture), all of which are associated with increased mortality.

To illustrate the impact on prognosis, 1-year mortality is 21.3% for misdiagnosed cases versus 5.6% and 8.4% for timely diagnosed STEMI and NSTEMI respectively. Complications associated with ACS also have a negative impact on a patient’s quality of life, due to physical limitations and psychological distress, with downstream consequences for those close to the patient.

How is acute coronary syndrome diagnosed?

Clinical

The hallmark symptom for ACS involves the acute onset of “chest discomfort” of prolonged duration (>15-20 minutes) occurring while at rest. Figure 1 illustrates the different descriptions of “chest discomfort” and their likelihood of being correlated with underlying myocardial ischaemia. While chest discomfort is the predominant symptom for ACS in up to 90% of cases, other symptoms include shortness of breath, nausea, palpitations, (pre)syncope, sudden unexplained fatigue, or other localised symptoms outside the chest (such as arm, throat, or jaw).

Prospective studies that used structured symptom evaluation found that women and men overall have similar symptom presentations when evaluated in emergency care. When evaluating patients with suspected ACS, the patient’s baseline risk for coronary atherosclerosis also plays a role. A summary of risk factors and their relationship with ACS can be found in figure 2. Though physical examination is most often normal, abnormal findings, such as hypotension and lung rales, are important indicators for ACS when present.

Fig 1 | Index of suspicion that chest pain is ischaemic in origin on the basis of commonly used descriptors. Adapted from AHA/ACC clinical practice guidelines

<table>
<thead>
<tr>
<th>Description of chest pain</th>
<th>Probability of ischaemia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shifting</td>
<td>Low</td>
</tr>
<tr>
<td>Fleeting</td>
<td>Low</td>
</tr>
<tr>
<td>Pressure</td>
<td>Low</td>
</tr>
<tr>
<td>Squeezing</td>
<td>Low</td>
</tr>
<tr>
<td>Tearing</td>
<td>Low</td>
</tr>
<tr>
<td>Ripping</td>
<td>Low</td>
</tr>
<tr>
<td>Burning</td>
<td>Low</td>
</tr>
<tr>
<td>Dull</td>
<td>Low</td>
</tr>
<tr>
<td>Aching</td>
<td>Low</td>
</tr>
<tr>
<td>Exertional related</td>
<td>Low</td>
</tr>
<tr>
<td>Retrosternal</td>
<td>Low</td>
</tr>
</tbody>
</table>

Fig 2 | Diagnostic accuracy of symptoms, risk factors, physical findings, and electrocardiographic changes in identifying acute coronary syndrome in undifferentiated patients presenting to emergency departments. Data adapted from Fanaroff et al. Sensitivity is the probability of a positive test in patient with disease; a negative result on a test with high sensitivity is useful for ruling out disease. Specificity is the probability of a negative test in a patient without disease; a positive result on a test with high specificity is useful for ruling in disease. Likelihood ratios (LRs) help determine whether a test result changes the post-test probability of disease. Positive LR is the probability of a person with disease testing positive divided by the probability of a person without disease testing positive; the higher the value the more likely a patient with a positive test is to have the disease. Negative LR is the probability of a person with disease testing negative divided by the probability of a person without disease testing negative; the closer the value to 0 the less likely a patient with a negative test is to not have the disease.

<table>
<thead>
<tr>
<th>Likelihood ratio (95% CI)</th>
<th>Sensitivity (95% CI)</th>
<th>Specificity (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Symptoms</td>
<td>&quot;Typical&quot; chest pain*</td>
<td>66 (58 to 74)</td>
</tr>
<tr>
<td>Radiation to arms</td>
<td>11 (8 to 15)</td>
<td>96 (95 to 96)</td>
</tr>
<tr>
<td>Dyspnoea</td>
<td>45 (42 to 49)</td>
<td>61 (59 to 63)</td>
</tr>
<tr>
<td>Pleuritic pain</td>
<td>27 (18 to 36)</td>
<td>86 (78 to 93)</td>
</tr>
<tr>
<td>Risk factors</td>
<td>Men</td>
<td>66 (62 to 76)</td>
</tr>
<tr>
<td></td>
<td>Coronary artery disease</td>
<td>41 (13 to 69)</td>
</tr>
<tr>
<td></td>
<td>Cerebrovascular disease</td>
<td>10 (8 to 13)</td>
</tr>
<tr>
<td></td>
<td>Peripheral arterial disease</td>
<td>8 (2 to 11)</td>
</tr>
<tr>
<td></td>
<td>Diabetes</td>
<td>26 (21 to 32)</td>
</tr>
<tr>
<td></td>
<td>Hyperlipidaemia</td>
<td>42 (31 to 55)</td>
</tr>
<tr>
<td></td>
<td>Hypertension</td>
<td>59 (53 to 66)</td>
</tr>
</tbody>
</table>

* Chest pain with a high probability of ischaemia
† Any T wave inversion, ST depression, or Q wave

EducaTion into PracTice

- Do you rely on a normal ECG to rule out ACS?
- Do you use clinical risk scoring systems, such as HEART, to risk stratify patients with suspected ACS?
- How might your clinical practice change after reading this article?
The suspicion of ACS in the office setting is largely based on clinical judgment and may be assisted by an ECG showing signs of ischaemia (new ST depressions or T wave inversions) or injury (ST elevation). Clinical judgment based only on a patient’s full history provides an important indication, as cases judged as “definite ACS” by clinicians are more likely (likelihood ratio [LR] 4.0) than those judged as “probably not ACS” (LR 0.20) to turn out to be ACS. Therefore, when a GP suspects ACS based on clinical judgment, the appropriate action is to refer the patient immediately to the emergency department. A pre-hospital ECG (performed in the office or ambulance) helps to detect ischaemic changes and arrhythmias and can potentially affect the destination hospital to which the patient is taken. However, a normal ECG alone cannot be used to rule out ACS, as up to 6% of patients with ACS have a normal initial ECG. In an emergency department, protocols are in place to serially measure serum cardiac troponin, a highly sensitive (but not specific) marker of myocardial damage, to ensure that virtually no myocardial infarctions are missed. Serial measurements are important because serum troponin concentrations may not appreciably increase for several hours after the onset of ACS. Clinical risk scores that incorporate the ECG and serum troponin alongside history and risk factors—such as the HEART score (see box)—have the best combination of sensitivity and specificity for ACS, and are therefore used for risk stratification and decision making purposes in many emergency departments.

The HEART score also holds promise for risk stratification in general practice, but requires further validation. Ultimately, the diagnosis is made by a combination of the clinical scenario (that is, whether a patient had symptoms consistent with myocardial ischaemia), ECG markers, and a typical rise and/or fall in serum troponin values for those with (N)STEMI.

<table>
<thead>
<tr>
<th>History</th>
<th>Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highly suspicious — 2 points</td>
<td>≥65 years — 2 points</td>
</tr>
<tr>
<td>Moderately suspicious — 1 point</td>
<td>45–&lt;65 years — 1 point</td>
</tr>
<tr>
<td>Slightly suspicious — 0 points</td>
<td>&lt;45 years — 0 points</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Risk factors</th>
<th>Total score</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥3 risk factors or history of atherosclerotic disease — 2 points</td>
<td>Score 0–3 — Low risk: likelihood ratio (LR) 0.20 (95% CI 0.13 to 0.30), 2.9% ACS</td>
</tr>
<tr>
<td>1 or 2 risk factors — 1 point</td>
<td>Score 4 — Indeterminate risk: LR 0.79 (0.53 to 1.2), 11% ACS</td>
</tr>
<tr>
<td>No risk factors — 0 points</td>
<td>Score 5–6 — Intermediate risk: LR 2.4 (1.6 to 3.6), 26% ACS</td>
</tr>
</tbody>
</table>

A normal ECG alone cannot be used to rule out ACS, as up to 6% of patients with ACS have a normal initial ECG.

Case resolution

The female patient faced diagnostic delay because her reported tiredness and shoulder pain were misinterpreted as related to covid-19. She then experienced heart failure due to late presentation of ACS (STEMI) to prevent further myocardial damage, preferably by primary percutaneous coronary intervention (PCI), or otherwise with fibrinolytic agents. For NSTEMI or unstable angina, early coronary angiography followed by revascularisation with PCI or coronary artery bypass grafting is recommended for moderate or high risk cases with obstructive disease.

Medical management involves lifelong treatment with a β blocker, angiotensin-converting enzyme (ACE) inhibitor (or angiotensin receptor blockers [ARB]), high intensity statin, aspirin, and (for 12 months) a P2Y12 inhibitor. Finally, cardiac rehabilitation reduces the risk of hospital readmissions by a fifth and cardiovascular mortality by a quarter and is therefore recommended for all patients with ACS. After hospital discharge, GPs and cardiologists should focus on supporting patients in optimising their cardiovascular risk factors, including the management of hypertension, hyperlipidaemia, and diabetes, and optimising health behaviours such as smoking cessation, nutrition, and exercise.

How is acute coronary syndrome managed?

Any patient suspected of ACS should be transferred to a facility with capabilities for stabilisation, monitoring, rapid diagnostic work-up, and adequate treatment. Transfer should be done by ambulance, as it allows for prehospital monitoring and treatment of arrhythmias and saves time. While waiting for ambulance transfer, the GP should assess the patient’s vital status and administer a loading dose of aspirin (160–325 mg). To relieve symptoms, glyceryl trinitrate should be given (except for patients with hypotension). An ECG should be obtained either by the GP or the prehospital providers, as many localities transport patients with ST segment elevation to hospitals with 24-hour cardiac catheterisation laboratory availability.

After transfer, immediate reperfusion of the culprit coronary artery is required for patients with STEMI to prevent further myocardial damage, preferably by primary percutaneous coronary intervention (PCI), or otherwise with fibrinolytic agents. For NSTEMI or unstable angina, early coronary angiography followed by revascularisation with PCI or coronary artery bypass grafting is recommended for moderate or high risk cases with obstructive disease.

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Finally, cardiac rehabilitation reduces the risk of hospital readmissions by a fifth and cardiovascular mortality by a quarter and is therefore recommended for all patients with ACS. After hospital discharge, GPs and cardiologists should focus on supporting patients in optimising their cardiovascular risk factors, including the management of hypertension, hyperlipidaemia, and diabetes, and optimising health behaviours such as smoking cessation, nutrition, and exercise.

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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)—in pregnancy is increasing. Imaging plays an important role in the investigation of many conditions in pregnancy, but also has potential to cause harm. Concerns about harm to the fetus and mother can make decisions difficult for patients and clinicians. However, risk is often lower than expected and, especially in many acute situations, is outweighed by the benefit.

This article outlines the potential fetal and maternal risks from commonly used imaging modalities. We also present frequently encountered emergency clinical scenarios, along with imaging suggestions for each situation, with the aim of enabling referring clinicians and patients to make informed shared decisions.

Imaging modalities and types of radiation covered include:

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

The following aspects are beyond the scope of this article:

- Elective scenarios which could potentially wait until after pregnancy; however, the principles discussed can be applied to all pregnant patients
- Issues that are primarily the role of radiology departments—eg, dose modification techniques, and prevention or management of inadvertent fetal imaging (when patients are unaware they are pregnant)
- Postpartum imaging and imaging in patients who are breastfeeding.

What is the evidence?

Evidence used to create this article includes experimental animal studies, observational epidemiological studies on human subjects, and, in the case of ionising radiation, studies from atomic bomb survivors in Japan. Most 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 (table 1). High dose ionising radiation such as CT is generally of more concern than ultrasound, MRI, and low dose ionising radiation such as plain radiography.

Is there a role for abdominal shielding?

Abdominal lead shielding was historically used for ionising radiation that did not directly expose the fetus (eg, chest radiography and CT pulmonary angiography (CTPA)). However, as most of the fetal dose in these investigations is from internal (rather than external) scatter, abdominal shielding is unlikely to be of benefit. Additionally, if the shield is inadvertently in the field of view during the scan, automatic exposure control can cause increased dose. Guidelines from the American Association of Physicists in Medicine and British Institute of Radiology suggest avoiding routine shielding, but recommend considering it case by case if it offers patient reassurance after adequate counselling about the above.

When does imaging pose a maternal risk?

**Ultrasound**

A meta-analysis performed on behalf of the World Health Organization found no evidence of adverse maternal outcome following ultrasound in pregnancy and it can be considered safe.

**Ionising radiation**

Breast tissue is particularly susceptible to the effects of ionising radiation and pregnant (and breastfeeding patients) are theoretically at increased risk because breast tissue is actively undergoing glandular proliferation. However, a retrospective population based cohort study with a short term follow-up period (<12 years) did not show an increased risk of breast cancer in patients exposed to CT chest or VQ scanning in pregnancy.

### What you need to know

- Consider imaging when the risk of potential pathology outweighs the potential risk of imaging
- In radiography and computed tomography (CT), the risk of childhood cancer induction is very low if imaging is above the diaphragm or below the knee. If intravenous contrast agent is used in CT, test thyroid function in the child after birth using heel prick
- Ultrasound and magnetic resonance imaging have no known risks for the fetus, although they have theoretical risks. Avoid contrast agents for both these modalities
Table 1 | Fetal risks associated with, and guidelines for, the use of specific imaging modalities in pregnancy

<table>
<thead>
<tr>
<th>Modality</th>
<th>Consideration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ultrasound</td>
<td>Potential indications in pregnancy: Suspected acute abdominal/pelvic pathology, Heart imaging (echocardiography)</td>
</tr>
<tr>
<td>MRI</td>
<td>Brain imaging, Fetal imaging, Acute abdominal pain</td>
</tr>
<tr>
<td>Ionising radiation</td>
<td>Potential indications in pregnancy: X-rays, Plain radiographs—eg, chest radiographs, CT—eg, CT head in suspected intracranial haemorrhage, CT pulmonary angiography (CTPA) in suspected pulmonary embolism, and CT abdomen in trauma</td>
</tr>
<tr>
<td>Evidence based summary of risk</td>
<td>Fetal malformation, growth restriction, intellectual disability, or death, should not occur with radiation levels used in diagnostic imaging. UK guidelines suggest this threshold is 100 mGy. US guidelines suggest 50 mGy. Theoretically, cancer induction can occur with any dose of ionising radiation, and as such no threshold exists below which this cannot occur. Risk is dependent on dose and body part imaged. See table 2 for childhood cancer risk with ionising radiation</td>
</tr>
<tr>
<td>IV contrast use (iodinated contrast)</td>
<td>Used in most body imaging including CTPA and CT abdomen studies. Not routinely used in brain imaging unless vascular assessment required (eg, CT venogram and angiogram studies). Contrast crosses the blood-placental barrier but no evidence suggests that IV contrast has caused harm to the fetus. A theoretical risk exists for neonatal hypothyroidism.</td>
</tr>
<tr>
<td>Evidence based summary of risk</td>
<td>No conclusive evidence that MRI causes fetal harm. Theoretical risks of fetal hyperthermia and inner ear damage can be mitigated by scanner modifications. Microbubbles can burst and cause cavitation. They enter the placenta, and placental damage risk has not been well investigated</td>
</tr>
<tr>
<td>Recommendations</td>
<td>Generally safe, but keep as low as reasonably achievable principle. Only request if clinically indicated. Generally avoid ultrasound contrast unless benefits clearly outweigh the risks. 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 of pregnancy. MRI can be used if clinically indicated—&lt;1 in 10 000-100 000—and can be justified when clinically indicated.</td>
</tr>
<tr>
<td>MRI</td>
<td>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). Others, such as the American College of Radiologists, suggest that patients in the first trimester of pregnancy should not be treated differently from those in later stages of pregnancy. Generally avoid IV gadolinium unless it will change management during pregnancy or no method of obtaining information is available.</td>
</tr>
<tr>
<td>Recommendations</td>
<td>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). Others, such as the American College of Radiologists, suggest that patients in the first trimester of pregnancy should not be treated differently from those in later stages of pregnancy. Generally avoid IV gadolinium unless it will change management during pregnancy or no method of obtaining information is available.</td>
</tr>
</tbody>
</table>

MRI

Usual MRI safety considerations for all patients apply. In pregnancy, the relatively long scan times (20 minutes to one hour) and claustrophobia may be difficult, particularly in late pregnancy. Consider reduced scan times and alternative (eg oblique) positioning.

Difficulties in interpretation

False negative and false positive findings can occur in pregnancy because of altered anatomy and physiology. For example, haemodynamic circulation causing difficulties in pulmonary artery opacification on CTPA, and displacement or compression of structures by the gravid uterus can make visualising suspected acute abdominal pathology on ultrasound difficult.

Incidentalomas

As with all patients, imaging presents a risk of detecting incidental findings, which may lead to further investigations and may increase patient anxiety unnecessarily.

How are shared decisions made?

For ultrasound, MRI, and low dose ionising radiation (tables 1 and 2) discussion may be relatively straightforward.

For techniques that involve exposure of the fetus or breast tissue to higher doses (eg, some plain radiography, CT), we suggest the following:

- Explain why 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—eg, the risk of missing serious pathology, acknowledging that this may be difficult to quantify.
- Give an estimated numerical risk of harm (table 2) in relative terms—eg, the background risk of childhood cancer is approximately 1 in 500, so an additional risk of 1 in 500 doubles the risk the baby will later develop childhood cancer—ie, “for every 500 times this scan is done in pregnancy, theoretically, one child would develop a cancer that they would not have developed otherwise.”
• Provide context—eg, exposure to the fetus from background radiation is approximately 1 mGy, and radiation exposure from a transatlantic flight is 0.01 mGy.
• Offer patient information leaflets if available (see below).

The Royal College of Obstetricians and Gynaecologists offers general advice to patients and clinicians on discussing risk that can be applied to imaging in pregnancy.27 28

Is written consent needed?
Consent for imaging processes vary. The ACR suggests that consent can be obtained in both verbal and written forms but in either case should be documented. ACR offers a sample patient consent form in its guidelines.29

Common clinical scenarios

Trauma
Trauma is the leading non-obstetric cause of maternal mortality and can also cause fetal loss, so early identification of injury is important.30 Consider radiology when the risk from trauma is likely to be higher than the risk from imaging.

Chest radiography and focused assessment with sonography in trauma may help to rule in some injuries (eg, pneumothorax, large volume haemoperitoneum) 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 (eg, active bleeding, organ injury, fractures).

Table 2 | Typical fetal doses and risks of childhood cancer for some common diagnostic ionising radiation modalities used in pregnancy

<table>
<thead>
<tr>
<th>Examination</th>
<th>Typical fetal dose (mGy) from a single scan</th>
<th>Risk of childhood cancer per examination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radiography</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teeth</td>
<td>0.001-0.01</td>
<td>&lt;1 in 1 000 000</td>
</tr>
<tr>
<td>Neck</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chest</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extremity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mammography</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chest</td>
<td>0.01-0.1</td>
<td>1 in 1 000 000</td>
</tr>
<tr>
<td>Pulmonary angiogram</td>
<td></td>
<td>1 in 100 000</td>
</tr>
<tr>
<td>Radiography</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abdomen</td>
<td>0.1-1.0</td>
<td>1 in 100 000</td>
</tr>
<tr>
<td>Pelvis</td>
<td></td>
<td>to</td>
</tr>
<tr>
<td>Hip</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CT</td>
<td></td>
<td>1 in 10 000</td>
</tr>
<tr>
<td>Chest and liver</td>
<td></td>
<td>to</td>
</tr>
<tr>
<td>Nuclear medicine</td>
<td></td>
<td></td>
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<td>VQ scan</td>
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<td>Radiography</td>
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<tr>
<td>Lumbar spine</td>
<td>1.0-10.0</td>
<td>1 in 10 000</td>
</tr>
<tr>
<td>CT</td>
<td></td>
<td>to</td>
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<tr>
<td>Lumbar spine</td>
<td></td>
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<tr>
<td>Abdomen (not pelvis)</td>
<td></td>
<td>1 in 1 000</td>
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<tr>
<td>CT</td>
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<tr>
<td>Abdomen and pelvis</td>
<td>10.0-50.0</td>
<td>1 in 1 000</td>
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<tr>
<td>PET/CT</td>
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<td>1 in 200</td>
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Based on data summarised by the UK’s Health Protection Agency, the Royal College of Radiologists, and the Royal College of Radiographers.11
Doses apply to early stages of pregnancy when the fetus is small.
Risk of childhood cancer has been rounded up to 1 in 10 000 per mGy.
For comparison, natural childhood cancer risk is ~1 in 500.

Fig 1 | CT scan of the abdomen and pelvis (with IV contrast) of a pregnant patient involved in a high speed road traffic accident. (a) Axial image (soft tissue windowing) showing the gravid uterus and anterior placenta (arrows), (b) axial image (bone windowing, arrows), (c) coronal image (bone windowing) showing a right sacral fracture (arrows)
When potentially life threatening thoracic or abdominal injury is suspected, CT scan is the imaging modality of choice and intravenous (IV) contrast is usually required (fig 1).

Discuss with the patient the risk of missing life threatening pathology versus the relatively small risk of childhood cancer induction from CT. Table 2 gives approximate risks (note, doses and risk in table 2 are for single scans, but trauma protocols can involve dual phase scanning\(^{11}\)). Offer reassurance that the fetus is not at definitive risk from any IV contrast administration, but because of the theoretical risk of hypothyroidism, neonatal heel prick is advised (table 1).

Once life threatening injury to the patient is excluded, consider obstetric ultrasound to look for fetal, placental, and uterine injury.\(^{30}\)

**Headache**

Headache in pregnancy is common and usually the result of primary headache disorders (eg, tension headache or migraine).

After 20 weeks’ gestation, pre-eclampsia is also a common cause and associated with hypertension with or without proteinuria.\(^{32}\)

Consider urgent radiological investigations if there is clinical suspicion of a life threatening diagnosis (eg, subarachnoid haemorrhage, venous sinus thrombosis).

CT is quick, widely available, can readily detect acute haemorrhage, and post contrast 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 imaging (using gadolinium) is generally not recommended in pregnancy\(^{50,51}\) (table 1).

If CT is clinically indicated and would be the usual first choice in a non-pregnant patient, the authors recommend not delaying CT (ie, avoid considering MRI as first line purely on the basis of fetal risk).

Advise the patient that the radiation dose to the fetus from CT scanning of the head is negligible (table 2).\(^{31}\)

If CT is negative, further investigation with MRI, post contrast CT, or lumbar puncture may be required, depending on the suspected diagnosis.

**Suspected pulmonary embolism**

The risk of missing pulmonary embolism or of anticoagulating a patient without pulmonary embolism puts the patient (and therefore fetus) at risk of illness or death, so imaging is recommended.\(^{35}\)

If the patient has clinical signs of deep vein thrombosis (DVT), perform lower limb vein ultrasound.\(^{46,47}\) In the absence of signs of DVT, guidelines for imaging of suspected pulmonary embolism in pregnancy are conflicting.\(^{38}\) Some suggest lower limb vein ultrasound to avoid ionising radiation. Others advise doing this only if the patient also has clinical signs of DVT.

Direct imaging is most commonly performed with CTPA (fig 2) or VQ scanning. Choosing between these studies is controversial and varies between institutions because each modality has relative risks and benefits (table 3, see bmj.com).

Reassure the patient that whichever modality is used, the risks of harm to the pregnant woman and fetus are likely to be less than those of missing a pulmonary embolism.

**Acute abdominal pain**

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

Ultrasound is safe in pregnancy. It is often the first modality used for abdominal and pelvic pain in a non-emergency situation. However, its usefulness is dependent on the skill or experience of the operator and views of deep structures can be poor owing to anatomical displacement. Ultrasound for acute appendicitis has 50-100% sensitivity and 33-92% specificity in pregnant patients.\(^{42}\)

MRI is potentially more accurate\(^{42}\)—eg, for acute appendicitis, sensitivity is 92% and specificity 98%.\(^{43}\)

It is, however, more time consuming and not as readily available as ultrasound, particularly out of hours.

**What alternatives to imaging do you offer?**

- Ultrasound
- MRI
- Dual phase scanning

**How often do you assess whether patients of pre-menopausal age could be pregnant before requesting imaging?**

- Weekly
- Monthly
- Never

**How do you communicate imaging risk to pregnant patients?**

- Verbal
- Written
- Both

**What alternatives to imaging do you offer?**

- Ultrasound
- MRI
- Dual phase scanning

**What local protocols and pathways does your institution use when imaging pregnant patients?**

- Standardised protocols
- Individualised pathways
- No specific guidelines
CASE REVIEW

A woman with erythema and pustules

A woman in her 60s presented with a one-week history of widespread erythema accompanied by pustules, scales, and mild itching. The lesions had started on the right side of her back and had spread to her trunk and limbs within two days. On examination, disseminated erythematous maculas with superficial scales and flaccid blisters filled with pus were seen (fig 1). She also had subungual hyperkeratosis and discoloration of the nail plate (fig 2). She received a diagnosis of pustular psoriasis and was treated with topical steroids, but her symptoms did not improve.

The patient had a history of hypertension, diabetes, myasthenia gravis, and lung cancer. For the myasthenia gravis she had taken oral methylprednisolone tablets at a maintenance dose of 4 mg/day for 10 years.

KOH smear of the lesions showed pseudohyphae. Histopathological examination revealed irregular epidermal hyperplasia and clustered neutrophils in the epidermis. The superficial dermis was infiltrated perivascularly by neutrophils and lymphocytes. Fungal culture showed Candida. Candida parapsilosis complex (including C parapsilosis, C metapsilosis, and C orthopsilosis) was identified by sequencing.

1 What are the main differential diagnoses?

Generalised pustular psoriasis (GPP) and acute exanthematous generalised pustular eruption (AGEP). GPP usually manifests as sterile pustules and erythema, and biopsy shows neutrophil accumulation in the epidermis. Patients may also have focal parakeratosis and psoriatic hyperplasia. AGEP is a severe cutaneous adverse reaction that is most commonly caused by drugs. It affects a wide range of drugs, including β-lactam antibiotics (eg, penicillins, aminopenicillins, cephalosporins) and non-β-lactam antibiotics, anticonvulsants, analgesics, and calcium channel blockers (particularly diltiazem). However, in this case the patient reported no contact with specific drugs associated with AGEP before she developed the rash.

2 What is the most likely diagnosis?

Disseminated cutaneous candidiasis. This usually appears as a few erythematous scaly plaques on the scalp and periorificial sites. Candida spp is a group of opportunistic fungi that may become pathogenic, especially in immunocompromised individuals. Although the most prevalent species is C albicans, infections caused by C parapsilosis are on the rise.

3 How would you manage this condition?

Treatments can be topical or oral. Voriconazole, ketoconazole, and itraconazole are effective antifungals against Candida spp; moreover, terbinafine is effective in vitro against C parapsilosis. Antifungal susceptibility testing may be used to guide therapy.

The patient was treated with oral terbinafine (250 mg/day) and topical terbinafine hydrochloride cream for three weeks and showed marked improvement.

LEARNING POINTS

• Consider cutaneous candidiasis in patients who are immunosuppressed and whose condition does not improve with topical steroids

• Early mycological examination (such as KOH) may help avoid the unnecessary and time-consuming process of tissue biopsy.

• Treatment of secondary bacterial infections associated with cutaneous candidiasis is important.

You can record CPD points for reading any article. We suggest half an hour to read and reflect on each. Articles with a “learning module” logo have a linked BMJ Learning module at http://learning.bmj.com.
**Paroxysmal purple palmar macules**

This is Achenbach’s syndrome on the left wrist of a woman in her 50s. The purple hue had developed within 30 minutes of a sudden stinging at the base of her left palm. No external trauma was evident.

On examination the patient had no pallor or reduced temperature in her fingers, capillary refill time was within two seconds, and blood flow in the radial and ulnar artery on duplex ultrasonography was normal.

Achenbach’s syndrome most commonly occurs in postmenopausal women and is due to thinning of veins in the fingers and palms with subsequent leakage of blood into the surrounding dermis.

Leakage is typically triggered by increased pressure to the area—for example, when carrying plastic bags. Bruising usually disappears within a few days.

Achenbach’s syndrome is a diagnosis of exclusion. Differential diagnoses are bruising caused by clotting disorders or low platelet count, capillary fragility from vitamin C deficiency or amyloidosis, and vascular ischaemic events (embolism or vascular spasm). Although the exact cause of Achenbach’s syndrome is unknown, symptoms might recur, as in this patient; thus, explanation and reassurance are important.

If you would like to write a Minerva picture case, please see our author guidelines at http://bit.ly/29HCdAL and submit online at http://bit.ly/29yyGSSx

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**A different sort of tablet**

Giving video enabled tablet computers to US veterans living in rural areas allowed them to access mental health care during the pandemic. A comparison of health service use before and after the distribution of tablets suggested that the intervention helped to reduce suicide behaviour and visits to emergency departments (JAMA Netw Open doi:10.1001/jamanetworkopen.2022.6250).

**Dementia risk in women**

An analysis of data from more than a quarter of a million women taking part in the UK Biobank study discovers that their reproductive experience influences their risk of dementia. Early or late menarche, younger age at first birth, and having a hysterectomy increased the risk of dementia. On the other hand, having been pregnant, having had an abortion, and having used oral contraceptive pills were associated with a lower risk (PLOS Med doi:10.1371/journal.pmed.1003955).

**Let’s reinvent the scientific paper**

Although the internet has transformed access to scientific literature, it hasn’t had much effect on how science is published. Obvious deficiencies of the current system include the unreliable judgment of editors and peer reviewers, vulnerability to fabricated data, delay in correcting errors, and publication bias. Instead, scientific papers might become mini websites, containing the full story of the investigation from planning to conclusions, and a downloadable dataset (www.theguardian.com/books/2022/apr/11/the-big-idea-should-we-get-rid-of-the-scientific-paper?).

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**Ocular adverse effects of phosphodiesterase 5 inhibitors**

Case reports of adverse ocular events after use of phosphodiesterase type 5 inhibitors are corroborated by a US healthcare database. Among 200 000 users of sildenafil, tadalafl, vardenafil, and avanafil, the incidence of retinal detachment, retinal vascular occlusion, and ischaemic optic neuropathy was roughly double that of a control group of non-users (JAMA Ophthalmol doi:10.1001/jamaophthalmol.2022.0663).

**Somatic mutation rates scale with mammalian lifespan**

Why do giraffes live longer than mice? One theory is that all mammals get about a billion heartbeats per lifetime (robdbunlab.com/projects/heats-per-life/). Small mammals with small hearts burn up their allocation in a few months, while large mammals eke out their heartbeats over decades. But the life clock is also linked to somatic mutation rates. Across 16 mammalian species with a 30-fold variation in lifespan and a 40 000-fold variation in body mass, the somatic mutation burden at the end of life varied only by a factor of 3 (www.nature.com/articles/s41586-022-04618-z).

**Systemic antibiotics and the skin microbiome**

Samples for microbial analysis were collected at different skin and mucosal sites (scalp, axilla, hands, gluteal and inguinal folds variation in body mass, the somatic mutation burden at the end of life varied only by a factor of 3 (www.nature.com/articles/s41586-022-04618-z)).

**Socioeconomic status and cardiovascular events**

Early life exposures are known to exert a powerful influence on later health. So findings from the long running Atherosclerosis Risk in Communities study are a surprise. People living in poor neighbourhoods as adults were at increased risk of cardiovascular events, but living in a poor neighbourhood as a child seemed to have no effect. However, participants weren’t recruited until middle age and faulty memories of childhood might have compromised data quality (Am J Epidemiol doi:10.1093/aje/kwac070).

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**MINERVA**

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