Adopting an expiratory or shallow breathing technique, low kVp protocols and higher iodine flux can all be used to improve the adequacy of CTPA studies. Despite these technical adaptations there remain patient factors beyond the control of the operator. Up to 40% of pregnant patients have been reported to have diagnostically inadequate CTPA studies. Due to a combination of high inadequacy rates and higher radiation dose CTPA is not recommended as the first line test in pregnant patients by the Royal College of Obstetricians and Gynaecologists. An inadequate perfusion scan is an extremely rare occurrence as the technique is fairly simple and robust, although ventilation studies are more technically demanding and can lead to equivocal outcomes from SPECT imaging. Adequacy of pulmonary magnetic resonance angiography (MRA) remains an issue, with variable performance between centres and inadequacy rates of 25% being reported.

Radiation dose

The individual radiation dose for a CTPA varies with patient size, but a range of 3-30mSv whole body dose is recognised by the International Atomic Energy Association. Modern CT scanners and dose optimisation protocols can substantially reduce doses, but the mean dose reported is still higher than perfusion scintigraphy.

The NICE guidelines do acknowledge a role for alternative testing strategies in patients where radiation dose is a concern (renal impairment and iodine allergies being the other reasons to consider using alternative technologies). The recently updated Royal College of Obstetrics and Gynaecology guidelines have retained a recommendation that half-dose perfusion scans are still preferred as a first line test in pregnancy. The guideline committee considered that for both V/Q and CTPA scans the radiation dose was below the threshold where there is a significant risk of adverse outcome to the fetus, whereas the organ specific dose to the female breast was in the range where an increased risk of breast cancer remains a clinical concern. A typical breast dose from CTPA is in the order of 10-70mGy (20-100 times greater in magnitude than a V/Q scan).

While the absolute cancer risk remains small from these diagnostic radiation doses, the evidence base used by the RCOG guideline estimates there is an increased relative risk of breast cancer of 13% per 10mGy of radiation administered to the breast tissue. Multiple attendances with PE symptoms are common in this referral population, often due to previous VTE events, concern about a family history of VTE or other factors driving patient behaviour. When considering the Lifetime Attributable Risk to patients from successive CT examinations this can add up to a sizeable increase in the risk of breast cancer in a relatively young population.

The less favourable dosimetry is also relevant to non-pregnant patients and CTPA should be used with caution in younger populations, balancing the radiation risks of CTPA with equivalent diagnostic strategies that deliver a lower dose. Consent for whichever technique is used has been advocated in the pregnant population. MRA is being developed as an alternative imaging technique in some centres. MRA has equivalent diagnostic accuracy for segmental emboli to CTPA and does not result in any irradiation of the patient. Unfortunately the diagnostic performance of this technique varies between centres and it remains dependent on locally available technical expertise and scanner availability that is currently lacking in most hospitals in the UK.
reported on the correlation between the increasing use of CTPA and an 80% increase in diagnoses of PE since 2000 in the USA.1 The mortality from PE has remained unchanged during this period, leading to concern that over-diagnosis is becoming a more significant issue as our diagnostic strategies and perspective on the disease evolves. The increased availability and sensitivity of CTPA and other techniques (such as V/Q SPECT) may lead to overtreatment and cause harm to patients from unnecessary anti-coagulation. This is also a consideration when looking at the CT perfusion imaging now available from spectral CT scanners (figure 3).

The incremental accuracy of dual source/spectral CT in the diagnosis of PE is derived largely from the additional sensitivity of CT perfusion imaging to detect small emboli.14 Controversy persists about the clinical relevance of subsegmental (and incidental) emboli and whether the benefit of anti-coagulation for these presentations is greater than the risk of haemorrhage.

In 2007, the Fleischner Society published a position statement in which an approach to avoiding anti-coagulation for subsegmental emboli is detailed.15 A recent review by the Cochrane Collaboration stated that there was still insufficient evidence to determine whether anti-coagulation of subsegmental emboli is in the patient’s best interest.16

Given these ongoing concerns about over-diagnosis, the reported increase in sensitivity for techniques utilising perfusion imaging (added to or instead of pulmonary angiography) may be of limited clinical value.17 However, it remains important to consider patients as individuals, rather than looking solely at population data. Ultimately, discussion with clinical colleagues about an individual determines the final decision regarding the risks and benefits of treatment. This is an area of ongoing study and further data is anticipated that will help to resolve these questions.

Non-embolic diagnosis

Clinicians value the ability of CT to exclude PE and at the same time evaluate for other pathology that may be causing chest pain or shortness of breath. V/Q imaging is less specific in its diagnostic performance as it looks at perfusion patterns, rather than directly visualising thrombus. The diagnostic performance of V/Q scans improves when there is a normal CXR and this is often used as an essential referral criteria.

Changing clinical practice and access to imaging have driven a more liberal testing strategy and the preference from clinical staff for a one-stop diagnostic shop is increasing the numbers of patients undergoing CTPA.18 While there are benefits to a more comprehensive imaging assessment, there are also downsides due to the presence of incidental findings that will have indeterminate significance. Lung nodules are a common incidental finding on thoracic CT and are reported to occur in over 25% of CT scans.19 The majority of pulmonary nodules are <5mm in diameter and have a very low incidence of malignancy (reported to be <1%), which raises concerns about harm to patients from subsequent unnecessary investigation and treatment.20 In the older age group the association of unprovoked VTE with unrecognised malignancy makes the screening element of a CT testing strategy more of an advantage. Currently the NICE guidelines use 40 as the age cut-off when a CT is recommended for cancer screening in cases of unprovoked VTE.21 This is also the age below which incidental pulmonary nodules of malignant aetiology are considered to be extremely unlikely.22

Availability

In most hospitals the only imaging modality for PE with consistent 24/7 access over 365 days of the year is the CT scanner. Access to definitive imaging is key to a timely diagnosis, and this is a quality standard needed to support a change towards ambulatory management of VTE. The ability to make a definitive diagnosis within a short timeframe is an essential part of any local imaging strategy. In patients that are haemodynamically compromised or being considered for thrombolysis a CTPA can be used to provide an immediate and specific diagnosis. Timely access to V/Q and MRA scans can be problematic as the technology may not exist locally or is limited by competing service demands and technical expertise.

Conclusion

Currently, and in the immediate future, CTPA will remain the main testing method by which PE is diagnosed. V/Q scanning (ideally with SPECT techniques) is an established alternative in selected patients, such as the young and pregnant populations. MRA remains a promising alternative, without the issues associated with harm from ionising radiation, but needs to become more liberally available and technically robust. Refinements to existing technology can improve the accuracy of testing but the improved sensitivity of some techniques changes the clinical perspective on the disease and carries a risk of over-diagnosis. More research is needed to improve risk stratification of the population where VTE disease is limited to smaller pulmonary emboli and help guide subsequent treatment decisions.

References

1. Wiener R S, Schwartz L M, Woloshin S. When a test is too good: how CT pulmonary angiograms find pulmonary emboli that do not need to be found. BMJ 2013;346:f1536.
Figure 1
Extensive proximal thromboembolic disease bilaterally in the lower lobes and involvement of a subsegmental artery in the right upper lobe. Coronal MIP images and slabs assist in the identification of smaller emboli.

Figure 2
Planar and SPECT V/Q scans performed sequentially on a patient with multiple PE.

Figure 3
Dual energy CT pulmonary angiogram and lung perfusion map improves sensitivity and interobserver variability.