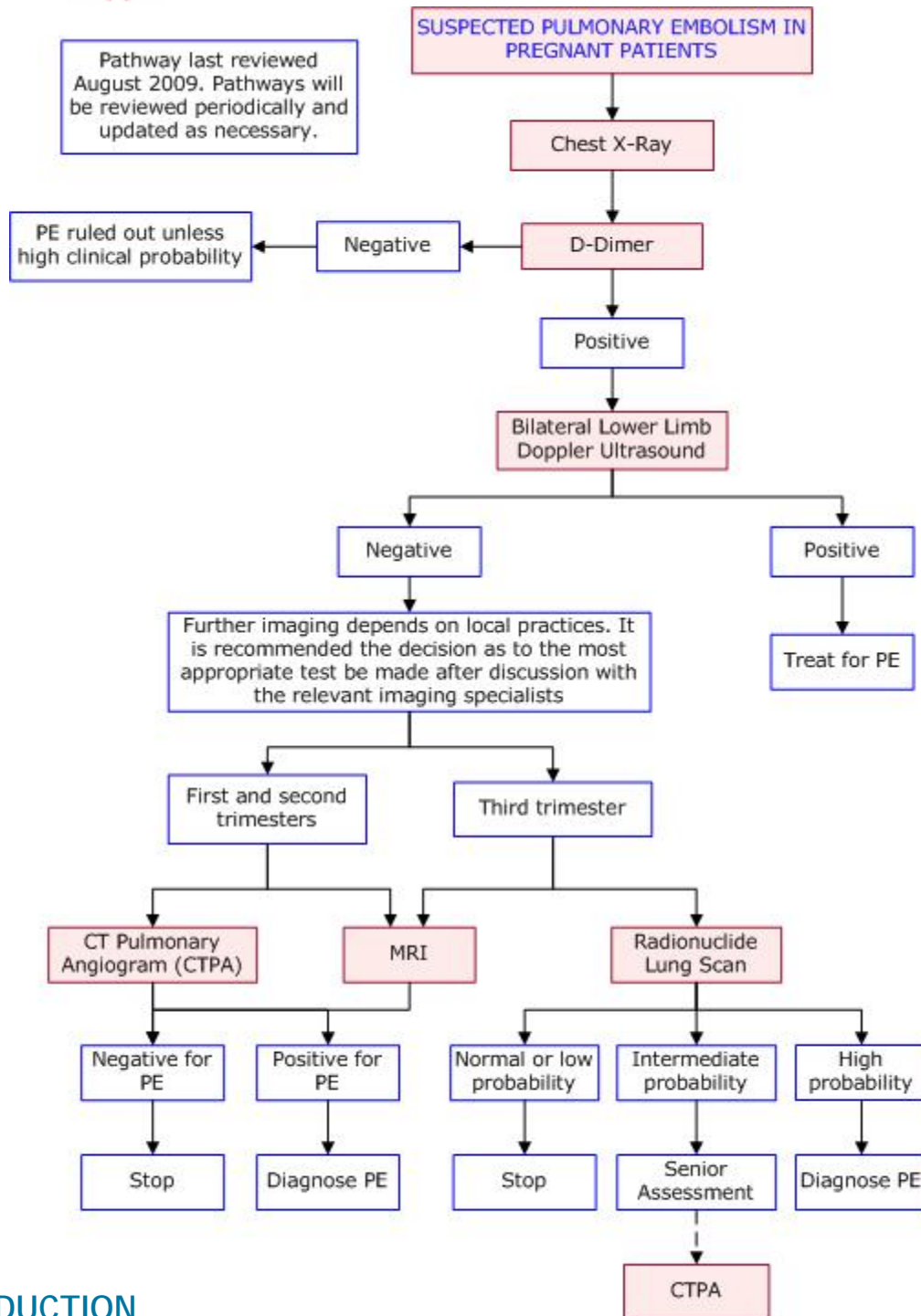




DIAGNOSTIC IMAGING PATHWAYS
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INTRODUCTION

- Pulmonary embolism (PE) is a leading preventable cause of maternal mortality during pregnancy
- The risks of inappropriate use of anticoagulation or missing the diagnosis of PE in pregnancy, far outweigh the risks of exposure to the mother and fetus of diagnostic radiation
- The difficulty in making the diagnosis of PE in pregnancy is compounded by physiological changes in women that result in symptoms that mimic PE. These include chest pain, shortness of breath and leg swelling which make the clinical diagnosis of PE difficult.

- Available evidence as to the most appropriate methods to investigate suspected PE in pregnancy is circumspet
- Due to differences in scanning protocols between institutions, it is important to discuss planned investigation of PE in pregnant patients with the radiologist and nuclear medicine physician

PLAIN RADIOGRAPHY

- Useful for excluding conditions that can mimic pulmonary embolism. [1](#)
- A chest Xray is also useful in triaging patients to the most appropriate next investigation. It has been demonstrated that a normal chest Xray results in a decrease in the number of indeterminate V/Q scans. [2](#)

D-DIMER ASSAY

- D-dimer assays have high negative predictive value in non-pregnant patients with suspected VTE and can be used to exclude the diagnosis.[3](#) Unfortunately, pregnancy causes d-dimer levels to increase even in uncomplicated cases, diminishing its usefulness.
- Recent attempts have been made to establish a normal range for d-dimer assays during pregnancy but have not been used in clinical practice. Studies show that d-dimer testing in the third trimester is almost certain to be of no clinical benefit as a d-dimer level above the reference range is probably universal. [4](#)
- Despite this, it is intuitive that as in non-pregnant patients, a negative d-dimer in a patient at low risk of PE rules the diagnosis of PE out. [5](#)

LOWER LIMB DOPPLER ULTRASOUND

- Used by some centres as the initial method of investigation if pulmonary embolism is suspected during pregnancy, as it does not use ionising radiation.
- Only around 10% of all patients with a PE will have an abnormal ultrasound. [6](#)
- Pulmonary embolism and deep vein thrombosis are both part of a single disease process, being venous thromboembolism. The rationale of performing ultrasonography is that detection of DVT in a patient suspected of having PE is sufficient for treatment to be commenced. Further investigation to specifically detect PE is not required and ionising radiation is avoided. [7](#)

COMPUTED TOMOGRAPHY PULMONARY ANGIOGRAPHY (CTPA)

- Both CTPA and radionuclide imaging have been advocated as being the first investigation of choice for pregnant patients with suspected PE. [5,8,9](#)

Information regarding the effects to the fetus

- CTPA has been recommended in the first two trimesters of pregnancy, as it is associated with less fetal radiation than V/Q scanning. However, V/Q examination is a valid alternative and there is likely to be little difference in the diagnostic utility between the two.

- Research into fetal radiation dose in pregnancy has shown a definite trend in favour of CTPA in the first two trimesters of pregnancy. [10-12](#)
- Phantom studies performed have demonstrated that fetal radiation dose varies with gestational age. Early in pregnancy, fetal radiation exposure occurs due to scatter and doses are as little as one-tenth that of V/Q. Later in pregnancy, doses increase towards that of V/Q scanning. [10](#)
- The National Radiological Protection Board (NRPB) estimates the risk of inducing a fatal or non-fatal cancer in a fetus till the age of 15 to be approximately 1/33,000 per mGy. [9](#) Hence the risk from a single V/Q study would be approximately 1/165,000. The risk from a CTPA would be as little as one-tenth of this, early in pregnancy.
- Careful attention must be made to scanning protocols in pregnant patients. Variation in fetal radiation dose for both CTPA and V/Q scanning (up to 30 times that for CTPA and 3 times that for VQ scanning) have been reported by one author. [14](#)
- No evidence exists that contrast administration during pregnancy is deleterious to the developing fetus. However, neonatal thyroid function should be checked in the first week of life to ensure normal thyroid function. [23](#)

Information regarding the effects to the mother

- Maternal doses of radiation for CTPA are higher than for V/Q. Average whole body doses for CTPA range from 2-10 mSv and 0.6-1.5 mSv for V/Q scanning respectively. [11,15,16](#)
- Of importance is the radiation dose to the breast caused by CTPA. Contention has plagued the literature and mistakes have been made in the interpretation of the evidence. [17-19](#) The average radiation dose to the breast from a CTPA is typically 10-20 mSv and 0.28-0.5 mSv for V/Q respectively. [11,17,20,21](#)
- The Biological Effects of Ionizing Radiation, seventh report (BEIR VII) estimates that the lifetime attributable risk for breast cancer from a dose of 20mGy is approximately 1/1200 for a woman aged 20, 1/2000 for a woman age 30 and 1/3500 for a woman aged 40. [22](#) That is, if a woman aged 30 has a CTPA with a breast dose of 20 mGy, there would be an additional 1/2000 chance of her developing breast cancer. The lifetime risk of breast cancer for women is approximately 1/8.
- Studies using bismuth breast shields have shown radiation dose reductions of 34-57% to the breast, without significant decrease in image quality or diagnostic accuracy. [17,27,28](#)

RADIONUCLIDE LUNG SCAN

- Lung perfusion images are taken after the intravenous injection of technetium-99m-macroaggregated albumin. Pulmonary embolism characteristically appears as a pleural based segmental perfusion defect. [4](#)

Information regarding the effects to the mother

- V/Q scanning is likely to be more efficacious in pregnant than non-pregnant populations and has been advocated by some authors as the investigation of choice for pregnant patients suspected of having PE. [8](#)

- The high rate of non-diagnostic (50-70%) radionuclide scans in non-pregnant populations has led to the increasing use of CTPA in patients suspected of having PE. [24,25](#) This is not the case in the pregnant population, as they tend to be younger and do not suffer from chronic lung diseases. Two studies evaluating 202 pregnant women showed that only 31% of V/Q scans were non-diagnostic. In addition, they indicated that with-holding treatment in patients with a low probability scan was very likely to be safe. [13,26](#)
- Radionuclide imaging is associated with significantly less radiation to the breast than CTPA. [11,17,20,21](#) Women with a higher risk of breast cancer should consider having radionuclide imaging instead of CTPA to limit their risk of radiation induced breast carcinoma.

Information regarding the effects to the fetus

- As radiation exposure of the fetus is a major issue during pregnancy, radionuclide scans in pregnant patients typically begin with perfusion only studies. It has been shown that the diagnostic accuracy of perfusion only scintigraphy in suspected pulmonary embolism is not reduced when compared to the gold standard of 'pulmonary angiography'. [29](#)
- Estimated fetal radiation dose for V/Q scanning is not dependent on fetal age and is approximately 0.1-0.3mGy. [11-13](#)
- During the first and second trimesters of pregnancy, radionuclide scans are associated with a higher fetal absorbed radiation dose compared with CTPA. However, during the third trimester of pregnancy, the increasing fetal size brings it closer to the CTPA scanning field and radiation doses approach that of V/Q. [10](#) Radionuclide scans are therefore preferred in the third trimester.

MAGNETIC RESONANCE IMAGING

- The use of MRI for the diagnosis of PE in pregnancy is relatively new and experience with this is generally limited depending on the institution. However, there is growing interest in this area as, compared to CTPA and VQ scintigraphy, MRI offers the distinct advantage of a radiation-free imaging modality.
- There are no known adverse effects of MRI on the fetus and no teratogenic effects have been described with the use of gadolinium-based contrast agents. [29](#) Thus, gadolinium may be administered to pregnant women if the study is considered necessary and follow-up neonatal tests are currently not required after delivery. [30](#)
- The sensitivity of pulmonary contrast-enhanced magnetic resonance angiography (MRA) for the detection of PE ranges from 71 to 100%. The specificity ranges from 92 to 100%. [31-33](#) MRI also has the ability to combine both morphological (MR angiography) and functional (perfusion MRI) assessment in a single imaging protocol. When used in combination, the sensitivity and specificity for the diagnosis of PE exceeds 90% and closely agrees with CTPA. [32](#)
- Recent technological innovations have also overcome previous limitations of this study such as improved spatial resolution (to detect peripheral emboli), reduced acquisition time (to minimise breathing artifacts) and wide bore magnets (to improve accessibility). [29](#)
- The main barriers to the widespread use of MRI for this indication at present is availability and the expertise required in its interpretation.

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