The diagnostic role of ventilation/perfusion scans versus computed tomography pulmonary angiography in obstetric patients investigated for pulmonary embolism at Wellington Hospital from 2010 to 2012

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ABSTRACT

AIM: To develop best practice clinical guidelines for the use of ventilation/perfusion (V/Q) scanning and computed tomography perfusion angiography (CTPA) in pregnancy and the postpartum period.

METHOD: Retrospective analysis of the clinical findings and radiologic investigation for pulmonary embolism (PE) in obstetric women at Wellington Hospital from 2010 to 2012.

RESULTS: Fifty-four women were investigated for PE with a V/Q scan or CTPA, including 29 antenatal women and 25 postnatal women. Eleven (37.9%) antenatal women had V/Q scans and 18 (62%) had CTPAs. Five (20%) postnatal women had V/Q scans, 19 (76%) had CTPAs and one (4%) had a V/Q scan followed by a CTPA. Three of the 54 women (5.6%) had a positive radiologic finding of PE (two by V/Q scan and one by CTPA). Four (22.2%) antenatal women and 5 (25%) postnatal women had a diagnosis made on CTPA, which was not seen on chest x-ray.

CONCLUSION: This audit found that clinicians varied in their investigation of cases suspected of PE. We have proposed a clinical pathway for the investigation of PE in pregnancy and the postpartum period.

Pulmonary embolism (PE) is the leading cause of non-obstetric mortality during pregnancy and the peripartum period in the developed world, and accounts for 10% of all maternal deaths.\(^1\)\(^-\)\(^4\) Investigation of suspected PE usually follows a pathway which includes physical symptoms and signs, an ultrasound investigation of any underlying deep vein thrombosis (DVT), a chest x-ray and imaging of the lungs with either ventilation/perfusion (V/Q) scanning or computed tomography pulmonary angiography (CTPA). The preference of imaging modality for diagnosing PE in the non-pregnant population has been studied by the Prospective Investigation of Pulmonary Embolism Diagnosis (PIOPED) Trials, which provided level one evidence that CTPA is superior to ventilation-perfusion (V/Q) scans in diagnosing PE.\(^2\) These trials, however, specifically excluded pregnant women, and are often
misinterpreted by some clinicians who presume that the findings are also valid in pregnancy. This may not be the case, as the underlying physiological changes which occur during pregnancy—such as alterations in cardiac output, changes in plasma volume and distribution of fluid between body compartments—reduces the accuracy of CTPA. Furthermore, the general population has a disproportionate number of indeterminate V/Q scans due to the inclusion of older patients with higher rates of underlying cardiac and lung disease. Pregnant women tend to be younger and healthier with lower rates of indeterminate V/Q scans.

There are currently no national or local guidelines for the management of PE in obstetric patients. Current widely-used international guidelines leave the choice of imaging modality to individual clinicians and do not specify recommendations based on gestation or for during the post-partum period. This audit aimed to look at the management of PE in obstetric patients at Wellington Hospital, particularly looking at the choice of imaging modality. It further aimed to calculate the yield of positive scans in these patients and to use this data to support the development of a local clinical pathway for best practice in pregnant women, taking into consideration the risks of radiation to both the mother and foetus.

Methods

Data were collected for all antenatal and postnatal inpatient and outpatient women investigated for PE with either a V/Q scan or CTPA at Wellington Hospital from 2010–2012. The patient cohort was identified from the electronic records held by the Department of Radiology by selecting all patients from the Women’s Health Department for whom V/Q scans or CTPA were performed during that time period. Records of all women in the cohort were screened and collected by the author from patient files and the electronic patient database used at Capital and Coast District Health Board (Concerto®), and gynaecology patients were excluded. The cohort was divided into antenatal and postnatal subgroups and analysed separately. The positive yield of PE for V/Q scans and CTPA was calculated as percentages.

Table 1: V/Q scans and CTPAs performed on all obstetric women at Wellington Hospital from 2010–2012 (n=54).

<table>
<thead>
<tr>
<th>Scan Type</th>
<th>Antenatal</th>
<th>Postnatal</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>V/Q Scan only</td>
<td>11 (37.9%)</td>
<td>5 (20%)</td>
<td>16 (29.6%)</td>
</tr>
<tr>
<td>CTPA only</td>
<td>18 (62%)</td>
<td>19 (76%)</td>
<td>37 (68.5%)</td>
</tr>
<tr>
<td>V/Q Scan -&gt; followed by CTPA</td>
<td>0 (0%)</td>
<td>1 (4%)</td>
<td>1 (1.9%)</td>
</tr>
<tr>
<td>Total</td>
<td>29</td>
<td>25</td>
<td>54</td>
</tr>
</tbody>
</table>

Results

Between 2010 and 2012, 54 obstetric patients (29 antenatal and 25 postnatal) were investigated for PE with either a V/Q scan or CTPA. Of the antenatal women, 11 (37.9%) had a V/Q scan and 18 (62%) had a CTPA. Five (20%) of the postnatal women had a V/Q scan, 19 (76%) had a CTPA and one (4%) had a V/Q scan followed by a CTPA (Table 1).

Three of the 54 patients (5.6%) had a positive radiological test with a high probability of PE. Two were antenatal patients, both diagnosed by V/Q scan (Table 2) and one was a postnatal patient diagnosed by CTPA (Table 2).

Six of the 29 antenatal women (20.7%) had a CTPA despite a normal chest x-ray, and three (10.3%) had a V/Q scan despite an abnormal chest x-ray. Chest x-rays were not performed in seven (21.4%) of the antenatal women (Table 3). Three postnatal women (12%) had a V/Q scan despite an abnormal chest x-ray. All the postnatal women had chest x-rays performed (Table 3).

There were 18 antenatal and 20 postnatal women who had a CTPA. Of the women who had normal chest x-rays followed by a CTPA (15), nine (24%) had a diagnosis
Table 2: Positive yield of imaging (Antenatal n=2/29 and Postnatal n=1/25).

<table>
<thead>
<tr>
<th>Yield</th>
<th>V/Q Scans</th>
<th>CTPA</th>
<th>V/Q Scan -&gt; CTPA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Antenatal</td>
<td>Postnatal</td>
<td>Antenatal</td>
</tr>
<tr>
<td>Positive</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Negative</td>
<td>9</td>
<td>5</td>
<td>18</td>
</tr>
<tr>
<td>Subtotal</td>
<td>11</td>
<td>5</td>
<td>18</td>
</tr>
<tr>
<td>Total</td>
<td>16</td>
<td>37</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 3: Scans performed following chest x-ray antenatal and post-natal women (n= 29) (one postnatal patient had both a V/Q scan and CTPA).

<table>
<thead>
<tr>
<th>Imaging</th>
<th>Normal CXR</th>
<th>Abnormal CXR</th>
<th>CXR not performed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Antenatal</td>
<td>Postnatal</td>
<td>Antenatal</td>
</tr>
<tr>
<td>V/Q Scan</td>
<td>8 (27.6%)</td>
<td>3 (12%)</td>
<td>3 (10.3%)</td>
</tr>
<tr>
<td>CTPA</td>
<td>6 (20.7%)</td>
<td>9 (36%)</td>
<td>5 (17.2%)</td>
</tr>
<tr>
<td>Subtotal</td>
<td>14</td>
<td>12</td>
<td>8</td>
</tr>
<tr>
<td>Total</td>
<td>26</td>
<td>21</td>
<td>7</td>
</tr>
</tbody>
</table>

made by CTPA, which was not seen on chest x-ray. This included six cases of pneumonia, and one case each of pericardial effusion, pleural effusion and pulmonary embolism.

Discussion

This study showed that there was wide variation in the choice of imaging modality used to diagnose PE, with inconsistencies in the application of imaging choices in relation to timing throughout pregnancy and the puerperium. In addition, only a proportion of women had a chest x-ray (87.03%) prior to further diagnostic imaging. The results reinforce the need to have clarity in evidence-based guidelines for the investigation of these women.

The major strength of this study is the use of data from a cohort of patients combined with empirical evidence to propose refinements of existing algorithms. Our clinical pathway has expanded on previous guidelines by including specific recommendations for each trimester of pregnancy and post-partum. We recognise that our study uses a small cohort from a single hospital and has the limitations associated with retrospective analysis of data, such as primary statistics could not be measured and a reliance on accurate record keeping.

It is controversial as to whether V/Q scans or CTPA is the preferred diagnostic modality for PE in pregnancy. Two retrospective studies by Cahill et al\(^1\) and Ridge et al\(^8\) concluded that pregnant women who had V/Q scans were more likely to have a confirmed diagnosis compared to pregnant women who had a CTPA, particularly if they had a normal chest x-ray (30% compared with 5.6% with an adjusted odds ratio of 5.4).\(^2,8\) Studies by Shahir et al\(^9\) and Revel et al\(^5\) found that both tests have equivalent accuracy, however, they concluded that CTPA can be more useful in some cases as it allows for better diagnosis of alternative pathologies.\(^5,9\)

The need for specific guidelines in relation to obstetrics is due to concerns about the risk of radiation to the foetus from any form of ionising radiation. The exact threshold dose of radiation to the foetus before detrimental effects occur is unknown, and is estimated to range between 50–100 mGy.\(^3,4,10-13\) V/Q scanning delivers considerably more radiation to the foetus than CTPA due to the pooling of contrast in the maternal bladder. The mean foetal radiation dose from a V/Q scan ranges between 0.1–1.8 mGy, depending on the dose of contrast, and if both ventilation and perfusion scanning are used.\(^3,9,10,12-17\) In contrast, the mean dose to the foetus from CTPA is estimated to range from 0.003 mGy to 0.66 mGy, with doses increasing with gestational age.\(^3,9-17\)

In contrast, maternal radiation is significantly higher with CTPA than
Risk factors for VTE in pregnancy:
- Age of ≥35 years
- Obesity
- Multiparity
- Gestation <36 weeks
- Inherited clotting disorders or strong family history
- Previous thrombotic event
- Recent trauma
- Immobilisation (>4 days of bed rest)
- Long-haul travel ≥4 hours
- Instrument-assisted or caesarean delivery
- Haemorrhage
- Prolonged labour
- Pre-eclampsia

Clinical suspicion of VTE in pregnancy and postpartum
- Full history and examination
- Assess risk factors (see box to left)
- FBC, Finger probe oxygen saturations
- DO NOT TAKE D-DIMER

High pre-test clinical likelihood of PE
Other pathologies considered unlikely

Clinical signs and symptoms of DVT

YES
Doppler USS

NO
CXR

Treat with anticoagulation and monitor

Review of CXR by SMO/ senior RMO
- Consider medical review

No alternate diagnosis
Further imaging required

Alternative diagnosis made on CXR

Call duty radiologist

Treat pathology as appropriate

Q Scan
- Normal CXR
- Use as first line in the 2nd and 3rd trimesters and postpartum as reduces radiation to maternal breast tissue

CTPA
- First trimester (lower radiation dose to fetus)
- Suspected massive PE
- Abnormal CXR (makes V/Q scan indeterminate)

Breast feeding:
- Decision made on a case by case basis

Breast feeding:
- No cessation of breastfeeding

Breast feeding: Decision made on a case by case basis

CTPA
- First trimester (lower radiation dose to fetus)
- Suspected massive PE
- Abnormal CXR (makes V/Q scan indeterminate)
V/Q scanning, particularly to the breast tissue. It is estimated that CTPA delivers between 10–70 mGy of radiation per breast, whereas a V/Q scan is estimated to deliver between 0.11–0.31 mGy per breast. The background risk of breast cancer in women of childbearing age is approximately 1 in 200. It is estimated that the delivery of 10 mGy of radiation to a woman's breast increases this risk by approximately 14%. It is theorised that this risk is further increased in pregnancy due to increased radiosensitivity of the proliferating breast tissue. This is supported by a study which has shown that pregnant women treated with radiotherapy for Hodgkin's disease have a significantly higher risk of subsequently developing breast cancer than non-pregnant women. The risk of breast radiation from CTPA can be reduced by up to 57% by using thin-layered bismuth breast shields. Nevertheless, CTPA still delivers significantly more radiation to the breast tissue than V/Q scanning.

There is debate regarding the best imaging modality in the post-partum period, particularly if a woman is breastfeeding. Factors that need to be addressed are maternal breast radiation and the effect of the isotope and contrast material on the breastfeeding infant. As already mentioned, CTPA scanning exposes the breast to much larger doses of radiation than V/Q scanning, therefore V/Q scanning is preferred in the lactating woman.

Although several governing bodies and review groups have taken the above factors into consideration, and developed recommendations for the diagnosis of PE in pregnancy and the postpartum period, this has not been translated into a gestation-specific clinical pathway. Using the findings from our audit and the principles from international review groups, we have proposed a clinical pathway for the investigation of PE in the three trimesters of pregnancy, and the postpartum period (Figure 1).

When there is a suspicion of venous thromboembolism, any pregnant or post-partum woman, at first, should have a full history taken and an examination performed, assessing for risk factors for PE (see Figure 1). Initial investigations should include a full blood count (FBC), and finger oxygen probe saturations should be taken. A D-dimer should not be taken, as levels are normally high during pregnancy and cannot be used to reliably rule out PE.

Patients with signs and symptoms of a DVT should have a compression ultrasound Doppler study of the affected leg. If positive, this needs to be treated with therapeutic anticoagulation, and further investigations for PE can cease because treatment for PE and DVT is the same, and imaging exposes the mother and foetus to unnecessary radiation.

If there are no signs or symptoms of DVT, but high clinical suspicion of a PE, women should then have a chest x-ray, as it can help diagnose or rule out other causes of the symptoms, such as pneumonia or pneumothorax, and to decide whether a V/Q scan or CTPA is appropriate. All women suspected of having a massive PE should have a CTPA, as should women with an abnormal chest x-ray suspected of having a PE when a clear diagnosis cannot be made. V/Q scans are less useful for diagnosing PEs with abnormal chest x-rays because the abnormalities make ventilation-perfusion matching difficult.

We suggest that women in the second and third trimester with a normal chest x-ray have a perfusion (Q) scan as first-line imaging for PE, because of the greater diagnostic accuracy in pregnancy as compared to CTPA, and delivery of lower radiation. We recommend the use of low-dose perfusion contrast and omission of the ventilation component.

During the first trimester, the foetus is most susceptible to the teratogenic effects of radiation. A case could be made for CTPA over Q scanning, while accepting that there are still some risks of radiation to maternal breast. For a 25-year-old whose background risk of developing breast cancer in the following 10 years is 0.1%, the extra risk of radiation from CTPA increases the risk by 13.6% of 0.1%, which is an increased absolute risk of 0.0136%. We feel the increased risk of teratogenesis to the foetus in the first trimester outweighs this very small increased risk of breast cancer to the mother.

During the postpartum period, Q scanning is recommended as first-line imaging to
avoid maternal breast radiation received from CTPA scanning, unless the women has an abnormal chest-x-ray or is suspected of having a massive PE. Women who are breastfeeding do not need to interrupt feeding after having a CTPA scan, however evidence is lacking as to whether women need to stop breastfeeding after having a V/Q scan. We recommend that women should express breast milk prior to the Q scan so they can feed their infant after the scan. If women are unable to express milk prior to scanning, a decision on whether to stop expressing for the following 12 hours should be made on a case-by-case basis.

In our study, eight other disorders were diagnosed by CTPA in women with normal chest x-rays; these included three cases of pneumonia and one case of pericardial effusion in our antenatal sub-group, three cases of pneumonia, and one of pleural effusion in our postnatal subgroup. It is uncertain if these pathologies would have been eventually detected if a Q scan was performed rather than a CTPA as recommended by our clinical pathway. This also highlights the importance of ongoing clinical assessment and investigation in patients where a diagnosis has not been confirmed and the illness does not resolve.

We believe that this clinical pathway would be a useful guide for clinicians in the investigation of PE in pregnancy and the postpartum period. Using the best evidence currently available, it evaluates the radiation risks to both the foetus and mother during the three trimesters of pregnancy and post-partum. Subsequent evaluation of its impact on investigation use and clinical management will be important.

### REFERENCES:


6. Royal College of Obstetricians and Gynaecologists. Thromboembolic disease in pregnancy and the


16. Huda W. When a pregnant patient has a suspected pulmonary embolism, what are the typical embryo doses from a chest CT and a ventilation/perfusion study? Pediatr Radiol. 2004;35:452-453.


