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What are two common indications for a VQ scan?

1. Acute pulmonary embolism evaluation. 2. Chronic pulmonary embolism evaluation in setting of pulmonary hypertension.

What is typically performed first—ventilation or perfusion scan?

Ventilation is typically performed before perfusion.

What radiotracers are commonly used for the ventilation portion of the VQ scan and what are the energies of these radiotracers?

1. Xenon 133 which emits an energy of 81 keV. Bonus points to remember that Xe133 is lipophilic and requires a negative pressure room when you use this. 2. TcDTPA or Tc-Technegas (outside of USA) with 140 keV.

What radiotracer is commonly used for the perfusion portion of a VQ scan?

Tc-MAA

What would happen if you perform the perfusion scan first immediately followed by the ventilation scan? Why would this be a problem?

Ventilation scan has a very short effective half life as you exhale the radiotracer quickly. You also have a very low energy when using Xe133 at 81 keV. Perfusion scan has a much longer effective half-life as the radiotracer becomes lodged in pulmonary capillaries. If you performed the perfusion scan first, the Tc from perfusion would still be present at the time of ventilation scan and would interfere with the ventilation scan images. You would also have downscatter on the image from the higher Tc 140 keV superimposed on the lower Xe133 keV of 81.

> In general, in nuclear medicine when using dual tracers, you image the tracer with the lower keV first to prevent downscatter contamination that occurs if you image with the higher keV first. If energies are the same (such as rest/stress cardiac imaging with Tc, you use a smaller dose first (rest imaging) followed by a much larger dose (stress imaging) to overwhelm the counts from the first study to prevent contamination on the second study. In case of VQ scan one uses a delivered dose of 1 mCi DTPA vs about 6 mCi MAA.

When might you want to perform the perfusion scan prior to the ventilation scan?

Pregnancy or other conditions where radiation dose minimization is of higher priority. In this case you perform ventilation scans only if the perfusion scan shows an abnormality. If the perfusion scan is normal you have excluded PE as a consideration. Disadvantage: downscatter will be present. However, often ventilation scans are performed 24 hours later (if the patient is clinically stable and doesn't need earlier imaging) so that downscatter is no longer an issue.

What is the most common cause of delayed washout on a VQ scan?

COPD.

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VQ scan with right upper quadrant abdominal uptake?

Think fatty liver from accumulation of lipophilic Xe133 in the fat-laden liver.

VQ scan with gastric activity?

Swallowed particles during ventilation portion of the scan.

How do I tell from images alone whether Xe or Tc was used for the ventilation scan?

Xe133 ventilation images show wash-in and wash-out. Tc-DTPA images do not. Tc-DTPA images show ventilation images in multiple projections including oblique views, Xe133 ventilation images are typically anterior/posterior views only.

What is the particle size of TcDTPA?

0.1 to 0.5 micrometers.

What is the particles size of TcMAA?

10-90 micrometers.

For boards, I would remember DTPA is 1 micrometer and MAA is 10 micrometers.

How is TcDTPA cleared from the body?

Renal clearance. TcDTPA eventually crosses the airways into the bloodstream for renal clearance.

How is TcMAA cleared from the body?

Reticuloendothelial system (RES) clearance.

What is Tc99m Technegas?

Used outside of USA. Tc99m labeled to graphite particles in argon carrier gas. Advantage? No central clumping like with Tc-DTPA.

For TcMAA what is stannous ion in the preparation kit used for?

Stannous ion reduces the Tc pertechnetate from a +7 to a +4 state so it can better bind the MAA. Random fact that can be tested.

How many particles of TcMAA are typically injected for a perfusion scan?

About 350k particles (there is a range, but this is a good number to keep in mind)

In what setting would you want to inject fewer TcMAA particles?

Pulmonary hypertension and known right to left shunt inject about 150k particles. Rationale is that you want to cause as few micro emboli as possible to the lungs and brain respectively.

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Do you inject fewer particles for a pregnant patient?

No. You inject the same number of particles, but mix those particles in in a lower dose of Tc (1-3 mCi vs 6 mCi standard).

What is the critical organ for TcDTPA?

Bladder (renal clearance)

What is the critical organ for TcMAA?

Lungs (larger particles don't cross into blood stream but stay in lungs until cleared by the RES)

Perfusion scan with brain and kidney uptake?

Right to left cardiac shunt

Perfusion scan with hepatic caudate lobe uptake? **Note that the episode states SVC occlusion but this is a mistake** The correct answer is Budd-Chiari with hepatic vein obstruction. Superior vena cava occlusion is classically associated with quadrate lobe uptake, and there are some reports of inferior vena cava obstruction also causing quadrate lobe uptake. See article here: doi: 10.4103/0972-3919.178325

Hot caudate lobe: Budd-Chiari

Hot quadrate lobe: SVC and/or IVC obstruction

What is the definition of a small defect?

<25% of a pulmonary segment

What is the definition of a moderate defect?

>25% but <75% of a pulmonary segment

Large size?

>75% of a pulmonary segment.

With what clinical criteria are VQ scan imaging results paired with to determine the overall probability of a PE being present?

Wells Criteria

What factors are considered in Wells Criteria?

Presence of DVT, HR >100, recent immobilization or surgery, prior history of DVT or PE, hemoptysis, malignancy undergoing treatment within 6 months, high suspicious for PE.

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What reading criteria exist for VQ scan interpretation?

PIOPED, PIOPED II and Modified PIOPED II

Given that there are multiple reader criteria, they will test you on the commonalities between these criteria, not the minute differences between the criteria. Commonalities include the following:

How many medium sized perfusion defects does it take to equal a large perfusion defect?

Two medium defects equal a large perfusion defect.

What constitutes a high probability VQ scan?

2 large or 4 medium mismatched perfusion defects.

What is the definition of a mismatched perfusion defect?

Perfusion defect in an area with normal ventilation OR perfusion defect that is larger than a ventilation defect.

How many small mismatched defects are required for a high probability scan?

The answer is that no number of small mismatched perfusion defects will qualify for a high probability scan. Only medium or large mismatched defects can get one to a high probability scan.

What is the definition of a matched defect?

Perfusion and ventilation defects that are similar in size OR a perfusion defect that is smaller than a ventilation defect.

What is a triple matched defect?

A matched perfusion defect with a corresponding opacity on a CXR or CT scan.

What is the probability for PE of a triple matched defect in the upper or mid lungs?

Very low.

What is the probability for PE of a triple matched defect in the lower lung zone?

Intermediate.

What is the probability for PE of a triple matched defect associated with a small pleural effusion with no other defects?

Intermediate

What if the pleural effusion is large (>1/3 of thorax) and no other defects?

Very low.

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What is the probability for PE of a single moderate sized triple matched defect?

Intermediate

What is the probability of PE for a single mismatched large defect?

Intermediate

What about 2 moderate mismatched defects?

Intermediate

What is the probability for PE of multiple small matched defects?

Very low

What is the stripe sign? If you see a stripe sign what is the probability for PE?

Stripe sign means there is a perfusion defect with a peripheral rim of uptake to show there is preservation of peripheral perfusion. This corresponds with a very low probability of PE.

What is the underling mechanism of a stripe sign?

Emphysema is most classic. You have decreased perfusion in the emphysematous lung parenchyma but can see preserved perfusion peripherally.

What is the probability for PE if there are non-segmental defects?

Very low. PE's present as segmental mismatched perfusion defects.

What is the probability of PE if an entire lobe or entire lung has a mismatched perfusion defect?

High probability.

What if there is a matched defect involving one entire lung?

Low probability.

Why does PE present early with a mismatched defect and later with a matched defect?

Physiologic hypoxic bronchoconstriction takes some time to set in. So early PE's will have reduced blood flow but preserved ventilation (mismatched defect). Once the hypoxia from absent perfusion has enough time to cause bronchoconstriction you will develop a corresponding ventilation abnormality in the region of absent perfusion (matched defect). If the hypoxic bronchoconstriction mechanism is not robust, you can have a chronic mismatched defect which is a cause of a false positive VQ scan in the setting of known prior PE.

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Why might you consider a follow-up VQ scan 3 months after a high probability scan, even if the patient has no residual PE symptoms?

Some advocate to follow-up a high probability VQ scan in 3 months to get a new baseline. The rationale is that the VQ scan usually reverts to normal at 3 months but if defects persist at 3 months they may never completely normalize. So you can repeat a VQ scan at 3 months to get a new normal in case a future VQ scan is needed. Otherwise, you could assume a future VQ scan is positive when you are really only seeing sequela of the prior known PE.