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Imaging with which radiotracer classically will show physiologic renal activity—Tc-99m tagged white blood cell scan or Indium tagged white blood cell scan?

Tc-99m tagged white blood cell scans show physiologic renal and GI activity whereas Indium tagged white blood cell scans classically have no renal or GI activity. Therefore, if you see renal uptake on an Indium tagged white blood cell scan one differential consideration is pyelonephritis or other cause of renal inflammation to include post-chemotherapy states. Given the GI activity on Tc but not Indium white blood cell scans, Indium is also preferred for evaluation of bowel infection/inflammation to include settings such as inflammatory bowel disease.

If a Tc99m MDP bone scan shows the renal cortex has more uptake than the osseous structures what entities can be considered?

Hemochromatosis, recent chemotherapy causing renal injury/inflammation, urinary obstruction.

How does horseshoe kidney or renal transplant present on a bone scan?

Lack of renal uptake in expected location. However, look to see the horseshoe kidney or renal transplant in the pelvis. This can be a trap on a multiple choice question to try to get you to incorrectly assess the image as a superscan. With horse shoe kidney you should also have soft tissue uptake and remember a superscan is lack of renal and soft tissue activity.

What is the pattern of normal renal uptake when imaging with Gallium-67?

Gallium-67 shows normal renal uptake at 24 hours but should not show robust renal uptake beyond 48 hours. If you see a Gallium-67 scan with prominent renal uptake on imaging > 48 hours think of renal infection/inflammation.

What are differential considerations when you see prominent renal uptake on a sulfur colloid scan?

Differential considerations include renal transplant rejection, pyelonephritis, congestive heart failure with reduced renal blood flow and filtration, thrombotic processes to include disseminated intravascular coagulation (DIC) and thrombotic thrombocytopenia purpura (TTP).

When considering Tc99m MAG3, Tc99m DTPA and Tc99m glucoheptonate, which of these are filtered by the kidneys and which are secreted?

Tc99m Mag3 is secreted, the others are filtered. Because Tc99m MAG3 is actively secreted and not passively filtered, it has better uptake and allows better assessment in individuals with renal failure.

Are renal scintigraphy images standardly obtained from anterior or posterior projections?

Standard renal scintigraphy projections are obtained posteriorly. Be cautions therefore when stating a finding is in the left or right kidney until you realize you are visualizing the kidneys from a posterior view so right kidney is on your right side which is opposite of usual radiology convention for imaging with CT or MRI. However, exceptions include anterior imaging that may be preferred for settings of pelvic kidneys such as in renal transplantation or horseshoe kidney.

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What are the 3 phases of imaging obtained during a MAG3 study?

Blood flow, followed by cortical phase, followed by clearance phase. Remember with MAG3 you are looking for function much more than anatomy. These various phases tell you a lot of specific information about the physiologic function of the kidneys.

What is the normal appearance of the kidney during the flow phase of a Tc99m MAG3 study?

Normal renal appearance on a flow phase of a MAG3 study is prompt aortic activity quickly followed within a few frames by renal artery uptake followed by symmetric renal uptake. The flow phase tells you a lot about whether the kidney is adequately perfused and you expect to see prompt, symmetric renal uptake following injection in the flow phase.

If you see asymmetric renal uptake on a MAG3 study in the flow phase what are some of the top differential considerations?

Thrombosis of the renal artery and/or renal vein, chronic obstruction of the kidney with delayed uptake, acute rejection if a transplanted kidney is imaged and shows delayed uptake in the flow phase, acute renal infection. Note that if both kidneys show abnormal delayed uptake in the flow phase this could be related to a weak radiotracer bolus vs entities such as chronic bilateral high-grade renal obstruction.

Remember also that if both kidneys show prompt uptake and one kidney shows asymmetric increased uptake while the other shows normal uptake one differential consideration is renal artery aneurysm.

True or false: Acute tubular necrosis presents with abnormal renal perfusion?

False. This is a key concept. Acute tubular necrosis and interstitial nephritis have normal renal flow. The problem is not with the arterial system of the kidneys. So, these entities will show normal flow on a MAG3 study.

True or false: differential renal function is typically calculated from flow phase data on a MAG3 study?

False. Differential function should typically be calculated based on the cortical phase data, sometimes also termed the parenchymal phase. This is the phase where the kidney is doing its work of secreting and filtering substances from the blood and this is the phase where calculating relative counts between the kidneys—a surrogate of renal function—can provide information about the differential function of the kidneys. To calculate the differential function, you place an ROI around each kidney and have a corresponding ROI for background correction. You want to calculate cortical uptake so ROIs are drawn something like 1 minute after injection so tracer has left the blood into the cortex but is mostly not yet in the renal collecting systems. A well-functioning kidney should have a steep uptake slope in the cortical phase to show it is able to uptake the radiotracer from the blood in a rapid manner.

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Episode 2

For the clearance phase of a MAG3 study, what is the T1/2 as well as the 20/3 and 20/peak ratios?

The clearance phase of a MAG3 study evaluates for renal urinary obstruction by evaluating the ability of urine within the renal collecting system to enter into the bladder. With obstruction along the urinary tract, delayed clearance times will be detected. The 3 metrics mentioned here are all different ways of assessing for adequate clearance of radiotracer from the renal collecting system. The T1/2 is the amount of time it takes for half of the radiotracer to clear from the renal collecting system, with a normal time of approximately less than 10 minutes. The 20/3 ratio assesses the peak count in the renal collecting system at 20 minutes compared to the peak count at 3 minutes. The 20/peak is simply the peak count at 20 minutes divided by the peak count in the renal collecting system at any time which would typically be the count at the beginning of the clearance phase when renal collecting counts are at a maximum. Of these, the most likely to be tested in the T1/2 (the time it takes to clear half of the total counts from the renal collecting system).

Why may Lasix be given as part of renal obstruction evaluation on a MAG3 study?

If the renal collecting system does not empty within normal limits Lasix is then given to help determine whether the delayed clearance is simply due to a dilated renal collecting system that can simply accommodate an excess capacitance of urine (the so-called reservoir effect) versus a true obstruction that prevents the normal emptying of the renal collecting system. Following Lasix, more urine is produced and, if the collecting system is patent, the radiotracer will readily clear from the renal collecting system in a normal emptying time. If the system is obstructed, however, the renal collecting system will fail to empty in a normal timeframe.

What is the T1/2 cutoff in minutes considered to represent significant obstruction?

There are different values out there but in general, a T1/2 of 20 minutes or greater following Lasix administration is consistent with significant obstruction. A T1/2 between 10-20 minutes is considered by some to be indeterminate, by others to represent a mild degree of obstruction from 10-15 minutes, and a moderate degree of obstruction from 15-20 minutes. A T1/2 of under 10 minutes is typically considered normal.

True or false: Renal failure can mimic obstruction on a MAG3 study?

True. Poor renal function can result in insufficient urine production to clear the radiotracer from the renal collecting system in a normal timeframe. Poor renal function can often be detected by abnormal flow, cortical, and clearance phases on a MAG3 study. Note that severe obstruction can also result in poor renal function, so in cases of severe renal dysfunction and corresponding hydronephrosis a MAG3 study may be limited for evaluation of degree of obstruction. Note also that a neurogenic or obstructed bladder (such as with severe benign-prostatic hypertrophy or obstructing mass) can also create sufficient back pressure in the renal collecting system to manifest as renal obstruction on a MAG3 study.

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What is the MAG3 protocol for evaluation of suspected renal artery stenosis?

The key when considering evaluation of suspected renal artery stenosis with MAG3 is that you are going to use an ACE inhibitor, often captopril, as part of the examination. You will first perform a standard study with no ACE inhibitor. You will then repeat the study following administration of an ACE inhibitor. Without getting into the details of the physiology, if you remember that no difference between the two studies means there is no renal artery stenosis that will help you stay on track on multiple choice questions. On the other hand, if you see a worsening of renal clearance in one kidney after administering the ACE inhibitor that is consistent with renal artery stenosis. Renal artery stenosis would be expected to show a unilateral process not a bilateral process. A positive MAG3 exam for renal artery stenosis is asymmetric worsening of renal clearance following administration of an ACE inhibitor. This is a highly tested concept so make sure you understand this.

What are ways to distinguish between acute renal transplant rejection and acute tubular necrosis on a MAG3 study?

A hallmark for acute renal transplant rejection is impaired blood flow whereas acute tubular necrosis has normal renal blood flow. On a MAG3 study in the flow phase you would expect to see delayed perfusion to the transplant kidney in the setting of acute rejection and normal renal perfusion in the setting of acute tubular necrosis. Both entities would be expected to show delayed cortical transit and excretion. Remember that both of these entities can occur in the immediate post-operative period. The classic appearance of ATN is normal renal perfusion followed by retention of radiotracer in the renal cortex as renal function is not sufficient to clear the radiotracer from the renal cortex for excretion.

What are differential considerations for post-operative peri-renal transplant fluid collections?

Differential considerations include post-operative hematoma as well as a urinoma and lymphocele.

True or false: A urinoma typically shows robust activity on MAG3 blood flow imaging?

False. A urinoma typically shows up on more delayed imaging on MAG3, most notably excretory phase imaging, as a peri-transplant kidney fluid collection. If you see tracer uptake on a MAG3 study, the peri-transplant kidney fluid collection is most consistent with a urinoma as the tracer is concentrated through the kidney into the urine.

For these types of questions, the time from surgery at which the fluid collection develops may also be helpful. Post-operative hematomas are typically present in the immediate post-operative state. Urinomas can take a week or so to develop and become clinically evident and lymphoceles can take a month or two to become clinically evident. To help remember this, I think of the rate of fluid accumulation and remember that urine would be expected to accumulate more rapidly than lymphatic fluid. Therefore, a urinoma would be expected to manifest in less time than a lymphocele.

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What is the critical organ of Tc99m DMSA?

The kidney is the critical organ for Tc99m DMSA. Remember that Tc99m DMSA binds to the renal cortex and is used for renal cortical imaging. Basically, the tracer gets to the renal cortex and essentially stays there as opposed to other nuclear renal imaging agents that pass through the kidney into the urine. Therefore, the critical organ for Tc99m DMSA is the kidney and the critical organ for other nuclear renal imaging agents such as Tc99m MAG3 and Tc99m glucoheptonate are the urinary bladder.

What are primary clinical uses for Tc99m DMSA?

Tc99m DMSA is probably most commonly used for pediatric renal cortical imaging in the setting of acute pyelonephritis evaluation. On such a study, look for areas of focal decreased uptake which can be solitary or multifocal to confirm areas of pyelonephritis and/or renal scarring. If the patient has acute symptoms consistent with acute pyelonephritis, imaging findings of focal decreased areas of uptake are consistent with acute pyelonephritis. If the clinical history is that of prior recurrent pyelonephritis, imaging findings are consistent with renal scarring, with renal masses not strictly excluded. If concern for renal masses is present other imaging such as ultrasound or MRI may be necessary.

Additionally, Tc99m DMSA can be used to evaluate for renal mass vs column of Bertin which is a column of normal renal tissue most commonly in the mid-pole of the kidney which is a normal anatomic variant that can look like a mass most notably on renal ultrasound imaging (this is sometimes referred to as a pseudotumor). A column of Bertin, as constituted by functional renal tissue, will show uptake similar to the renal cortical tissue elsewhere whereas a renal mass would be expected to show less uptake or be cold (particularly on a board exam question).