Dynamic Renal Radionuclide Studies

1. Purpose
This guideline must be read in conjunction with the BNMS Generic Guidelines. The purpose of this guideline is to assist specialists in Nuclear Medicine and Radionuclide Radiology in recommending, performing, interpreting and reporting the results of dynamic renal radionuclide studies. This guideline will assist individual departments in the development and formulation of their own local protocols.

2. Background
The use of tracers which are taken up and excreted by the kidney allows the estimation of renal perfusion, divided, drainage and assessment of the lower urinary tract.

\(^{99}\text{Tc}^{m}\text{DTPA}^1\) is cleared by glomerular filtration, and can be used for measurement of GFR.

\(^{99}\text{Tc}^{m}\text{MAG3}\) is the agent of choice in children and patients with impaired renal function. It is cleared by a combination of glomerular filtration and tubular secretion.

\(^{99}\text{Tc}^{m}\text{MDP}\) is used for bone scintigraphy. It is probably also cleared by glomerular filtration, and can be used for renal scintigraphy. If a patient needs both bone and renal imaging, then both studies may be obtained with one dose of activity.

\(^1\)In 1995 the Government agreed to abide by a European directive with the objective of ensuring consistency of the names of medicinal products used throughout the European Union. This Law requires the use of the recommended International Non-propriety Name (rINN) which will therefore replace the British Approved Name (BAN). BNMS propose to gradually introduce this terminology over the next year in all published guidelines. Thus DTPA will be pentetate; MAG3 will become tiatide; and MDP will become medronate.

3. Common Indications
3.1. Assessment of renal perfusion.
3.2. Evaluation of divided renal function.
3.3. Assessment of possible obstruction.
3.4. Assessment of bladder function.
3.5. Post surgical evaluation of a previously obstructed system.
3.6. Evaluation of possible renovascular disease. (see Captopril protocol)*.
3.7. Follow-up of vesico-ureteric reflux by indirect micturating cystogram (MCUG).*
3.8. Assessment of renal transplants.*

*See separate protocols.

4. **Contra-indications:**
4.1. Absolute: None.
4.2. Relative: Recent use of radiographic contrast media.

5. **Procedures**

5.1. **Patient preparation**
5.1.1. The request form should be vetted prior to sending the patient instructions to decide whether diuretic stress or other intervention is required or appropriate. It may also be necessary to make arrangements for bladder catheterization if the patient is known to have bladder outflow problems and there is a question about upper tract obstruction.

5.1.2. The patient should be well hydrated prior to the study. For adults, 300-500 ml of clear fluids should be taken in the hour prior to the study (unless clinically contra-indicated). Very occasionally, intravenous hydration with 10-15 ml/kg of normal saline may be needed.

5.1.3. All medication being taken by the patient should be recorded (especially ACEIs, AII-inhibitors, and NSAIDs).

5.2. **Injection technique.**

In order to obtain good quality images, a good bolus injection is required. This may require prior cannulation. The recommended techniques are the use of the Oldendorff technique or the “double-bubble” technique using an extension tube. For 1st pass studies a good bolus injection is required.

5.3. **Special precautions**

None.

6. **Radiopharmaceutical.**

6.1. $^{99m}$Tc$^m$MAG3 is the most widely used agent. The ARSAC diagnostic reference level is 100 MBq (or 200 MBq if first pass blood flow imaging is being
6.2.  $^{99}\text{Tc}^m$ DTPA is also widely used. The ARSAC diagnostic reference level is 300 MBq (or 800 MBq if first pass blood flow imaging is being performed).

6.3.  $^{99}\text{Tc}^m$ MDP can be used for combined bone and renal scintigraphy. The ARSAC diagnostic reference level of 600 MBq gives excellent renal images.

7.  Image Acquisition

7.1.  Camera

7.1.1.  The camera should be peaked on 140 keV, with a 15% window.

7.2.  Collimator

7.2.1.  Low energy - usually a LEGP or LEHR.

3.  Patient position.

7.3.1.  All images are usually obtained from the posterior.

7.3.2.  The patient should be made comfortable in a supine position.

7.3.3.  If there is a pelvic kidney, this is best assessed with an anterior position of the camera.

7.4.  Views etc.

7.4.1.  The patient should empty their bladder prior to the study, and the time is then recorded in order that flow rate should be calculated.

7.4.2.  The posterior dynamic study is then performed. The field of view should include the bladder.

7.4.3.  An erect posterior image is then acquired for 1 minute to include the kidneys and bladder.

7.4.4.  The patient then empties their bladder, recording the volume passed and the time.

7.4.5.  A repeat erect posterior image is then acquired for 1 minute to include the kidneys and bladder.

7.4.6.  If the patient is catheterised, but the tube is not clamped, images should also be recorded of the catheter bag, even if there is no activity in this.

7.4.7.  A late image may sometimes be helpful.

7.5.  Computer acquisition.

7.5.1.  The images should be recorded to give a final pixel size of about 2mm.

7.5.2.  For most purposes, a 20-second frame rate is adequate. If deconvolution analysis of transit times is being performed, then a 10-second frame rate is required. For first-pass studies, 1 frame/second for 30 or 40
seconds is required.

7.5.3. The normal time for a dynamic study is 20 minutes (minimum 15 minutes). If delayed frusemide (furosemide) is being administered, then at least a further 15-minute study at a 20-second frame rate is required.

7.5.4. If all images are acquired at the same zoom, matrix size, and frame time, then comparison of images from different stages of the study is simplified.

### 7.6. Interventions.

7.6.1. Diuretic.

7.6.1.1 If it is known from the request form that there is a clinical suspicion of obstruction, then a maximum diuretic response is obtained by the administration of frusemide 0.5mg/kg (or 40 mg for an adult) intravenously 15 minutes before the start of the study ("F-15"). If venous access is difficult, there is some evidence to suggest that Frusemide (furosemide) given immediately before the tracer through the same cannula ("F+0") is almost as effective.

7.6.1.2 If the first part of the study shows possible obstruction (as assessed from the P-scope/computer or from “real-time” curves if available), then frusemide(furosemide) may be given at the end of the first part of the study ("F+20"). However, particularly if $^{99}$Tc$^{m}$ MAG3 is being used and the patient has good renal function, there may be little activity left to demonstrate the response.

7.6.1.3 In any case, it is essential to document the response to the diuretic by showing an adequate diuresis rate. If this is less than 10ml/min, the kidney cannot be considered to have been stressed, and consideration should be given to repeating the study.

7.6.2. ACE-Inhibitor

This protocol does not cover the use of ACEI-stress studies.

### 8. Data Analysis

8.1. Regions of interest should be drawn over the kidneys to include the renal pelvis; background areas (defined as a perirenal area around the whole kidney, taking care not to cut across the renal pelvis); and the bladder on the pre- and post-micturition images.

8.2. Background-corrected activity-time curves should be derived from each kidney. The divided function may be most simply obtained from the integral
of these curves, starting not before 60 seconds and ending before 2 min 30 secs. A more reproducible and robust divided function may be obtained from a Rutland-Patlak plot, particularly if $^{99}$Tcm DTPA is used. The output efficiency is a useful method of quantitating renal clearance in possible obstruction.

8.3. The patient’s urine output rate is obtained from the time and volume of urine passed (see i, iv, and vii under views above).

8.4. The residual volume may be estimated from the pre- and post-micturition images and a knowledge of the urine volume passed.

8.5. Hard Copy /Printout.

8.5.1 This must be labelled with the patient’s name; number; date of study; pharmaceutical; whether diuretic was given, and if so the time; diuresis rate. Images must be labelled with the side (L/R) clearly identified.

8.5.2 Images should be generated from 0-30 or 0-40 seconds (to show summed perfusion); at about 2-3 minutes (to show parenchymal uptake pattern); then at intervals to show the different phases of the study. If supplementary frusemide has been given, images at the start and end of this phase should also be recorded. The images from 2 minutes onwards should be displayed on an absolute grey scale to allow visual assessment of parenchymal clearance. The pre- and post-micturition images should also be recorded.

8.5.3 Curves should be recorded and labelled so that there is clear indication of which curve corresponds to which kidney. The ROIs from which they are produced should also be recorded.

8.5.4 The divided function must, and the method of its calculation should, be recorded.

8.5.5 If the output efficiency has been calculated, the curves and output should be recorded.

8.5.6 To allow comparison between studies, it is helpful to display the curves either as a percentage of the injected dose, or normalised to a standard activity and patient size.

9. Interpretation and report:

9.1. The aorta and the relative perfusion of the kidneys may be assessed from the summed first pass image.

9.2. The relative perfusion of the kidneys may be assessed from the ratio of the up-slopes of the first-pass curves.

9.3. The pattern of parenchymal uptake at two minutes is a good indicator of morphology, size, and possible gross scarring.
9.4. The parenchymal clearance is assessed from serial images, provided that there is an adequate diuresis rate.

9.5. Possible obstruction is assessed from the diuretic response provided there is an adequate urine output rate.

9.6. The effect of gravity and bladder emptying is assessed by comparison of the final supine image with the erect images pre- and post-micturition.

9.7. The adequacy of bladder emptying is assessed from the erect images pre- and post-micturition, together with the calculated residual bladder volume.

10. Pitfalls

10.1. Inadequate hydration.

10.2. Extravasation and/or poor bolus.

10.3. Vasovagal attack or hypotension of other cause - often NOT appreciated clinically.

10.4. NSAID's e.g. Diclofenac (ref. 6).

10.5. Back pressure from overfilled bladder.

10.6. $^{99}$Tc$^{m}$ MAG3 cannot separate ATN from obstruction in acute renal failure, whereas $^{99}$Tc$^{m}$ DTPA gives very different appearances.

11. Controversies

11.1. Definition of obstruction.

11.2. Timing of diuretic administration

11.3. Value of deconvolution analysis

11.4. Attempts to measure total renal function from the gamma camera study

12. References


10. Date Agreed/Approved
April 2001

11. Date for Review/Update
April 2005

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These guidelines do not constitute a formal protocol but highlight the aspects of a study where variation in practice may significantly affect the quality of outcome of the study.