A symptomatic unilateral renal pelvic dilatation (UPD) is a common condition challenging paediatric surgeon or the clinician. There has been a shift to more expectant management during the last decade as natural history studies revealed stable kidney function based on dynamic renography. Dynamic renography is a simple method providing both assessments of renal uptake and drainage functions, yet its value in assessment in renal drainage function in infants and children has become less popular. This is related to the results from natural history studies on antenatal hydronephrosis and to the lack of standards in defining impaired drainage. Accurate assessment of renal uptake / differential renal function (DRF) using dynamic renography has become a critical cornerstone in clinical decision making of infants with UPD. In this commentary, the authors attempt to provoke a critical perspective on DRF measurement in infants with urinary pelvic dilatation.

**What is the clinical impact of DRF in infants with UPD?**

The natural history of prenatal UPD is now better understood following randomized studies comparing non-operative with operative management. Prenatal UPD is a relatively benign condition and may not necessary indicate obstruction but may either spontaneously improve or remain unchanged with time and only a small proportion require surgical intervention. All clinicians are totally dependent on scintigraphy and ultrasonography on deciding which infants can be managed safely without surgery. Surgery is generally reserved for those kidneys with poor renal function at initial presentation or decreasing DRF in the follow-up and progressive hydronephrosis on ultrasound. Ulman et al suggested non-operative management with close follow-up combining scintigraphy and ultrasonography during the first 2 years of life even in those with high grade hydronephrosis. In a retrospective analysis, our group has also noted stable DRF, improvement of pelvic dilatation and drainage in both surgically and non-surgically managed children. It is now well-documented that if
the renal function and dilatation is stable during the follow-up, then the kidney is stated to be in equilibrium and therefore surgery is unnecessary.

An empirical approach has been adopted by many clinicians that a decrease > 5% or 10% of DRF between the repeated studies is an indication for surgery, a crucial assumption is that the opposite kidney is normal.

Thus it is essential for practitioners of radiology and nuclear medicine to provide reproducible DRF on sequential dynamic renal scintigraphy.

**DRF is an easy concept; the devil is in the detail. What are the crucial aspects to providing reliable and reproducible results?**

DRF is simply the ability of the kidney to extract the tracer from the blood, measured before any tracer leaves the kidney i.e. in the period between 40/60 to 120 seconds after peak arterial activity of the injected tracer. It represents the relative contribution of each kidney to the overall renal function.

The consensus document of the Scientific Committee of Radionuclides in Nephrology and Guidelines for standard and diuretic renography prepared by paediatric committee of EANM have been the main publications to improve quality of dynamic renography in daily practice. Critical aspects of processing of the dynamic renogram are, the tracer used, kidney and background ROIs and processing of these curves.

Renal function in the infant is immature so the younger the infant the worse the signal-to-noise ratio. This will cause additional inaccuracies especially in the poorly functioning kidney.

The tracer should have a high extraction fraction, so Tc 99m MAG3 or EC are preferred. These tracers also remain in the blood pool as their biodistribution is mainly intravascular. Comprehensive work by Lythgoe et al investigated the effect of many variables of renography and showed renal ROI could be rectangular or irregular, what was essential was that the ROI did not cut the kidney. Looking at different background ROIs, this work found similar results if the global renal function is good but justified the use of peri-renal background subtraction when the kidney function is poor, this is in keeping with the recommendations referred to above. However, great attention is essential to correctly place both the kidney and background ROIs in the very young baby with a huge kidney extending to the body outlines; in that case a ROI below or above the kidney can be selected. Very careful scrutiny of the resultant curves are essential (see below) as no reliable or reproducible DRF may be obtained, the same is true in very poorly functioning kidneys when the signal to noise ratio is very low.

Analysis of the background subtracted curves should be done after complete mixing of the tracer (40/60 seconds) and before any tracer leaves the kidney (+/- 120 seconds) using either the area under the curve (AUC) or Patlak-Rutland analyses as suggested by both reference methods. Piepsz et al have also obtained reproducible measurements using integral method with perirenal background correction and the Patlak-Rutland plot in patients with normal or moderately impaired overall renal function. DRFs obtained from AUC and Rutland-Patlak methods have found to be within 5% of each other in majority of children with UPD. The younger the child, the greater difference between AUC and Patlak-Rutland methods may be noted. One easy quality control technique is to compare the DRF result obtained from both methods, when the techniques show a DRF > 5% of each other, the ROIs as well as the curves need to be studied. Most frequently the cause for the discrepancy is noisy curves due to poor signal to noise ratio. Changing the ROIs and the time period of the analysis may be helpful, but even this careful reanalysis may not result in a reproducible DRF. Most hospitals use a variety of renal software packages as provided by the gamma camera manufactures, so the results obtained in daily practice may vary from one center to another. In order to raise standards of renogram analysis, substantial efforts by experts in this area are ongoing and their reports are essential resources for nuclear medicine physicians to provide good quality results. Ongoing work by IAEA may
provide software that will run on a PC and allow standardisation of processing of renography.

What range of DRF is normal? Does a normal DRF indicate a normal kidney?

When the overall renal function is good, a DRF value between 45-55 % is accepted as normal. However, in the presence of renal failure or bilateral renal damage a DRF between 45-55% does not reflect a normal kidney.9

A mild abnormal parenchymal appearance, even in the presence of good DRF has been noted. Using quantitative SPECT with Tc-99m DMSA, without loss of individual renal function, Groshar et al documented decreased percentage of injected dose per milliliter of renal tissue in infants with hydrenephrosis.10 In a work focusing on the clearance of Tc-99m MAG3 images, our group has found regional parenchymal defects in majority of kidneys with pelvic dilatation. This is thought to be related to the stretching of the renal parenchyma around the dilated calices and pelvis which were improving with time.11 Although obtained in a pig model and with a different tracer, Dissing et al have recently showed intra-renal changes of Tc-99m DMSA biodistribution despite the normal DRF and improving hydronephrosis following relief of partial ureteric obstruction.12 It appears that further research is required for the evaluation of regional functional changes related to the hydronephrosis even in the absence of global alterations.

What does supranormal DRF mean?

The hydronephrotic kidney may occasionally have a higher DRF than the contralateral side which is defined as supranormal DRF (> 55 %). Whether this situation represents a fact of physiologic hyperfiltration or technical origin is still under debate.13-20 This debate also leads to controversy about how to manage this group children. Supranormal DRF function could be technical in origin. Factors such as asymmetric kidney size, large renal ROI size, improper background selection, the large kidney volume in a very young baby and the use of AUC method may lead to overestimation of DRF in the hydronephrotic kidney.7 Comparing MAG3 DRF with Cr-51 EDTA single kidney GFR, Meenhout A et al reported that supranormal DRF of the affected kidney might be related to the borderline hypofunctioning contralateral kidney.20

In conclusion, DRF is a critical parameter in clinical management of children with prenatal hydronephrosis however it is not without pitfalls. The nuclear medicine physician should, on rare occasions, be sufficiently convinced that no exact number can be given due usually to a very large kidney in a young infant. Every department should ensure that the results from dynamic renography are reliable and reproducible both with different operators and on different days so that the clinicians have confidence in the % DRF they receive. Integration of all clinical information with imaging findings obtained from standardized protocols is essential for reporting physicians.

REFERENCES


