GUIDELINES ON ^{99m}Tc-DMSA SCINTIGRAPHY IN CHILDREN

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I Purpose

The purpose of this guideline is to offer to the nuclear medicine team a framework that could prove helpful in daily practice. This guideline contains information related to the acquisition, processing, interpretation and indications for ^{99m} Tc-DMSA scintigraphy in children[(1,2)].
This guideline summarizes the views of the Paediatric Committee of the European Association of Nuclear Medicine. It should be taken in the context of "good practice" of nuclear medicine and local regulation.

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II Background Information and Definition

The main reason for performing DMSA scintigraphy is the detection of cortical abnormalities related to urinary tract infection. Compared to ultrasound and intravenous urography, the sensitivity is high, in both acute and chronic pyelonephritis [(3-6)]. Lesions are non-specific, since similar lesions can be found in renal abscess, cyst, duplex kidney, and hydronephrosis: the combination of ultrasound and DMSA scintigraphy allows a better differentiation between these clinical situations. In case of noteworthy dilatation of the upper urinary tract, tracer may accumulate into the renal cavities causing difficulties in the interpretation of the cortical images. Experimental studies in animals have validated DMSA scintigraphy as an accurate technique for the detection of both acute infection and chronic lesions, also in comparison to newer imaging modalities [(7-12)]. Although contradictory data have been published, reproducibility in reporting on DMSA images is excellent if the question is limited to normality or abnormality of the kidney. DMSA scintigraphy is nowadays recommended as the technique of choice for evaluation of renal sequelae; 6 months seem to be an acceptable delay after acute infection in order to be able to consider the DMSA abnormalities as permanent sequelae. The situation is less clear in the case of acute pyelonephritis (the so-called "acute" DMSA). Those in favor of using DMSA in the acute phase, argue that clinical and biological evidence constitute imperfect evidence for acute pyelonephritis; moreover, acute DMSA might help defining the group at risk to develop renal sequelae [(13)]. Other investigators suggest that acute renal scintigraphy is not necessary, because only stable damage matters for clincal decision making[(14)]. The consensus meeting in Copenhagen has shown that only 50 % of the nuclear medicine experts consulted considered that "acute" DMSA was mandatory in their hospital. It was nevertheless recently reported that after a normal result of an "acute" DMSA scan micturating cystourethrography (MCU) is unnecessary[(15)].

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III Common Indications

Indications

Detection of focal renal parenchymal abnormalities

Detection of renal sequelae, 6 months after acute infection

Detection of acute pyelonephritis.

Detection of associated abnormalities: abnormal duplex kidney, small kidney, dysplastic tissue, horseshoe kidney

Detection of ectopic kidney.

Confirmation of non-functional multicystic kidney.

Contra indications

There are no contra indications.

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IV Procedure

A. Information about Previous Examinations relevant to this Procedure

The clinical history, ultrasound data and previous radionuclide imaging should be reviewed. Information related to the structural renal abnormalities (hydronephrosis, duplex kidney, ectopic kidney, expansive lesions) may be of help in deciding on additional views and the need for attenuation correction and the appropriate time for imaging (see C. Precautions).

B. Patient Preparation

B.1 Information with appointment letter

Before arriving at the department, the parents and the child should receive written information about the procedure itself and especially the waiting time between injection and imaging acquisition, as well as the probable duration of the scan.

B.2 Prior to injection

Anaesthetic cream:	is optional; if used, it should be applied at least 60 minutes before the injection.
Hydration:	We recommend a slightly elevated diuresis in order to reduce the pelvic retention of activity.
Sedation:	Drug sedation is only rarely needed for DMSA scintigraphy, whatever the age of the patient. An adapted environment, an adequate attitude toward the child, a well-trained technologist for paediatric procedures and involved parents before and during the procedure generally provide effective circumstances to assist in obtaining adequate immobilization of the child during the acquisition[16-17]. The most difficult age is between 1 and 3 years: in this category of patients, sedation may be required, but in less than 5% of the cases [2]. The safest drug is then obviously intranasal or per-rectal midazolam, which will help reduce extreme anxiety [18-19]. If sedation is used, it must follow local hospital guidelines.

C. Precautions

If significant hydronephrosis exists late images (4 to 24 hr) or furosemide injection may then be useful. In these cases it should be considered to perform instead a dynamic renal scan with MAG3.

Tubular defects such as the Fanconi syndrome or nephronophtisis may result in poor renal visualization (defective binding of the isotope within the tubular cell and urinary excretion).

D. Radiopharmaceutical

D.1 Radionuclide

Technetium-99m (^{99m}Tc)

D.2 Pharmaceutical

DMSA (Dimercaptosuccinic acid).

Although several tracers are available for cortical imaging, the most appropriate tracer for that purpose is ^{99m}Tc-DMSA. The tracer is taken up by the tubular cells of the pars recta, directly from the peritubular vessels[20].

Dynamic tracers with high excretion rate, such as ^{99m}Tc-MAG3 or ^{99m}Tc-EC, give less accurate information on regional cortical abnormalities and constitute only a second choice tracer (see guideline on "Standard and diuretic renogram").

D.3 Dose Schedule

Minimal activity: 15 MBq

Administered activity should be scaled according to recently published dose card in Eur J Nucl Med Mol Imaging [21]. This new card is based upon the publication by Jacobs et al [22]. National regulations may indicate different reference activities; it is suggested to scale the administered activity according to the lower one.

D.4 Injection Technique

A fine Butterfly needle (gauge 23-25 according to child's age) is recommended.

D.5 Radiation Burden

This is approximately 1mSv / examination regardless of the age of the child, providing that the dose is adapted according to body surface [23-25]

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E. Image Acquisition

E.1 Timing for imaging

Images should be acquired 2 to 3 hours after tracer injection.
Late images are sometimes useful (see C. Precautions).

E.2 Collimator

High, ultra-high resolution or pinhole collimator is required.

E.3 Position of detector

Position camera with the collimator facing up.

E.4 Positioning of the child

Supine position, which will minimize renal depth difference and assist in keeping movement to a minimum. To reduce movement, support the child with either sandbags and Velcro straps on either side of the child or place the child in a vacuum cushion. When possible, the child should lie directly on the collimator surface.

E.5 Views

Posterior and posterior oblique views are recommended; an additional anterior view should be performed in case of horseshoe kidney or ectopic pelvic kidney.

E.6 Computer acquisition set up

At least 300.000 counts per image should be collected or use preset time around 5 minutes. For pinhole views, collect between 100.000 and 150.000 counts or use a preset time around 10 minutes.

Matrix:	Use at least a 128 x 128 matrix.
Zoom:	A zoom for acquisition is recommended for paediatric studies, varying between 1 to 2 as function of body size. This may require a longer acquisition time. An optional additional approach could be to acquire the data in dynamic mode over a given preset time and reframe to a single image, after correcting for movement and ıf possıble dıscardıng blurred frames. The matrix and minimal counts acquired must be the same as above.

E.7 SPECT

This guideline is devoted to planar images. There is at the present time no consensus about the usefulness of SPECT for DMSA scintigraphy in children[(2)].

When performing SPECT, attention must be paid to the risk of false positive images [(26-29)] and to the necessity of heavy sedation in young children. Some institutions also increase considerably the amount of radioactivity given and so increase the radiation burden. There is no clinical or experimental data to justify this increase.

F. Interventions

Furosemide injection may be useful (see C. Precautions).

G. Processing

Whenever DMSA is used, differential renal function should be calculated.

We recommend:

- to draw large regions of interest around the kidney, using highly contrasted images.
- to introduce a correction for background by subtracting from the renal area activity close to the kidney. In case of renal failure, this correction method is inaccurate.
- correction for attenuation is not mandatory for relative function [(30)], except in case of ectopic kidney anteriorly displaced. In this last case, two methods can be used: either the acquisition in lateral view, with a marker on the posterior skin, or the geometric mean using the anterior and the posterior view. In case of pelvic kidney, the relative function remains inaccurate even after attenuation correction, because of the additional attenuation due to pelvic bone.

H. Hard Copy Output

A gray scale should be used rather than color images.

The intensity of the image should be adapted in order to allow to differentiate the outer part of the kidney (cortex) more active than the inner part (medulla, calyces, vascular structures).

Reporting is preferably done directly on the computer screen but hard copies can be used.

I. Interpretation / Reporting / Pitfalls

I.1 Relative uptake

Usual normal values are between 45 and 55 % uptake [2, 31]. Values outside this range may be seen when there is an uncomplicated unilateral duplex kidney [31]
Values within the normal range may be seen with bilateral small kidneys.
Pelvic retention, in case of hydronephrosis, may cause falsely high differential function.

I.2 Images - Normal variants

DMSA scans are not performed in normal children; however the consensus of experts has considered the following features as normal:

The contours of the kidney are generally round-shaped; there is a contrast between the active outer part and the less active inner part.

A contour can be flat without suggesting a lesion.

The lateral aspect of the superior half of the left kidney can be flattened due to the presence of the spleen.

In young children, it is not exceptional that the kidney appears normally as a triangular shaped kidney, with flattened external sides.

A "slender" kidney, characterized by a short transverse axis in the posterior view, is generally normal and corresponds to a rotated kidney.

The transverse axis can be sometimes shorter at one pole (upper or lower) than on the other, giving an aspect sometimes defined as "pear shaped".

The pole, and particularly the upper pole, can appear as a pathological hypoactive one, simply because of the contrast with the hyperactive columns of Bertin underlying the pole.

The number and size of the columns of Bertin differ from patient to patient (variable thickness of the cortical rim) and may cause false interpretation of the image.

Attention should be paid to the presence of fetal lobulation. This may be difficult to distinguish from a scar without the help of other imaging modalities.

I.3 Images - Abnormal patterns

The number, size and location of areas of cortical loss should be noted. Deformation of the contours may or may not be present.

Differentiation between acute lesions that will improve or disappear and chronic lesions (sequelae) is not always possible.

A large polar hypoactive area, without deformity of the outlines and with indistinct margins will generally heal; marked localized deformity of the outlines or deformed outlines (volume loss) generally correspond to permanent sequelae.

Renal sequelae should anyway best be estimated on a DMSA scintigraphy performed at least 6 months after acute infection.

J. Quality Control

It is important to check for kidney movement prior to the child leaving the department: blurred or double outlines generally reflect the presence of movement. Internal architecture should be visualized (see H: Hard copy output).

Air introduced into the reaction vial can degrade the DMSA complex, resulting in decreased renal uptake and increased hepatic and background activity

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V Issues requiring further clarification

1. Systematic studies on pinhole views: pitfalls and contribution.
2. Validation of a classification system of DMSA abnormalities: prospective evaluation of the prognostic value of various scintigraphic patterns.
3. Clinical usefulness of "acute" DMSA and clinical impact of this examination in the further strategy of management and treatment.
4. Clinical significance, on a long term follow up, of various types of scintigraphic sequelae (renal function, blood pressure).

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