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Diffusion-weighted magnetic resonance imaging is more sensitive than dimercaptosuccinic acid scintigraphy in detecting parenchymal lesions in children with acute pyelonephritis: A prospective study

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Summary

Introduction
Static renal scintigraphy is the gold standard for detection of inflammatory changes in the renal parenchyma in acute pyelonephritis. Our aim was to determine whether diffusion-weighted magnetic resonance imaging (DW-MRI) was comparable with static renal scintigraphy (DMSA-SRS) to demonstrate acute renal parenchymal lesions.

Objective
To compare ^{99m}Tc-dimercaptosuccinic acid static renal scintigraphy (DMSA-SRS) with diffusion-weighted magnetic resonance imaging (DW-MRI) for detecting acute inflammatory changes in the renal parenchyma in children with febrile urinary tract infection.

Methods
Thirty-one children (30 girls) aged 3–18 years with a first episode of febrile UTI without a previously detected congenital malformation of the urinary tract, were prospectively included. DMSA-SRS and DW-MRI were performed within 5 days of diagnosis to detect renal inflammatory lesions. The DW-MRI examination was performed without contrast agent and without general anesthesia. Late examinations were performed after 6 months using both methods to detect late lesions.

Results
DW-MRI confirmed acute inflammatory changes of the renal parenchyma in all 31 patients (100%), mostly unilateral. DMSA-SRS detected inflammatory lesions in 22 children (71%; $p = 0.002$). The lesions were multiple in 26/31 children (84%) on DW-MRI and in 9/22 (40%) on DMSA-SRS. At the control examination, scarring of the renal parenchyma was found equally by DW-MRI and DMSA-SRS in five patients (16%), three of whom were the same patients. The overall concordance of positive and negative late findings occurred in 87% of patients. There was correspondence in the anatomical location of acute and late lesions.

Discussion
The clinical significance of acute and late parenchymal findings on DWI-MR is yet to be determined. A limitation of our study is the age of the patients (older than 3 years) who are less sensitive to scar development; therefore, a smaller number of patients with scars could be analyzed during control examination. Further studies using the DW-MRI should confirm its reliability to detect acute and late lesions in younger children and infants and determine the clinical consequences.

Conclusion
DW-MRI has higher sensitivity for detecting acute renal inflammatory lesions and multifocal lesions than DMSA-SRS. The incidence of scars was low and corresponded with the anatomical location of acute and late lesions.

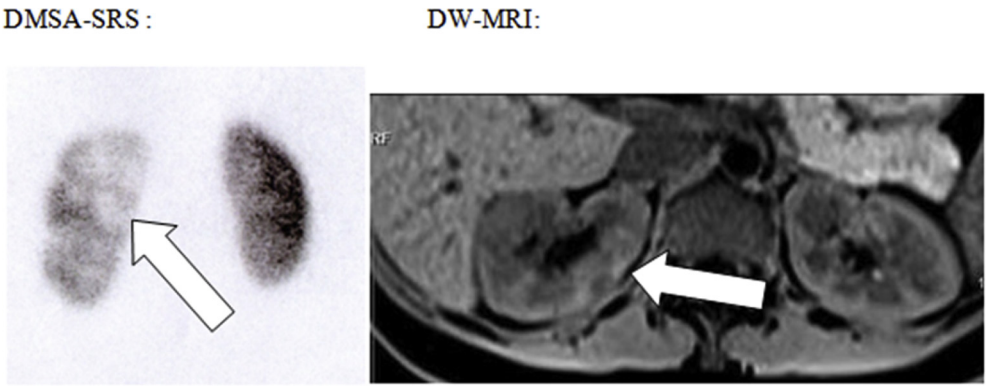

Fig Acute inflammatory changes in the right kidney on DMSA-SRS (A) and DW-MRI (B) in our study.

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Introduction

Febrile urinary tract infection is defined by both clinical and laboratory characteristics: fever above 38 °C, elevated inflammatory parameters (C-reactive protein, white blood cell count), elevated leukocyte count in urine and positive urine culture ($\geq 10^5$ colonies/mL in reliably collected urine). Unlike adults, infants and young children may have non-specific clinical signs such as poor appetite, failure to thrive, lethargy, irritability, vomiting, or diarrhea [1]. Children and adolescents may have differing symptoms according to age: fever, flank and back pain, fatigue, sleepiness, loss of appetite, sick-looking appearance. Early ^{99m}Tc dimercaptosuccinic acid (DMSA) static renal scintigraphy (SRS) was introduced in attempts to diagnose pyelonephritis and parenchymal damage. This highlights acute inflammatory defects (photon cortical defects of radionuclide uptake), which are detected in 50—91% of patients with acute pyelonephritis [2,3]. DMSA-SRS scans were found to be more sensitive than ultrasound and have been accepted as a gold standard method for demonstrating acute renal parenchymal inflammatory lesions in the diagnosis of febrile urinary tract infections (UTI) [4,5]. The higher sensitivity found in an animal model for DMSA and MRI with gadolinium may be related to the use of artificially induced pyelonephritis in standard conditions, which does, however, show a similar and predictable clinical response to a group of children with a different type and course of pyelonephritis [4,5]. The mean effective dose per administered activity may be around 1 mSv on DMSA-SRS [6]. Gadolinium-enhanced MRI has been found to be reliable in detection of acute pyelonephritic lesions in comparison with DMSA-SRS, and can discriminate acute pyelonephritis and chronic scarring [7,8].

Diffusion-weighted magnetic resonance imaging (DW-MRI) was described in 1985, reflecting differences in the rate of molecular diffusion between tissues. In some pathological conditions, this diffusion pattern is disturbed and the amount of diffusion changes in the affected area [9]. This imaging method does not require gadolinium administration. In 2004, the DW-MRI modality was preliminarily introduced to differentiate normal renal parenchyma and different renal diseases (hydronephrosis, pyonephrosis, simple renal cysts, benign and malignant tumors) [10]. Recently, it has been used to diagnose acute inflammatory lesions in the renal parenchyma, providing results comparable with gadolinium-enhanced MRI, and achieving higher sensitivity than non-contrast or contrast-enhanced CT [11—14].

The primary objective of the current prospective study was to compare the DW-MRI modality with the ^{99m}Tc DMSA scintigraphy in diagnosis of acute pyelonephritis in children. An age limit of over 3 years was used to avoid general anesthesia or sedation. The secondary objective was to detect scars after 6 months and their relationship with the acute lesions. To our best knowledge, a comparison between native DW-MRI and DMSA-SRS to identify acute inflammatory changes in the renal parenchyma has not yet been published.

Patients and methods

All patients older than 3 years of age who were hospitalized at our department with a first episode of febrile UTI and without previous detection of any congenital malformation of the urinary tract from 2011 to 2015 were included. Although patients with febrile UTIs in our community are not routinely hospitalized, it is possible that the patients in our cohort were more sick than customary.

In total, 31 children (30 girls and one boy) aged 3—18 years (median 11.0) were included. Patients who were younger than 3 years of age and patients who did not pass both examinations during the acute phase were excluded from the study. For this pilot study, we selected children older than 3 years because they do not require general anesthesia and sedation during the DW-MRI examination, and urine collection is more reliable in patients who are toilet-trained.

The study was prospectively designed with a prospectively followed protocol. ^{99m}Tc DMSA static renal scintigraphy and MRI with native DWI plus T1- and T2-weighted imaging were performed during the first 5 days following the diagnosis of acute pyelonephritis; the DMSA-SRS scan was performed first and the DW-MRI on the following day. Native DW-MRI means DW-MRI without contrast medium, that is without use of gadolinium.

All children responded well to antibiotic therapy by resolution of fever and pain and normalization of urine findings. None of the children had any complications during therapy. Follow-up DMSA-SRS and DW-MRI (the same protocol as for the acute phase) were performed in all children 6 months later to detect any scarring (persistent late lesions) of the renal parenchyma.

The study was approved by the university ethics committee. Parents of all patients signed informed consent for the study, which was documented in the medical records of the child.

Static renal scintigraphy with 99Tc-DMSA (DMSA-SRS)

An examination was performed after administering ^{99m}Tc-labeled DMSA. The minimal activity of the radiopharmaceutical was 18.55 MBq, and the dose was weight-adjusted according to a recommendation by the European Association of Nuclear Medicine [15].

Two hours after radiopharmaceutical administration, static scintigraphy acquisition was performed. We used a dual-headed tomographic gamma camera (E.CAM, Siemens Medical Solutions, USA) equipped with low-energy high-resolution collimators.

Neither anesthesia nor sedation was needed during the DMSA-SRS examination.

The patient was positioned in a supine position; planar scans in the anterior, posterior and both oblique posterior views, each of 5 min duration, were obtained. In the early scan (i.e. acute phase of pyelonephritis) any defect or globally diminished uptake of the RF in the renal region was determined as a positive finding (Fig. 1). During the follow-

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