

## High resolution UTE-MR imaging in lung disease in children and young adults

Karl-Heinz Herrmann<sup>1</sup>, Martin Krämer<sup>1</sup>, Martin Stenzel<sup>2</sup>, Hans-Joachim Mentzel<sup>2</sup>, and Jürgen R Reichenbach<sup>1</sup>

<sup>1</sup>Medical Physics Group, Institute of Diagnostic and Interventional Radiology I, Jena University Hospital - Friedrich Schiller University Jena, Jena, Germany,

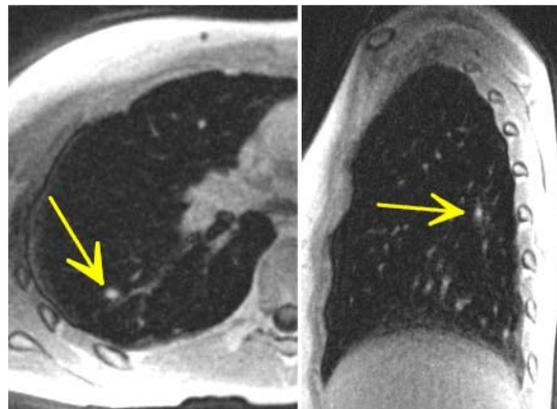
<sup>2</sup>Pediatric Radiology, Institute of Diagnostic and Interventional Radiology I, Jena University Hospital - Friedrich Schiller University Jena, Jena, Germany

**Target Audience** – Clinicians interested in a new measurement modality for lung imaging; Scientists interested in UTE applications;

**Purpose** – In pediatrics clinicians and radiologists often would like to avoid invasive and ionizing radiation modalities, especially since many severe illnesses in childhood require frequent monitoring during disease or treatment progression. MRI is therefore very popular but can not replace CT in areas, where standard MR sequences fail to deliver diagnostic image quality. Concerning lung imaging there are two common types of disease groups for which CT is currently the only imaging option. During treatment of oncologic diseases, children often are immune suppressed which makes the lung prone to opportunistic, fungal infections, which need to be diagnosed as early as possible. Since infectious foci can be very small it is crucial to detect these lesions that are on the order of 2-3 mm in size. Other diseases that need to be diagnosed are interstitial lung diseases and postinfectious states. Ground glass opacities, which can be detected with CT, indicate circumscribed subtle edema and may help in making the correct diagnosis. *Ultra short echo time* (UTE) MR imaging has been successfully employed in the lung [1,2]. The short echo times make it possible to image even tissue with very fast T2 and T2\* relaxation rates while 3D radial trajectories make the sequence quite robust against motion. Here we evaluate a 3D radial center out UTE implementation for imaging the lung.

**Methods** – MRI scan of patient 1 was performed on a 3T scanner, the scans of patient 2 and 3 were performed on a 1.5T scanner (TIM Trio and Avanto, Siemens Healthcare, Erlangen) using the standard spine and body array coils in CP mode. The acquisition was performed with a spoiled gradient echo, 3D radial center-out UTE sequence [3] with a short template scan (~5s) to estimate gradient delays. Readout oversampling of factor 2 was applied. Reconstruction was performed by delay compensated 3D gridding [4], taking the readout oversampling into account to suppress fold over artifacts. Due to the different age, body size, cooperation and prior anamnesis of the patients as well as the available scan time, scan parameters were adjusted individually, thus flexibly trading off image quality and scan time (see figures for details). All data were acquired shortly after administration of 0.1 ml/kg body weight of Gadobutrol (Gd-DO3A-butrol). The examinations were acquired under free breathing conditions and no triggering or gating was employed.

**Results** – Figure 1 shows patient 1 (age 22, female) with a small focal lesion (4 x 2.5 mm) in agreement with the diagnosis of a fungal infection. The lesion is clearly delineated and separable from blood vessels. In a follow up examination 7 weeks later, after posaconazole treatment, the lesion was no longer detectable (not shown). Figure 2 shows an UTE image of patient 2 (age 13, female) with diffuse, ground glass opacity, indicating localized edema. The lesion is well delineated and the extent and size can be determined accurately. Figure 3 shows the UTE images in different orientations of a fully awake 7 year old female child who suffers from persistent consolidation after childhood pneumonia and who was agitated during the scan. Still the consolidation (arrows) is clearly visible. A follow-up ultra-sound examination was unable to detect the pathology due to its unfavorable location within the lung.



**Fig. 1:** Patient 1, diagnosed with a relapse of an acute myeloid leukemia, showing a small (4x2.5mm) focal fungal lesion (arrows). Scan parameters were 3T, TE/TR/FA/dwell time =65  $\mu$ s/3.3 ms/10°/ 1.75  $\mu$ s, voxel size 0.7 mm, number of spokes 154992, TA=8.6 min.



**Fig. 2:** Patient 2, diagnosed with an acute myeloid leukemia, 71 days after hematopoietic stem cell transplantation. The arrow marks ground glass opacity as a sign of local edema, indicating virus infections or interstitial lung diseases. Scan parameters were 1.5 T, TE/TR/ $\alpha$ /dwell=70 $\mu$ s/3.5 ms/10°/1.56  $\mu$ s, voxel size 0.7 mm, number of spokes 116276, TA=6.8 min.

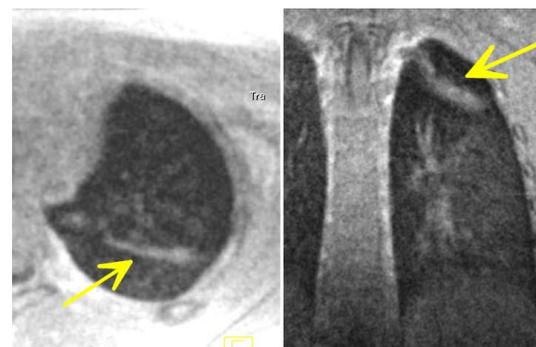
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**Discussion** – The three cases shown here illustrate the potential of UTE sequences for lung imaging in patients with different pathologies. The highly sampled images of patient 1 (Fig. 1) profit from the improved SNR at 3T and provide excellent resolution. However, 3T is not a requirement as demonstrated with patient 2. With nominally the same resolution and even slightly smaller number of spokes the ground glass opacity can still be clearly distinguished from the healthy lung tissue. While patient motion causes some image blur, as seen in patient 3, there are no MR typical motion artifacts due to the highly sampled 3D radial trajectories, and respiratory as well as cardiac motion is “averaged out”. The applied spoiled gradient echo FLASH technique provides T1-weighted contrast for anatomical and contrast agent enhancing lesions. Further advantages of the 3D radial acquisition are the effective oversampling in all directions, so fold-over artifacts are of no concern. Furthermore, the isotropic data sets allow full 3D reslicing, cross sectional imaging and volumetry. In addition, image quality and exam time can be traded off very flexibly by adjusting the radial over-/undersampling factor, thereby making it easy to adjust the UTE scan to the actual patient situation.

**Conclusion** – Traditionally, computed tomography is the imaging modality of first preference for detecting small focal parenchymal lesions and interstitial pulmonary disease. 3D UTE shows high spatial resolution and excellent contrast enabling detection of even subtle anomalies. Especially in chronic disease, repeated examinations are required to detect

complications of treatment, such as opportunistic lung infection, and to monitor disease progression. To summarize, UTE is a very promising sequence technique for assessment of pediatric and young adult patients in whom the ionizing radiation of computed tomography should be avoided.

**References:** [1] Strobel K et al., MRM 2012; [2] Nagle S et al., Proc. Intl. Soc. MRM. (2012), #1343; [3] Grodzki DM et al, MRM 2012; [4] Zwart NR et al., MRM, 2012;



**Fig. 3:** Patient 3 suffering from persistent consolidation after childhood mycoplasma pneumonia. The consolidation of the left upper lung lobe is clearly delineated (arrows). Scan parameters were 1.5 T, TE/TR/ $\alpha$ /dwell=65  $\mu$ s/ 3.6 ms/10°/ 2.7  $\mu$ s, voxel size 0.7 mm. Due to patient motion and scan time restrictions number of spokes was reduced to 68040, TA=4.1 min.