Reproducibility of Quantitative Lung Perfusion MRI

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Introduction

The aim of this study was the determination of the reproducibility of quantitative determination of pulmonary blood flow (PBF), pulmonary blood volume (PBV) and mean transit time (MTT).

Materials and Methods

MRI:

17 healthy volunteers were examined at 1.5T (Magnetom Sonata, Siemens Medical Solutions, Germany) using first pass perfusion imaging of the lung in end-expiratory breath hold. An ECG-gated Saturation Recovery TurboFLASH-Sequence with TR/TI/TE/α = 188ms/100ms/0.96ms/18° was used. 40 measurements with 3 or 4 slices were acquired during one breath hold. 2ml of a Gd-based contrast agent (CA, Magnevist®, Schering, Germany) were injected after the first 5 acquisitions (~0.0175mmol/kg BW). The measurement was repeated after at least 20 min. In 11 volunteers, a free breathing phase contrast flow-measurement was performed before each perfusion measurement.

Image post processing:

The arterial input function (AIF) was determined from the pulmonary trunk. Signal intensity-time-curves of AIF $SI_{aif}(t)$ and tissue $SI_t(t)$ were converted to concentration-time-curves $C_{aif}(t)$ and $C_t(t)$ assuming a linear correlation between CA-dose and signal intensity. To get the residues $R(t)$, the tissue-curves $C_t(t)$ were deconvoluted with the AIF $C_{aif}(t)$. PBF, PBV and MTT-maps were calculated for each slice following the central volume principle [1, 2]:

$$PBF = \frac{PBV}{MTT} \quad \text{[Eq. 1]} \qquad PBV = \int_0^\infty C_t(t)dt \Big/ \int_0^\infty C_{aif}(t)dt \quad \text{[Eq. 2]} \qquad MTT = \int_0^\infty \frac{R(t)}{R(0)}dt \quad \text{[Eq. 3]}$$

The perfusion maps of the two measurements were compared on a histogram- and on a ROI-basis. For the histogram-based method, perfusion values of each lobe of the lung were compared. For the ROI-based method values in 6 manually positioned ROIs per slice in the lung parenchyma were examined. In both methods vessels were excluded from evaluation.

The flow-values of the phase contrast measurements were evaluated in the pulmonary trunk.

Results

In the second measurement a significantly higher pre-contrast signal-noise-ratio (SNR) during the first pass was found in the lung (first measurement: 4.1 ± 0.7, second measurement: 4.6 ± 1.0). The peak signal increase in the AIF was also significantly higher (first measurement: 9.7 ± 3.0, second measurement: 7.5 ± 1.7).

The perfusion values PBF (127.1 to 253.0 ml/min/100g), PBV (16.6 to 29.0 ml/100g), MTT (6.5 to 7.9 s) were in a physiological range and showed agreements to other studies [3, 4, 5].

The reproducibility of MTT was good (-9.8% to 3.1 %) and suboptimal for PBF (-16.6% to 40.2%, see Fig. 1) and PBV (-1.2% to 31.4%). Differences in global flow measurements and PBF show a correlation of R^2= 0.79 (Fig. 2).

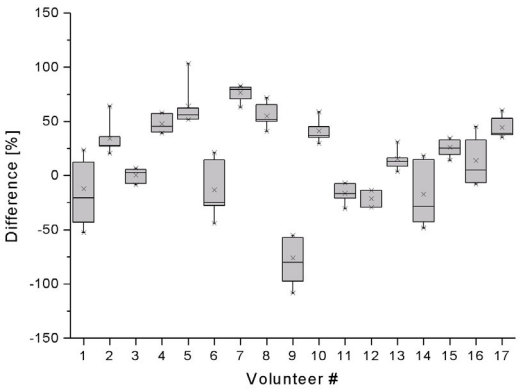

Fig. 1: *Reproducibility of PBF for every volunteer*

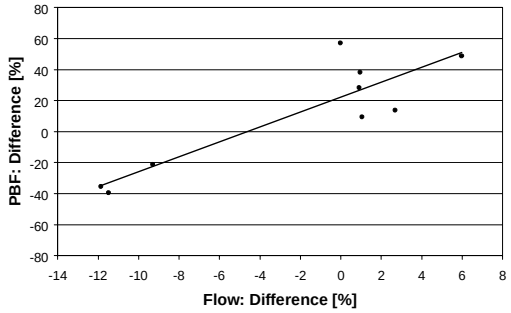

Fig. 2: *Correlation of differences in global blood flow and PBF*

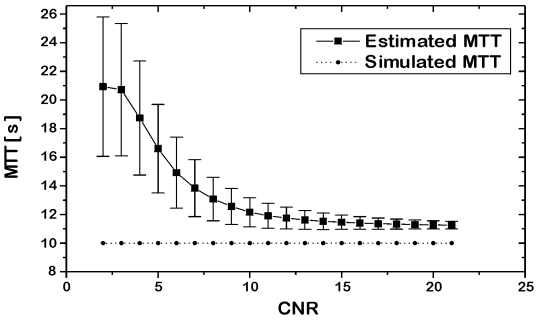

Fig. 3: *MTT is overestimated if image quality is poor [6]*

Discussion

No significant differences could be found between the histogram- and the ROI-based evaluation method.

With the elevated precontrast SNR in lung parenchyma and reduced peak signal change in the AIF clear indicators for residual contrast agent during the second perfusion measurement were observed. Previous work from our group ([6], c.f. Fig. 3) showed that a variation of the CNR results in a variation of the systematic error of the analysis method. This may be one reason for the suboptimal reproducibility.

Another source of variation may be physiologic variations of the global pulmonary blood flow (Fig. 2).

Acknowledgements

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Literature

[1] Steward, G., J Physiol, 1894. 15: 1-89
[2] Ostergaard, L. et al., Magn Reson Med, 1996. 36: 715-25
[3] Fink, C. et al., Röfo Fortschr Geb Rontgenstr Neuen Bildgeb Verfahr, 2004. 176: 170-4
[4] Ohno, Y. et al., J Magn Reson Imaging, 2004. 20:353-65
[5] Serizawa, S. et al., Chest, 1994. 106: 1145-51
[6] Viallon, M. et al., Proc. Intl. Soc. Mag. Reson. Med. 9 (2001): 1994