Determination of optimal temporal resolution and optimal total acquisition time for MR-renal perfusion and filtration measurements

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Background

Renal perfusion measurements are becoming an important part of comprehensive renal exams and allow to quantify the renal parenchymal perfusion, the filtration fraction and the split renal function [1-4]. However, there is still uncertainty which temporal resolution and total acquisition time is required for accurate quantification of perfusion and/or filtration. Therefore, the aim of this study was to determine the minimal temporal resolution as well as the necessary total acquisition time.

Materials and Methods

After IRB approval 15 healthy volunteers (mean age 29.1 years) were included in this prospective study. They all underwent saturation-recovery TurboFLASH renal perfusion measurements at 1.5T (Siemens Magnetom Avanto) after a bolus injection of 7cc of Gd-BOPTA (Multihance, Bracco-ALTANA) at 4cc/s. The sequence acquired 4 slices/second with a voxel size of 2.9 x 2.3 x 8 mm³. Total acquisition time was 4-5min. From a region of interest over the kidneys the quantitative perfusion parameters plasma flow (PF) and plasma volume (PV) characterizing the renal perfusion, as well as tubular flow (TF) and tubular volume (TV) characterizing renal excretion, were calculated using a dedicated software (PMI [3]) and a two-compartment model[4]. The influence of the temporal resolution and of the total acquisition time was analyzed by discretisation and truncation of the dynamic data. In a first step the parameters PV, PF, TV and TF were calculated from data sets which were regridded to new temporal resolutions from 1s increasing second-wise to 30s. In a second step, the same parameters were calculated for different acquisition times by truncating the data to total acquisition times of 30s to 270s in 5s increments. From the mean values and deviations of all four parameters the discretisation error (DE) and the truncation error (TE) were calculated. The non-truncated data with a temporal resolution of 1s served as a standard of reference.

Results

The DE showed a marked increase with a temporal resolution of more than 5s (PF/PV, Figure 1) while the parameters characterizing the renal function (TF/TV, Figure 2) were not as sensitive to a decreased temporal resolution. The critical temporal resolution threshold for these two parameters seems to be 8s. The TE revealed minimal acquisition times for the PF and PV (Figure 3) of at least 35s and 85s respectively. In contrast, prolonged acquisition time of at least 230s (TF, Figure 4) and 255s (TV, Figure 4) are required to characterize the renal excretory function correctly. Shorter acquisition times lead to irregular results with huge TE of more than 400% (Figure 4).

Conclusions

This study outlines the temporal requirements for a calculation of the quantitative perfusion parameters PF, PV, TF and TV. A minimal temporal resolution of 5s is dictated by the necessity to measure the first pass perfusion parameters (PF, PV). For determination of the PF only an acquisition time of 35s would be sufficient. In contrast, the minimal total acquisition time of 255s for a comprehensive assessment of the renal perfusion and function is mainly set forth by the parameters characterizing filtration (TV, TF).

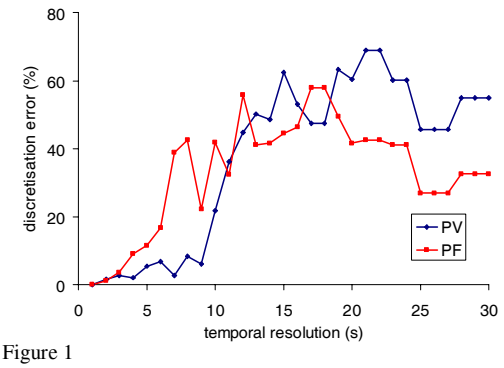

Figure 1

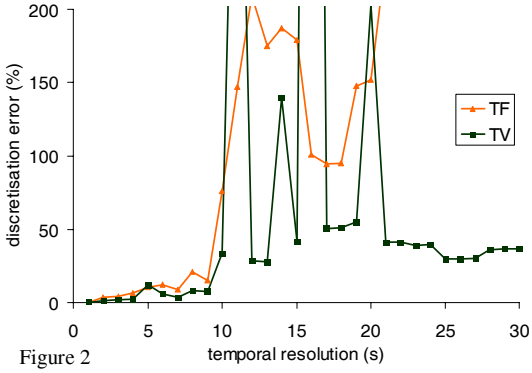

Figure 2

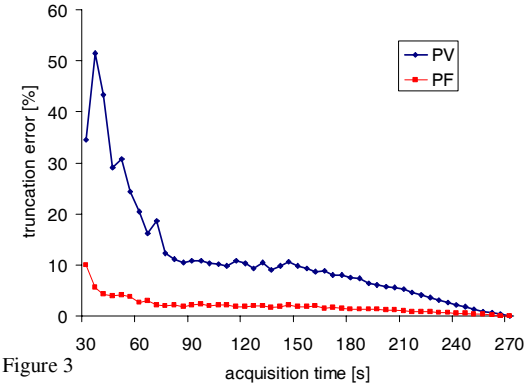

Figure 3

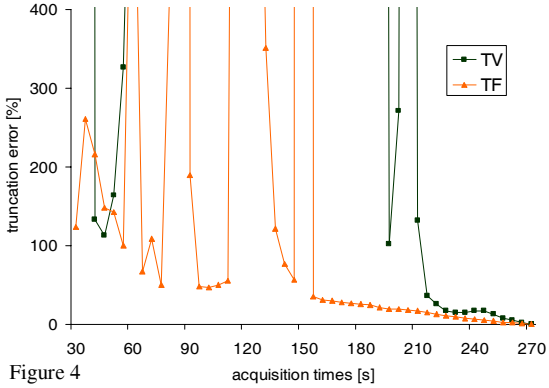

Figure 4

References

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