Motion of the Proximal Renal Artery

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Introduction

Contrast-enhanced MR angiography of the renal arteries is necessarily performed during a breathhold to eliminate the artifacts due to respiratory motion [1]. However, the renal arteries also show a secondary motion at the cardiac frequency due to the pulsating blood pressure and flow. Respiratory motion mainly affects the distal part of the renal arteries, whereas this secondary motion mainly affects the proximal renal arteries. Due to the relatively short available scan time in a single breathhold (max. 25 sec), current techniques for renal angiography do not incorporate any form of cardiac synchronization. To investigate the validity of these techniques, we have determined the motion of the proximal renal arteries in a large group of hypertensive patients using cardiac triggered MR Quantitative Flow measurements. The quantitative information reported here can subsequently be used to decide on issues of spatial resolution and cardiac synchronization in renal MR angiography.

Materials & methods

A group of 54 hypertensive patients suspected of renovascular obstructive disease were referred for contrast-enhanced MR angiography on our Philips Gyroscan ACS-NT 1.5T scanner (Powertrak 6000) using the body-coil for signal reception. All patients gave informed consent.

First, a non cardiac-gated 3D phase contrast angiography scan was performed [2]. Next, using maximum intensity projections and the original slices, 2D quantitative flow measurements were planned perpendicular to the proximal left and right renal arteries. Scan parameters were: Fast Field echo, FOV 300x310 mm, acquisition matrix 256x108, slice thickness 6 mm, TR/TE/TI = 14/6/20°, and Venc = 120 cm/s. The scan was retrospectively triggered using a peripheral pulse unit (PPU) yielding 25 heart-phases at a frequency of 65 beats/min within a scan-time of 2 min. Note that these flow measurements were performed during normal breathing, but that respiratory motion is expected not to affect the proximal renal arteries. Finally, a 3D contrast-enhanced renal MR angiogram was made, the results of which will be reported elsewhere.

For each heart-phase, the cross-section of the renal artery was determined in the signal magnitude image by using an active contour model that automatically tracks the maximum gradient in the signal intensity [3]. The center position of the renal artery contour was registered in two perpendicular directions. Due to the oblique sagittal slice orientation, these directions were oblique Anterior-Posterior (AP) and oblique Foot-Head (FH). Motion of the renal artery was defined as the difference between the minimum and the maximum center position throughout all heart-phases. Since renal artery motion was found to be in a straight line, the full motion was calculated as the quadratic sum of the motions in the above two perpendicular directions. Patient data showing insufficient image quality due to either improper slice angulation or to flow voids during systole was discarded.

Results & discussion

Figure 1 shows the average motion of the left renal artery in the oblique AP direction (1.1 ± 0.4 mm) is smaller than in the oblique FH direction (1.7 ± 0.6 mm) (paired t-test, $p < 0.001$). A smaller difference was found for the right renal artery: Oblique AP direction (1.5 ± 0.5 mm) and oblique FH direction (1.7 ± 0.5 mm) (paired t-test, $p = 0.006$). Notice that none of the patients showed zero or almost negligible motion. This is partly due to image noise which slightly affects the center position of the active contour in all 25 heart-phases and therefore results in a small minimum amount of motion. However, the measured motion has a large range from 0.25 to 3 mm which can only be explained by an actual physiologic motion of the proximal renal artery.

Figure 2 shows the full motion of both the left renal artery (2.1 ± 0.5 mm) and the right renal artery (2.3 ± 0.6 mm). From this histogram it is clear that selecting a submillimeter resolution without cardiac triggering would not be effective, since all patients showed a renal artery motion of at least 1 mm. Current non cardiac triggered sequences use a spatial resolution of about 2 mm, which is close to the average renal artery motion. This implies that in almost 50% of patients the renal artery motion is smaller than the voxel dimension, and will just slightly affect image quality. In the other 50% of patients, the renal artery motion is larger than the voxel dimensions, and will therefore degrade image quality. It is obvious that for some patients it will be necessary to use some form of cardiac synchronization in order to obtain sufficient diagnostic image quality for the accurate assessment of renal artery stenosis.

Conclusions

Motion of the proximal renal arteries due to pulsations of the blood pressure and flow was found to be comparable to the voxel dimensions in current contrast-enhanced renal angiography. This study has quantified this motion for a representative group of patients and thereby provides objective arguments for the optimization of current scan protocols. Whetever a high spatial resolution is essential for a certain imaging task, the data presented here can be used to decide whether cardiac synchronization is required.

References