Automated Detection of the Optimal Arterial Phase in Dynamic 3D Contrast Enhanced Imaging of the Liver

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Target Audience Automated selection of relevant information in high frame rate dynamic contrast enhanced imaging.

PURPOSE Obtaining an optimal arterial phase in contrast enhanced MR imaging of the liver is crucial for the detection and characterization of liver lesions, and is especially challenging for liver-specific contrast agents that are administered with a lower doses leading to a shorter bolus. High temporal resolution dynamic imaging has been shown to significantly increase the chance of capturing an optimal arterial phase. However, the substantial increase in the number of images presents an additional burden in the radiological read. In this study, we present an algorithm that automatically selects the optimal arterial phase from a series of 3D image data sets in the liver.

METHODS The proposed algorithm consists of the following steps: **(1)** Maximum intensity projections (MIPs) of the inferior 75% of the imaging volume are computed for each frame to remove cardiac signal enhancement in the superior slices. **(2)** The time-averaged image *M* of the MIPs is computed. **(3)** An elliptical mask surrounding the aorta is computed whose center and axes are the center of mass and half the radius of gyration of *M*, respectively. **(4)** This mask is applied to the MIPs and pixels whose signal temporal standard deviation falls below a threshold are removed. **(5)** A k-means clustering is performed to divide the pixels into clusters depending on their signal evolution over time. In this algorithm, correlation is used as a distance and 3 clusters are assumed. A morphological opening is performed on each of the 3 resulting pixel clusters or masks. **(6)** For each of the 3 pixel masks, the median signal over the mask is computed at each time point. **(7)** For each of the 3 resulting time curves, the first signal peak (local maximum) that is within 20% of the overall signal maximum is retained. **(8)** The curve with the earliest signal peak is assumed to coincide with the arterial enhancement curve and the temporal location of that peak is assumed to indicate the optimal arterial phase. The algorithm was retrospectively performed on *N*=40 consecutive clinical dynamic spiral LAVA acquisitions [1, 2]. For comparison, a manual selection of the arterial phase was performed by an experienced reader by placing an ROI over the aorta in a central slice location and selecting the phase with maximal aorta signal [3]. Dynamic spiral LAVA acquisition parameters were: 48 leaves, 256x256x(34-60) acquisition matrix, 5mm slice thickness, 32-46cm FOV 32-48cm, ±62kHz bandwidth, Magnevist/Eovist (Bayer Healthcare) injected at a dose based on patient weight, 6 acquired phases reconstructed to 21 phases (sliding window), ~1min total scan time. The patient was instructed to hold their breath as long as possible. The technologist then guided the patient to start a new breath-hold while scanning continued. This was repeated until scanning ended.

RESULTS The algorithm detected the same optimal arterial phase as the reader in 37/40 patients. In 2/40 patients, the selected frame was off by 1. In 1/40, it was off by 2 caused by a significant inferior displacement of the heart due to diaphragmatic paralysis post left nephrectomy. A Matlab implementation of this algorithm took approximately 0.27s.

DISCUSSION The preliminary results in this study show the feasibility of automatically detecting an optimal arterial phase among a dynamic 3D contrast enhanced acquisition of the liver. The run-time efficiency of the proposed algorithm will allow a straightforward inclusion into the online reconstruction software on the scanner. The same algorithm has the potential to detect other phases such as portal venous phase by selecting a different enhancement curve.

REFERENCES [1] Xu B et al. MRM, 2012, Early View: DOI: 10.1002/mrm.24253 [2] Agrawal M et al, JMRI in press [3] Thimmappa ND et al, ISMRM 2012, p401

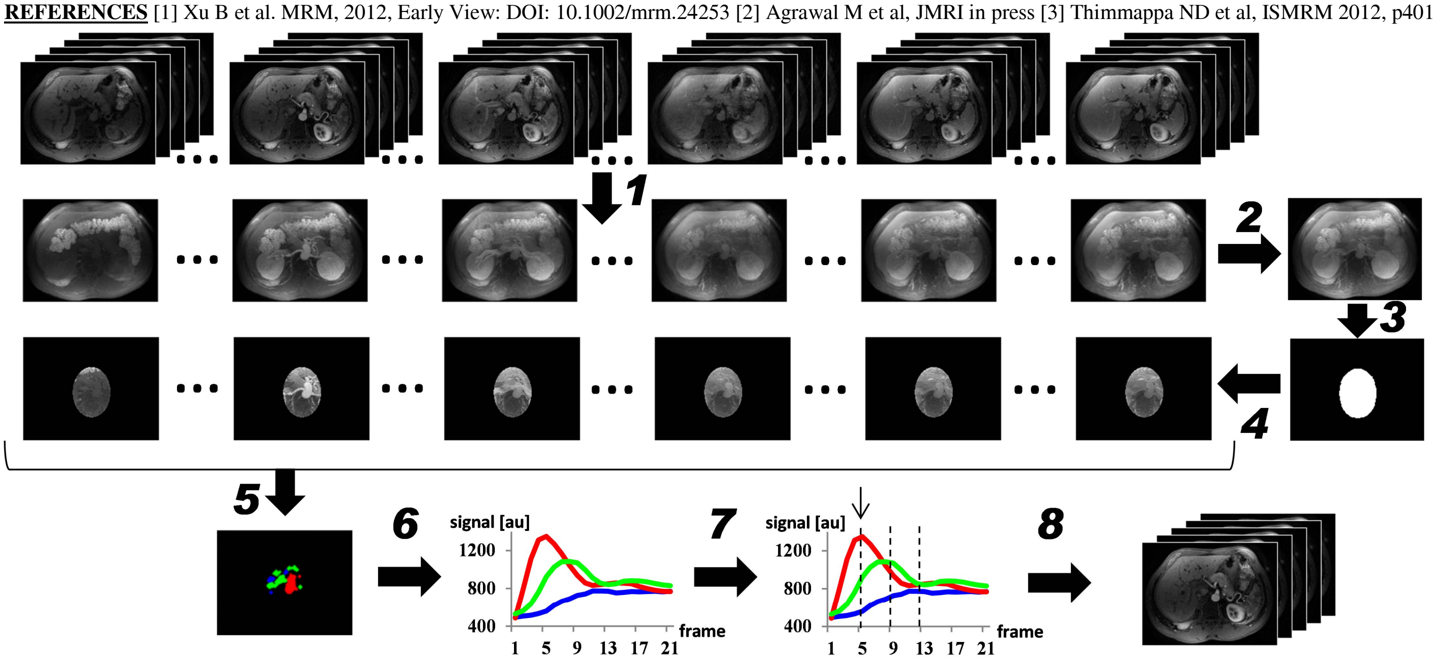

Fig 1 Illustration of the proposed algorithm using the data from subject 19. Only 6 out of the available 21 frames are shown. A description of each of the steps is given in the text.