A comprehensive MR examination of the heart in less than 25 minutes using a semi-automated image acquisition prototype

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Purpose: Current complexity in cardiac MR (CMR) has been identified as a major roadblock for the widespread clinical use of CMR. The purpose of this study was to evaluate a prototype which was designed for simplicity and speed in CMR examinations. The prototype contains: application-specific simplified user interface with user guidance and patient-centric parameters; simplified, marker-based localization of the heart [1]; automatic FOV calculation; automatic adjustment of MR sequence parameters to the cardiac cycle; automated evaluation of ventricular function [2]; standard cardiac views available as protocol parameters after localization.

Methods: 65 patients with suspected ischemic heart disease were imaged using the above-described examination prototype on a 1.5 T Siemens MAGNETOM Avanto system using two six-channel matrix surface coils. The scan program included (i) localizers (ss-TrueFISP), followed by (ii) CINE imaging (retrogated, segmented TrueFISP in the 2-, 3-, 4-chamber and short-axis views covering the whole left ventricle), (iii) rest and stress perfusion imaging (TurboFLASH , 3 short-axis slices and one optional long-axis slice) and (iv) delayed-enhancement imaging (ss-TrueFISP in all orientations and, in the presence of pathology, additional high-resolution images with a segmented TurboFLASH sequence). All protocols utilized GRAPPA parallel imaging. There was a minimum break of 10 minutes between the stress and rest perfusion acquisitions as well as a 5-minute break after the last contrast medium injection and delayed-enhancement imaging. Most of the CINE images were acquired between the stress and rest perfusion acquisitions. Supported by guidance text and example images (figure 1), the user localized the standard cardiac views using the marker localization method described in [1]. These views were subsequently available as protocol parameters. The automatically applied optimal FOV for each view combination was calculated based on body-bounding boxes computed from the acquired long- and short-axis view localizers. The cardiac cycle was detected automatically upon opening each scan protocol and image parameters such as trigger delay and number of phases per slice were updated accordingly. The endo- and epicardial borders were segmented automatically [2] in the short-axis CINE images. Quantitative parameters such as EF and stroke volume were computed and displayed immediately after image calculation.

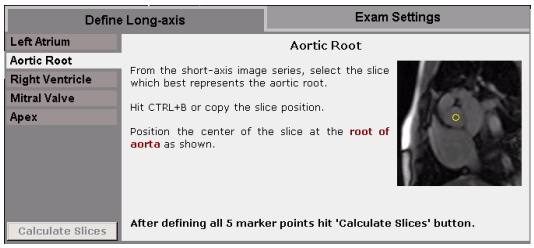

Figure 1. User interface for marker-based localization of the heart.

Results: 65 examinations were conducted by operators with various skill levels. The examination was successful in 64 cases, due to a software crash of the prototype one patient needed to be rescheduled. Operators were divided into 2 different levels according to experience: 1) two users experienced in CMR imaging, 2) one beginner with only 4 weeks experience in CMR imaging. The overall examination time per patient, image quality in general as well as accurateness of the automatic FOV calculation, auto-segmentation of the left ventricle and long axis view quality were evaluated. The mean time from the acquisition of the first localizer to the calculated images of the last protocol is reported in the table below. Image quality was rated excellent in 60 cases and diagnostic in 4 cases. The automatic FOV calculation was optimal in 59 cases, with minimal wrap while still delivering diagnostic images in 1 case, and slightly too large in 4 cases. The inline myocardial segmentation was accepted without modification in 35 cases, needed minor modification in 26 cases and a complete new evaluation in 3 cases. Of 192 long-axis views, calculated from user-defined markers, 187 cases were rated as optimal, 4 cases as sub-optimal but clinically sufficient and 1 case as incorrect and needed manual correction. No correlation was found between the experience level of the operators and the few negative results mentioned above.

	Mean acqu. time	St.dev
Experienced	24 min 34 sec	2 min 22 sec
Beginner	33 min 16 sec	5 min 7 sec

Conclusion: We have demonstrated that we can speed up the data acquisition and processing for a cardiac rest/stress imaging program to achieve examination times below 25 minutes without reducing the accuracy and quality of the result. A user new to cardiac MR managed to successfully complete a cardiac examination with excellent image quality in around 30 minutes.

References: [1] Schmidt M, Speier P, v.d. Recke G, Mosa A, Guehring J, Mueller E. Semi-Automatic Marker Based Localization of the Heart, SMRT 16th Annual Meeting, Berlin, Germany 2007. [2] Hayes C, Guehring J, Jolly MP, Schmidt M, Wintersperger B, Bhargava A, Mueller E. Fully automatic segmentation of the left ventricle in cardiac cine MR images, Proc. Intl. Soc. Mag. Reson. Med. 15 (2007) 3695.