Rapid Comprehensive Cardiac Examination in an Integrated Real Time Suite

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Introduction:

Magnetic resonance imaging has been demonstrated as an important clinical tool in the evaluation of qualitative and quantitative ventricular function, cardiac morphology, myocardial viability, coronary artery, and valvular morphology [1-4]. However, to date these approaches require separate pulse sequences for each application. This limits the flexibility for sharing scan locations and other parameters. We have developed a novel dynamic real-time cardiac imaging environment to provide a comprehensive *suite* of cardiac applications with a single "switch-on-the-fly" user interface. This architecture enhances flexibility and efficiency in performing a complete cardiac evaluation.

Methods:

The real-time cardiac suite was implemented on a GE 1.5T Signa Twinspeed system (GE Medical Systems, Milwaukee, WI) with a high performance gradient system achieving a maximum gradient strength of 40mT/m and maximum slew rate of 150mT/m/msec. The configuration included EXCITE technology with vector array processors running optimized sliding-window, gridding reconstruction software, and a Linux host for high display rates [5].

The different modes of operation available in the new cardiac suite are illustrated in Figure 1. The cardiac applications included left ventricular (LV) function, coronary artery imaging, cardiac morphology, myocardial viability and valvular morphology. Switching between modes can be accomplished with a single mouse click. These imaging modes are enabled by the following dynamic capabilities: switch between real-time (RT) and high-resolution with cardiac-gating and breath-holding (HR) images, RT shim, and RT inversion time (TI) setup. Contextual information including slice location, flip angles, prescan parameters, and shim values is automatically shared between the different modes. The imaging parameters common to all modes include a 13ms spectral-spatial excitation pulse and a 16ms spiral readout gradient. Although the current implementation utilizes a spiral acquisition, the infrastructure can be combined with other acquisition strategies.

Following informed consent, five subjects were placed in the scanner and complete cardiac examination was performed using the new integrated cardiac suite. The study was performed by a trained cardiologist. In the study ventricular function was assessed at 5 short-axis and 3 long-axis locations (corresponding to the two, three, and four-chamber views). Cardiac morphology was assessed at 3 short-axis and 3 long-axis locations. Delayed enhancement imaging was also obtained in 3 short-axis and 3 long-axis locations. Coronary artery images were obtained at four locations that included 2-5 views of the right coronary artery, 1-2 views of the left main and proximal left anterior descending artery, 1-2 views of the mid left anterior descending coronary artery and 1-3 views of the circumflex arteries.

Results:

Representative images acquired during a typical cardiac evaluation using the integrated real-time cardiac suite are shown in Figure 2. Table 1 shows the mean times for individual cardiac applications that are part of the comprehensive exam. The average total examination time for the 5 subjects was 32min ± 4min.

Discussion and Conclusion:

Cardiac magnetic resonance imaging is a clinically useful tool for a broad range of cardiac pathology. However, widespread clinical application of these techniques are limited by the inability to perform dynamic adjustments of contrast preparation, local shims, and flip angles as well as the dynamic switch between real-time and high-resolution scan to optimize the imaging plane during the breath-hold prior to the gated high-resolution acquisitions. In addition, scan time limitations often prevent a true comprehensive examination including cardiac function, valvular morphology, myocardial characterization, coronary artery imaging and cardiac morphologic imaging. The improvement in the workflow and the efficiency achieved with our real-time cardiac environment brings us much closer to that goal.

References:

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Cardiac App.	Average Times
LV function	5.8min ± 1min
Coronary Artery	10.6min ± 2min
Cardiac Morphology	7.0min ± 2min
Delayed Enhancement	9.2min ± 3min

Table 1. Mean times for individual cardiac applications from 5 subjects are shown.

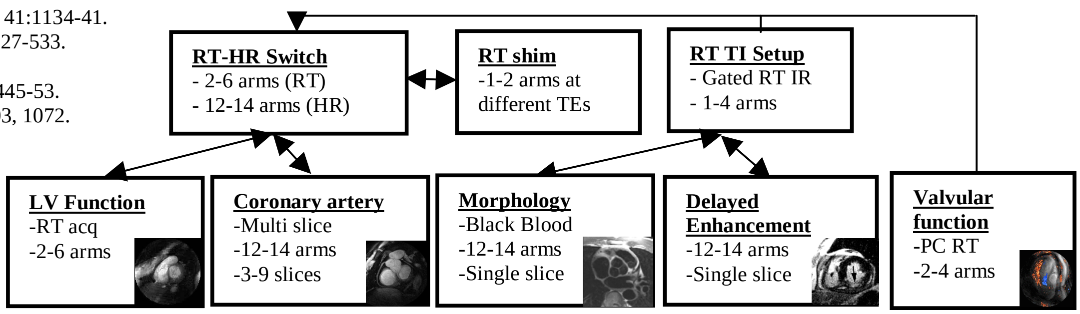

Figure 1. Imaging modes available in the integrated real-time cardiac suite. The top row shows the basic functionalities available in the real time suite. The bottom row shows the imaging applications integrated in to the cardiac suite. Arrows illustrate some of the transitions between real-time and high-resolution gated modes. Each mode has its own unique set of imaging parameters.

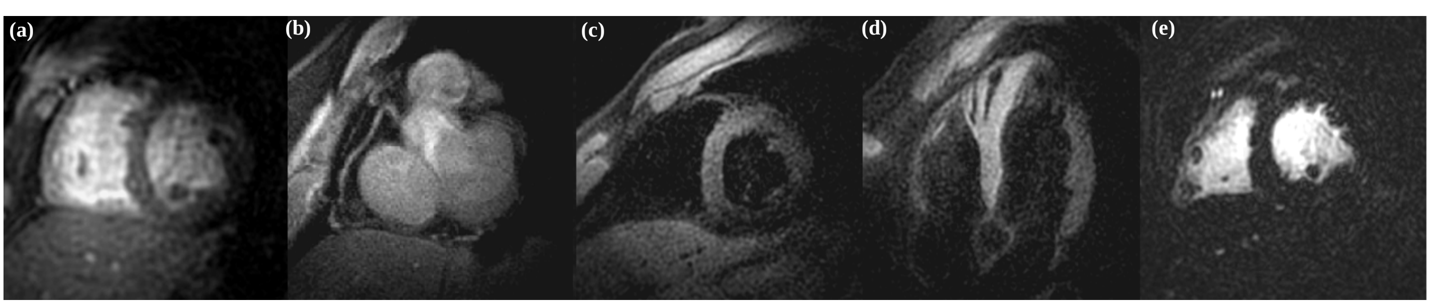

Figure 2. Representative images from a comprehensive cardiac examination of a volunteer. (a) low resolution real time short axis (SA) view for ventricular function (b) high resolution image of right coronary artery (c) and (d) SA and long axis (LA) view for cardiac morphology and (e) delayed enhancement for SA view. Note that the whole study for this volunteer took around 40min.