Technology and Physics

Rapid cardiovascular magnetic resonance protocol utilizing compressed sensing real-time imaging during the COVID-19 pandemic

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Background: Coronavirus Disease 2019 (COVID-19) poses many workflow challenges for healthcare systems. Elective cardiovascular magnetic resonance (CMR) exams were postponed until safety protocols were instituted. Since reopening, imaging labs are managing COVID-19 safety triaging, exam backlog, and increased referrals, thus innovative solutions for process improvement are needed.

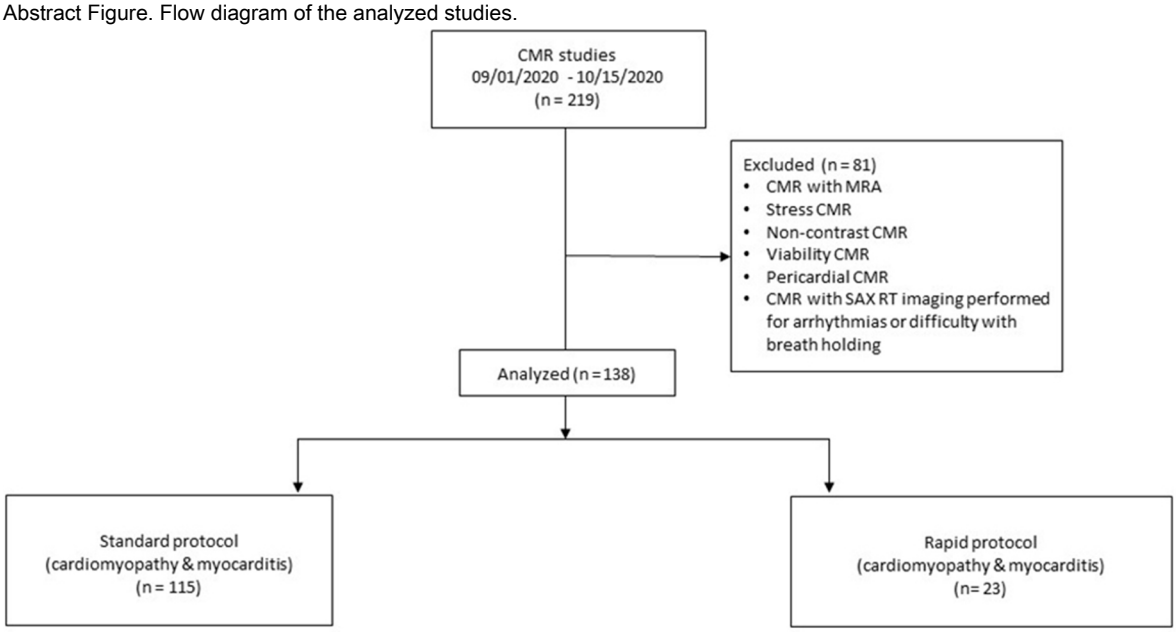
Purpose: An accelerated compressed sensing (CS) real-time (RT) technique offers dynamic cardiac imaging with high spatial and temporal resolution without image degradation. We sought to evaluate the efficiency of a rapid RT CMR protocol with a goal to decrease scan time without compromising study quality and comprehensiveness.

Methods: We retrospectively evaluated 219 CMRs (Siemens Magnetom Sola 1.5T) performed 09/01/2020 - 10/15/2020. After excluding 81 exams due to heterogeneous protocols (Figure 1), we analyzed 138 CMR exams using standard cardiomyopathy or myocarditis protocols. CMR studies utilized either a rapid RT short axis (SAX) cine (spatial resolution of 2.5 mm2 or better and temporal resolution of 55 ms or better) or standard breath-held (BH) SAX cine protocol (Figure 2). Protocols were chosen by the interpreting physician. Previous internal quality control demonstrated similar volumetric quantification between RT and BH SAX cines. RT cines were reconstructed inline using a CS-based method. We analyzed the length of time needed to complete each protocol and the number of series performed. Statistical analysis included student t-test with p value <0.05 considered significant.

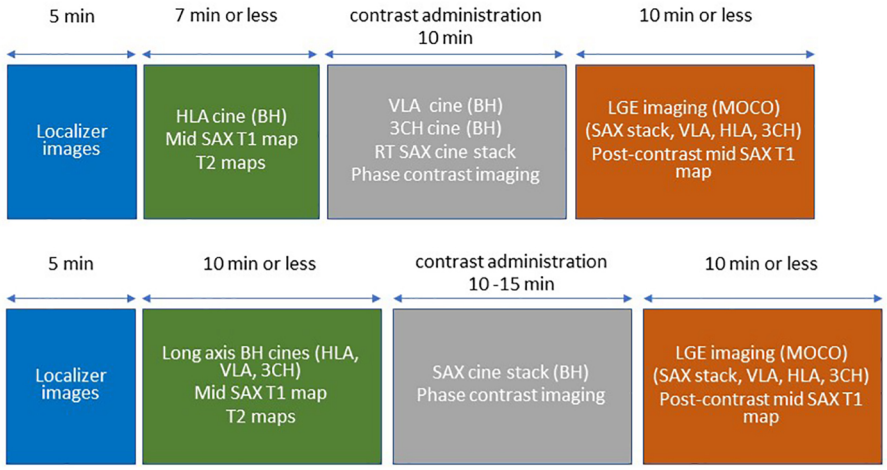
Results: Of 138 analyzed CMR exams, there were 23 rapid protocols and 115 standard protocols performed. The mean image acquisition time for the rapid protocol was significantly shorter at 26 ± 6 minutes (range 18-44 min) vs 33 ± 6 minutes (range 22-49 min) for the standard protocol, $p < 0.001$. This represents a mean relative reduction in scan time of 21%. More time was saved in rapid myocarditis (scan time 25 ± 6 min vs 34 ± 6 min, $p = 0.01$; relative time reduction 26%) vs rapid cardiomyopathy protocols (scan time 27 ± 6 min vs 31 ± 6 min, $p = 0.04$; relative time reduction 13%). There was no significant difference in the number of series performed (62 ± 14 series in rapid vs 67 ± 11 series in standard protocols, $p = 0.09$). T1 and T2 maps constituted the same percentage of acquired images regardless of protocol used (T1 maps 1.8% vs 1.7% for cardiomyopathy, 1.4% vs 1.4% for myocarditis in standard vs rapid protocols respectively; T2 maps 1.8% vs 1.7% for cardiomyopathy, 5.6% vs 5.8% for myocarditis in standard vs rapid protocols respectively).

Conclusions: A rapid CMR protocol utilizing a CS-based RT imaging is significantly shorter as compared to the standard protocol with adequate diagnostic quality. Rapid CMR protocols are an effective tool for process improvement during the COVID-19 pandemic.

Abstract Figure. Flow diagram of the analyzed studies.



Abstract Figure. Rapid (top) and standard CMR (bottom).


5 min
7 min or less
contrast administration
10 min
10 min or less
Localizer images
HLA cine (BH)
Mid SAX T1 map
T2 maps
VLA cine (BH)
3CH cine (BH)
RT SAX cine stack
Phase contrast imaging
LGE imaging (MOCO)
(SAX stack, VLA, HLA, 3CH)
Post-contrast mid SAX T1 map
5 min
10 min or less
contrast administration
10 -15 min
10 min or less
Localizer images
Long axis BH cines (HLA, VLA, 3CH)
Mid SAX T1 map
T2 maps
SAX cine stack (BH)
Phase contrast imaging
LGE imaging (MOCO)
(SAX stack, VLA, HLA, 3CH)
Post-contrast mid SAX T1 map