Cardiac MRI: Image Quality Improvement and Examination Time Shortening After MAGNETOM Avanto^{fit} Upgrade

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Introduction

Cardiac MRI examinations have long been considered too difficult for general radiologists and radiographers and have therefore often been restricted to academic or dedicated heart centers.

The main technical difficulty of a standard cardiac MRI protocol for the assessment of cardiac function and tissue characterization is the high number of breath-hold and cardiac triggered sequences (about fifty) along cardiac planes, which differ from the anatomical sagittal, coronal and axial planes used in almost every other body application.

Gaining time

However, at the Radiology Department of Cardinal Massaia Hospital in Asti, Italy, thanks to the 2014 upgrade of our MAGNETOM Avanto scanner to MAGNETOM Avanto^{fit}, cardiac MRI has progressed steadily from being the nightmare of every radiographer – due to its length and difficulty – to become a routine examination of about the same duration as a conventional brain protocol for multiple sclerosis.

Before the upgrade, a conventional cardiac MRI protocol including cine SSFP on cardiac long and short axis, evaluation of myocardial edema with triple inversion recovery sequences, perfusion FLASH sequences, early and late enhancement IR or PSIR T1w images, lasted about one hour from the first scout sequence to the last one (Figure 1, Group A).

The first innovation – the introduction of the automatic commands for breath-hold – has shortened the examination time. Since the radiographers are no longer focused on speaking to the patient, they can instead plan the next sequence (Figure 1, Group B), a saving of about 10 minutes.

The second improvement has resulted in a better image quality due to the higher number of coil channels and the possibility to use GRAPPA in cine SSFP sequences: Image resolution is higher, SAR (specific absorption rate) is lower, and it is possible to increase the flip angle of cine SSFP from 55° to 80°, performing short axis cine SSFP sequences after

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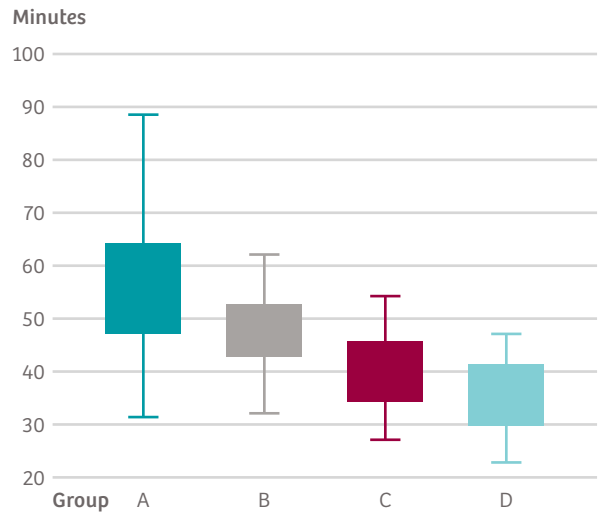

Figure 1: Length of MRI examinations in four groups showing the changes in cardiac MRI protocol.

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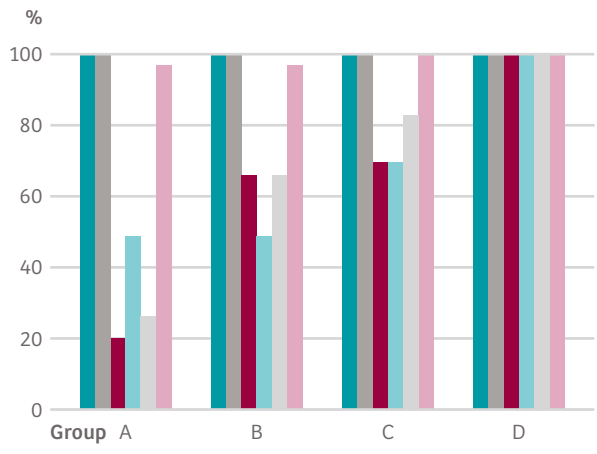

Figure 2: While scout and axial images (petrol), cine SSFP (gray) and late enhancement images (light red) were almost always performed in every group, the percentage of examinations with T2 triple IR (red), perfusion (light petrol) and early enhancement (light gray) increased from less than 50% in group A to almost 100% in group D.

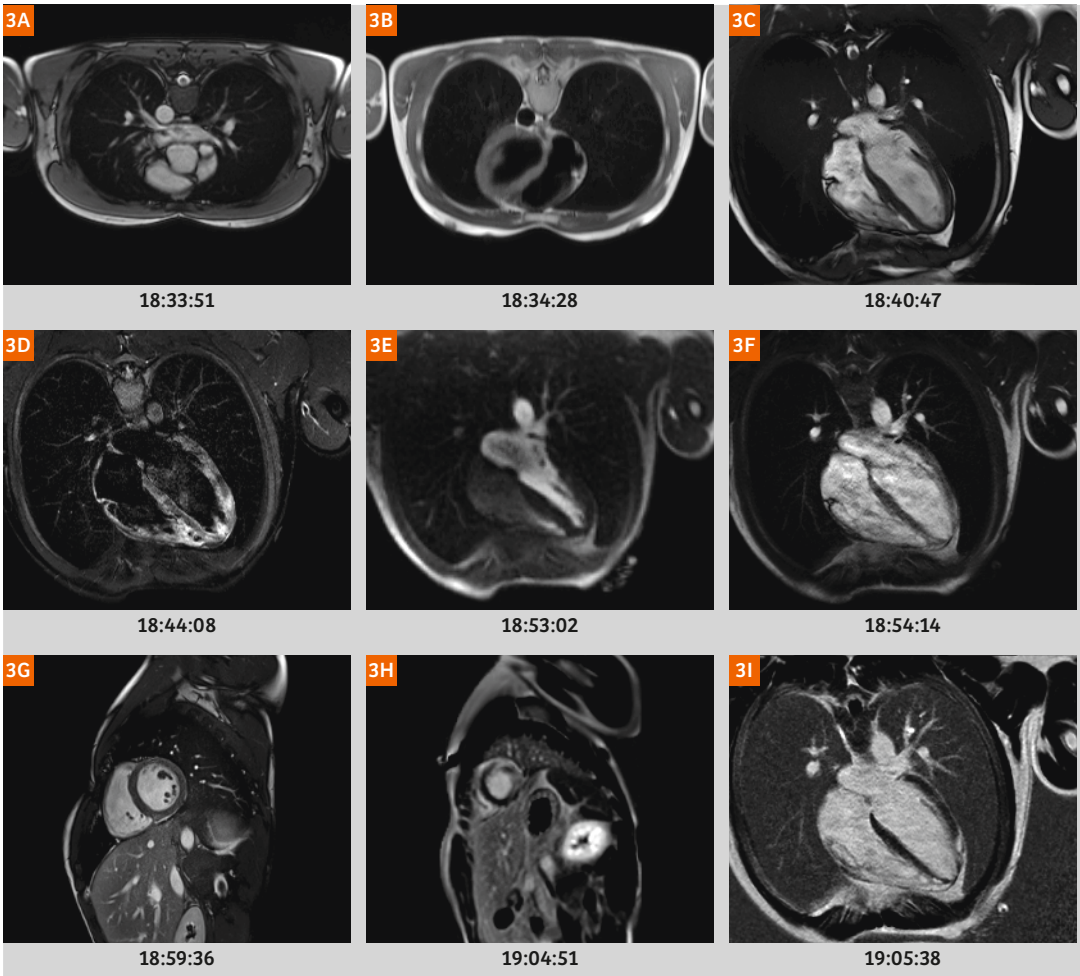

Figure 3:
A 32-minute complete protocol for myocarditis using axial TrueFISP and T2w HASTE sequences **(3A, B),** TrueFISP cine long axis **(3C),** T2w triple IR images **(3D),** GRE perfusion images **(3G),** PSIR late enhancement sequences along short and long cardiac axis **(3H, I),** showing patchy edema, early and late enhancement in the apical anterior, lateral and inferior walls of the left ventricle and in the apical free wall of the right ventricle.

the administration of paramagnetic contrast medium. This protocol change has also allowed a mean reduction in scan time of an additional 8 minutes (Figure 1, Group C).

Finally, by changing the protocol design, we were able to further exploit the features of the *syngo* MR D13 software. Once the radiographer has set the cardiac long axis and short axis planes, the following sequences automatically copy the measurement parameters, including field-of-view, phase oversampling and matrix. All the radiographer needs to do is adapt the sequence to the cardiac cycle, shortening the examination time even further to 35.8 minutes (Figure 1, Group D).

Conclusion

An analysis of our cardiac examinations reveals a reduction in acquisition times of about 40%, alongside an actual increase in the number of sequences (Figure 2). Prior to the scanner upgrade, the length of the examination meant that rest perfusion imaging, T2 triple inversion recovery imaging and early enhancement were performed in less than 50% of our patients. With the upgrade, almost all our patients undergo a complete examination. Moreover in the definition of acute myocarditis it is now possible to perform every long axis early enhancement IR sequence twice, increasing the number of positive findings because of fewer movement artifacts.

As an example, we share images of a patient who underwent a cardiac MRI examination before the upgrade in the follow-up exam of myocarditis, and after the upgrade during a myocarditis relapse. The first examination lasted one hour and included cine long and short axis and late enhancement PSIR images. The second examination lasted 32 minutes, including cine SSFP short and long axis, T2 IR, rest perfusion imaging, early and late enhancement (Figure 3).

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