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Editorial for “Impact of Temporal Resolution and Methods for Correction on Cardiac Magnetic Resonance Perfusion Quantification”

Stanislas Rapacchi, PhD¹, Magalie Viallon, PhD², Pierre Croisille, MD-PhD^{2,3}

1. Aix-Marseille Univ, CNRS, CRMBM, Marseille, France
2. University of Lyon, UJM-Saint-Etienne, INSA, CNRS UMR 5520, INSERM U1206, CREATIS, Saint-Etienne, France
3. Department of Radiology, University Hospital Saint-Etienne, Saint-Etienne, France

Cardiac perfusion MRI is proving to be a valuable noninvasive assessment tool in the armamentarium for patients with suspected coronary artery disease or microvascular disease, both for initial diagnosis and for follow-up to therapeutic decision. In particular, it has recently been shown to be comparable and more cost-effective than invasive fractional flow reserve for therapeutic guidance of patients with suspected CAD¹. This is especially true since the long-awaited results of the ISCHEMIA study challenge invasive management of coronary artery disease and demonstrate the value of optimal medical treatment². The Orbita study also masterfully demonstrated that an invasive approach is not the ultimate solution to propose to symptomatic coronary patients³. In this context of decreasing radicality and slowing down of the therapeutic approach with an increasing role of an optimized medical approach, it is clear that dynamic cardiac perfusion MRI with contrast imaging therefore promises to become the cornerstone of regular follow-up that will be proposed in future guidelines.

The blooming of perfusion cardiac MRI can be associated with the extended availability of quantitative perfusion cardiac MRI techniques, allowing users world-wide to overcome the hurdles of visual assessments and the strong dependence on the user and its experience. Quantitative perfusion cardiac MRI builds on the advances of both sequences and image algorithms that have been made available through either open-source solutions⁴ or commercial solutions⁵.

Among many improvements, significant efforts have been made into the addition of the arterial input function (AIF) sampling and signal correction, motion correction to allow breathing and cardiac motion to be compensated for and align image time series, and robust pixel-wise model-based algorithms to eventually map myocardial blood flow (MBF). By extension, the quantification of MBF consecutively measured in stress and rest states enables to probe the myocardial perfusion reserve (MPR) and further reveal sub-clinical ischemic deficiencies.

From these technical developments, the leading thread has mainly been to pay attention to every step along the way, and to provide a robust and reliable quantification of MBF. In this issue of JMRI, Milidonis and colleagues⁶ addressed the specificity of temporal resolution, and subsequent corrections methods in the quantification of MBF and MPR based on cardiac perfusion MRI, that samples each slice at most every heartbeat. Hence, perfusion cardiac MRI is inherently limited in temporal resolution by the subject's heartrate with large disparities between patients' heartrate and the different conditions between rest and stress measurement for MPR, which legitimate a reasonable concern about the accuracy of MBF quantification depending on the subject's heartrate. It is worth noting that if the impact of temporal resolution has been studied in perfusion MRI on static organs⁷, the recommendations derived for these applications remained largely organ specific and hardly applicable to the heart perfusion.

In their study, Milidonis and colleagues first addressed the problem through numerical simulations, to extensively consider all possible scenarios. Arguably, they investigated very extreme heart rates, from 30bpm to 120bpm, with a lower end almost unrealistic, that served as a worst-case scenario of low and disadvantageous sampling rates. They evaluated two correction methods, MBF-scaling and temporal interpolation, for the variability of temporal resolution, coupled with three models for perfusion quantification. Their results, unexpectedly, showed that temporal interpolation to a higher sampling rate enabled to restore reliable MBF estimation while MBF-scaling corrected results depended on the initial heart rate, independently of the quantification algorithm. The numerical study also concluded that interpolating to 240bpm maintained the perfusion error below 10%. The correction methods were then applied retrospectively on in vivo data, in association with the Fermi quantification model⁸, the most popular and validated model-independent method⁹ using the Fermi function.

Their results from in vivo data proved that correcting for the heart rate was crucial for accurate MBF quantification, but more importantly it showed how the bias in the MBF-scaling correction could lead to an overestimation of MBF and MPR. While focal perfusion defects could be distinguished regardless of temporal sampling rate correction, it appears very relevant to provide a reliable MBF, and MPR, quantification for diagnosing microvascular deficiency or multi-vessels coronary stenosis. As such, the study by Milidonis is commendable and paves the way towards a reliable and reproducible quantitative measure of myocardial perfusion that can integrate guidelines and recommendations¹⁰.

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