This issue of MAGNETOM Flash highlights several developments and advances in the field of cardiovascular magnetic resonance imaging (CMR). They demonstrate the continuing development of this fascinating technique, which looks set to continue. A few general trends can be observed:

Quantification
CMR is becoming fully quantitative, as evidenced by the rapid development of mapping techniques quantifying T1 and T2 relaxation and allowing calculating extracellular volume. Several cases demonstrating its clinical value are shown in this issue. This development is a revolution in CMR imaging as we move away from black, white and grey values, visual assessment and contrast differences to fully quantifiable data approximating to physiology. While the development of these technologies is ongoing, we can already appreciate their value in the detection of early changes [1], assessment of underlying pathophysiology rather than its consequences [2] or quantification of alterations in absolute terms [3, 4]. Novel data also demonstrates that these quantifiable measures are superior to classic markers such as volumes, ejection fraction and even late gadolinium enhancement in predicting cardiovascular events in patients with, for example, non-ischemic cardiomyopathies [5] or informing on the acuity of inflammation (myocarditis) [6]. Similar changes are imminent in perfusion analysis and flow imaging.

Speed
Today’s CMR is fast and continues to accelerate. The increase in speed is due to two changes. Firstly, with increasing capabilities of navigator sequences data acquisition has become less dependent on breath holding. Navigator sequences used to be slow, unpredictable and frequently of low quality. This was mainly due to the imperfect estimation of cardiac displacement based on measurements of the right hemidiaphragm and – as a result of the suboptimal correction of breathing motion – the rejection of a large proportion of the data acquired. Novel image navigators use the true position of the heart, yielding a much better correction for cardiac displacement during breathing allowing to increase scan efficiency to nearly 100% [7]. This efficiency may make navigator sequences faster and more patient friendly than breath holding for routine scanning in the very near future.

Secondly, the amount of redundant data acquisition is reduced. Changes such as parallel imaging have altered cardiac imaging strategies dramatically, as they allow a majority of acquisitions to be performed within a single breath hold rather than requiring long scans averaged over multiple breathing cycles. Compressed sensing now allows squeezing 3D volumes into a single breath hold or a short navigator scan, finally making CMR a truly 3D (or 4D) method.

New applications
Novel abilities continue to emerge. This is partially a consequence of an increase in speed and the development of novel sequences. The greater speed allows transferring imaging methods to the heart, which were previously reserved for non-moving structures. An example is diffusion tensor imaging, which has been successfully used in the brain and other structures and starts to emerge as a cardiac option [8]. Novel sequences utilize contrast better than previous...
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methods, as highlighted by the articles on QISS MRA, which generates unprecedented contrast in non CE MRA [9]. I am sure that coronary MRA will also challenge CTA in the next few years.

CMR in 2030

The trends described above are only a small proportion of the opportunities that will open up to us in the near future. Our approach to imaging will change drastically. Whilst an accurate prediction of the future is almost impossible, I’d like to present my vision of CMR in 2030. A glance back 15 years will remind us of the speed of change. In 2000, the newly-launched iMac boasted a quarter of RAM, a CPU with half the speed and about the same display matrix as a 2010 iPhone. And at about the same time in CMR we were replacing Turbo Gradient Echo with SSFP, testing the first perfusion sequences (with a single shared prepulse) and using large external optical disks to store the data. So, how do I think the next 15 years may pan out?

In my vision, diagnostic tools will have immediate public access. Medical care will be much less confined to hospitals or require doctors. People will be able to scan their hearts (function, structure, blood flow, synchrony, coronary arteries, contractility, cardiac efficiency, cell size) in public diagnostic centres without referral. They will be checked for contraindications by an artificial intelligence (AI) robot. Additional modules can be added based on the findings. The data will be automatically analysed and compared to a large database of age-gender-ethnicity-height-weight-matched controls, people with similar co-morbidities as well as the person’s own previous scans. The results will be available immediately and if any therapy is needed a further meeting with an AI robot will assess possible contraindications and co-morbidities. The person will then be issued with the ingredients for his home-based pill-printer: a software update will provide the correct medication on a daily basis. Some patients will still need to see a doctor, as the AI robot has not yet been FDA cleared for certain diseases where information remains insufficient for adequate algorithms.

Of course, all therapy will require accurate, quantifiable and reproducible diagnostics before approval by health insurers. Continuation of therapy will be only reimbursed if a therapeutic effect can be demonstrated by imaging. As an example, a quantitative analysis of myocardial ischemia will be required before any anti-anginal therapy or even revascularization is approved. Interventionalists will be required to follow the imaging guidance. More expensive drugs will only be reimbursed if shown to be effective in the specific patient.

Trials will require full phenotypisation of participants before, during, and at the end of the study. Endpoints will increasingly be based on the underlying pathophysiology rather than symptoms, outcomes or consequences of disease.

These are just some examples of what may lie ahead. Does CMR have a role here? It’s hard to tell, but to remain at the heart of developments in 15 years’ time we need to pursue the following five strategies.

Firstly, we must continue the drive for speed. Speed reduces costs, provides access, generates large numbers and creates the convenience required for success.
Institute for Experimental and Translational Cardiovascular Imaging, DZHK Centre for Cardiovascular Imaging, University Hospital Frankfurt, Germany (Goethe CVI)

This new institute will provide a platform for interdisciplinary multimodality cardiovascular research. The institute is equipped with a state-of-the-art 3T MAGNETOM Skyra MR and a SOMATOM Force CT exclusively for cardiovascular research. It is situated on the campus of the University Hospital within the European Cardiovascular Science Centre, which also houses several excellent groups in basic cardiovascular science. The Institute is embedded in and supported by the German Centre for Cardiovascular Research (DZHK), a cluster of 28 members with outstanding cardiovascular research capacities.

Strong connections with the clinical partners in the university hospital namely Prof. Dr. Andreas Zeiher (Cardiology, Angiology, Nephrology) and Prof. Thomas Vogl (Interventional and Diagnostic Radiology) provide access to patients, practical know-how, clinical equipment and support.

Secondly, we must become fully quantitative. This may not require everything to be measured in signal intensity units, but it does require everything to be measured in units that are reproducible, have normal ranges with small standard deviations and relate to the severity and extent of the abnormality. Quantification enables comparability, follow-up, assessment of therapeutic needs and success and replaces the human eye with all its limitations by a reliable system. This will require standardization, reduction of freedom in parameters and massive improvement in postprocessing software.

Thirdly, we must strive for evidence-led approaches and overcome the battles of turf and power for access and reimbursement. We need to bring highly qualified teams together to push the borders of technology and knowledge. Failing this, other techniques, markers or groups will provide the services that we could lead on.

Fourthly, we must share knowledge and empower the next generation [10]. Our strength will depend on our ability to provide rapid services to large populations.

Lastly, we must not think in silos. I believe that CMR has all the advantages required to be a core modality in the type of diagnostic center I have described above (no ionizing radiation, 3D coverage, high spatial and temporal resolution, excellent soft tissue contrast, endless possibilities). However, there are other techniques and blood markers that may provide similar information. We should embrace these techniques to allow for true comparison of their relative values, strengths and weaknesses, and also to remain at the forefront of this knowledge. We need to ensure that we are the ones to train the AI robots, not the other way round.

Our goal remains to reduce the burden of cardiovascular disease. I believe that advanced imaging can play a major role in this goal. Together, we will be strong enough to make sure the therapies of the future (cardiac regeneration, cardiac rejuvenation, printable electronic membranes) will be based on diagnostic imaging before, during and after therapy, thus ensuring maximal benefit for our patients while remaining within the given financial framework.

I wish you an exciting and inspiring SCMR 2016.

With best regards

References

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Prof. Nagel also leads the new Clinical Interdisciplinary Cardiovascular Imaging Service provided by the Institute of Interventional and Diagnostic Radiology and the Clinic for Cardiology, Angiology and Nephrology. This interdisciplinary service allows for rapid translation of research findings into clinical routine and the transfer of clinical questions into research, and also provides a platform for truly interdisciplinary clinical training and service.

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