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Precision Medicine and Adaptive Technologies in Medical Imaging

Dear colleagues, dear readers,

I feel honored and excited to be invited to write an editorial for MAGNETOM Flash on the topic of ‘precision medicine’ – a term that might seem overused these days. Whilst this term is not new – medicine always wants to deliver the right treatment to the right patient at the right time – our understanding of correlations between genome, habits, and diseases is evolving rapidly and exponentially. It feels like there is a need to re-imagine and re-organize health services.

All fields of medicine are adapting to an increasing and increasingly complex demand of phenotyping and genotyping our patients, identifying precise cohorts, and optimizing health care. To us as radiologists, it may seem obvious, that radiology should certainly play a key role in phenotyping these sub-populations by means of dedicated imaging strategies [1]. This should be complementary, and not compete with other ways of phenotyping, including, for example, advanced laboratory tests, histo-pathology, and immuno-pathology. To integrate our radiological imaging data and reports in a phenotyping system that categorizes patients into well-defined prognostic and therapeutic categories, we will have to learn and adapt to a rising demand of ‘imaging biomarkers’, ‘reproducible parameters’ and ‘standardized’ as well as ‘structured’ reporting.

I am sure our readers are optimistic as I am that we will be able to successfully master these challenges. However, at the same time, we are facing new opportunities and threats,

in terms of increasing economic pressure and increasing workload, ‘value-based’ healthcare, introducing artificial intelligence in clinical routine, and commoditization of imaging procedures and radiological reports [2, 3]. We need clear and concerted strategies to handle these challenges and these include,

- A) Accepting and taking on a stronger role of radiologists, as clinical partners and information specialists,
- B) Setting new standards in quality and workflows, and
- C) Finding answers to an increasing demand of personalization and parametrization in our daily routine.

In this volume of MAGNETOM Flash, exciting views and reports on advancements in MR technologies, enabling us to improve quality, workflows, flexibility, and standardization, clearly reflect these trends and endeavors – in a way that I find very convincing.

1. A new role for radiologists?

Radiologists will have to adapt. And we will have to adapt quickly, to both an increasing economic pressure and to the ‘fourth industrial revolution’, i.e., a rapidly improving process automatization on the basis of big data and artificial intelligence (AI) [4, 5]. The first challenge will be to adapt and re-invent our ever more complex imaging procedures and skills in the era of ‘value-based healthcare’. Since ‘value’ is defined as health or patient outcomes, or

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costs, we should therefore be measured on the results and quality of our care and not on the volumes of service delivered. However, if we agree to enter this circle of optimizing our workflows and outcome-centered care, will we be degraded to delivering standardized services and reports within a (short) given time, i.e., will medical imaging become a commodity? The strength of radiology is not only in the delivery of (automated) results from using sophisticated technologies, but even more by providing an optimized diagnostic process and data integration, provided by dedicated, highly skilled, specialized and communicating colleagues in our field, i.e., radiologists and technicians.

Radiology's value chain has to be high-quality, patient-centered, and results-oriented at the same time. This will enable us to develop from volume-based imaging to value-based imaging, demonstrating the added value of imaging in each phase of patient care and transforming imaging results into measurable metrics (e.g., quantitative imaging results, or cost effectiveness). The primary objective is to maintain and improve our visibility and demonstrating our capabilities as radiologists, imaging experts and highly trained specialists to our clinical partners and patients in daily practice, in our conferences, tumor boards, telephone calls, patient interactions, and interventional procedures. Optimizing our workflows and constant quality-control of our daily work (scheduling, protocols, procedures, reporting, distribution, and communication) is the foundation, basis, and pre-requisite for this, and should be self-evident, but how our report affects therapeutic decisions will directly influence patient outcome and costs of healthcare.

Will this process include an increasing automatization of our reports, at least in parts? Maybe yes. Is this detrimental or dangerous for our field? No, not, if we lead the way and use these new tools to our and our patients' advantage. Even the best trained colleague will not be able to stay perfectly up-to-date with all medical advancements. At the same time, age distribution in our western societies is changing drastically and imaging volumes are steadily

increasing and will continue to do so. Thus, should we not embrace help from technology, rather than to fear it?

There are a number of ways how we could profit from AI. Besides the problem of data, image and information overflow, we will need AI for rare diseases, complex syndromes, or for decision-support systems, to face the growing complexity of our multi-disciplinary, multi-modal, and multi-scale clinical work, combining information from imaging, -omics, lab test, clinical history, and physical exams. The risk is not in the automatization, even of routine reports on frequent imaging procedures such as chest X-rays, mammograms, or CT angiographies to exclude pulmonary embolism. The crucial question will be: Who is in the driver's seat, for technical implementation of these new AI techniques, and for the final decisions. We will have to take action and participate in these developments rather than ignore them, and – if we do it right – we will be able to improve our services and quality. In this process radiologists will transform to information specialists, implementing innovative forms of data handling and data presentation, and focusing on image-guided personalization of our own interventional measures and procedures.

2. New quality standards of radiological services

Multimodal, molecular, and functional imaging is becoming increasingly important in the context of personalized medicine. Our non-invasive diagnostic and imaging procedures are increasingly used to support and complement the data of advanced molecular diagnostics. Complementary qualitative and quantitative imaging parameters play a major role in the assessment of our patients' individual prognosis, the prediction of treatment success and in the monitoring of the therapy effectiveness and outcome. With '-omics' technologies reaching maturity, these will be more and more implemented in clinical practice. Prospective and, where necessary, randomized clinical studies will be needed to validate novel imaging biomarkers, imaging phenotypes, and imaging signatures.

“With recent advances in MR technology, we will optimize workflow and scanning efficiency, while providing consistent, high-quality personalized examination results at the same time, entering a new era in precision medicine.”²

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High quality collections of biological samples procured in a standardized manner from age- and disease-stratified collections coupled to omics- and imaging-based phenotype information are required for the purpose of identification and validation of new, ideally quantitative, imaging biomarkers. By implementing these reproducible, quantitative, and standardized imaging biomarkers, multimodal image information can be integrated with patient-specific data for the development of individualized and predictive disease models.

To reach this goal, examination protocols and image acquisition must be standardized and homogenized as far as possible, in order to achieve a comparability and transferability of results from the various imaging modalities and between different sites. In addition, strategies for a systematic structuring of our reports and findings will have to be implemented, in order to replace the traditional, descriptive reporting of findings. Structured reporting will lead to the possibility of systematic data extraction from our reports, making them more accessible to statistical correlative analyses and bioinformatics. The term ‘structured analysis and reporting’ thus describes the establishment of objective, quantitative, extractable, and reproducible standards, e.g., in the context of tumor-specific diagnostic criteria and follow-up. This results in complete and comprehensive reports and considerably increases the objectivity and comparability between different investigators and sites and at the same time creates the possibility to link these image data with those from molecular diagnostics and to scientifically evaluate them or integrate them in complex disease models. The implementation of standardized vocabularies and reporting rules, supported by radiological lexicons and glossaries, established and disseminated by national and international radiological societies, will further harmonize the use of radiological terms and expressions and will enable optimized indexing of our reports.

3. Adaptive imaging technologies in the era of precision medicine

So how, we may ask, do recent MR developments anticipate these challenges and react to the growing demands described above? Due to high levels of exam complexity, patient properties, and user variability, MRI is still considered to be one of the most complex medical imaging modalities. Innovative MR scanner technology should therefore be able to automatically or semi-automatically address anatomical and physiological differences among individual patients, thus, a wider range of routine scanning procedures as well as complex protocols will be applicable to a larger extent of patients, even those formerly not eligible for MRI examinations, delivering more robust and more consistent results. Also, in times of economic pressure, MR scanning will have to be more cost-effective, by greater robustness and acquisition speed, reducing re-scans and increasing productivity.

To provide our patients with individualized and personalized diagnostic strategies and tailored therapies, we need robust, standardized, and reproducible acquisition techniques that are constantly delivering high and comparable quality. Only then we can compare results and link them with additional information, such as data from laboratory medicine or genetic analyses. Recent technologies will allow us to access new and growing clinical fields – for instance, enabling scans in patients with cardiac arrhythmias, excess weight, or other health problems that prevent them from actively supporting the scan.

An impressive array of various innovative MR technologies will be discussed in this present edition of MAGNETOM Flash. For example, dedicated acceleration techniques implementing Compressed Sensing (GRASP-VIBE³) enable dynamic, free-breathing liver examinations in one comprehensive scan by the push of button and for every patient, making breath-holds and complex timing of several dynamic contrast phases unnecessary. Optimized shimming technologies based on new hardware and transmit technologies, such as

CoilShim¹, one of the BioMatrix Tuners, homogenize the static magnetic field and significantly improve fat saturation and signal exploitation, e.g., in diffusion-weighted imaging (DWI) of body regions difficult to image, such as the neck. Slice-specific shimming (SliceAdjust¹) is introduced with MAGNETOM Vida¹ as an effective method to reduce susceptibility effects in whole-body DWI at 3T. Automatization of whole-body MR examinations, e.g. the Whole-Body Dot Engine¹, will significantly reduce overall imaging time, increase patient comfort and will potentially change our use of MRI, e.g., for an increased implementation of whole-body tumor staging. In cardiac imaging, implementation of highly accelerated real-time sequences will preserve diagnostic image quality even in challenging scenarios, such as in arrhythmic patients. Finally, complete free-breathing cardiac examinations¹ will become possible.

The challenges in our field are increasing and may be greater than ever; our clinical and scientific working environment is getting more complex and more demanding. Only if we understand the challenges and take our chances, we will stay in the driver's seat, developing radiology to play an even more central role in clinical care. With recent advances in MR technology, we will optimize workflow and scanning efficiency, while providing consistent, high-quality personalized examination results at the same time, entering a new era in precision medicine.

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¹ 510(k) pending. The product is not commercially available. Future availability cannot be guaranteed.

² The statements by Siemens' customers presented here are based on results that were achieved in the customer's unique setting. Since there is no 'typical' hospital and many variables exist (e.g., hospital size, case mix, level of IT adoption), there can be no guarantee that other customers will achieve the same results.

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