ESMRMB 2024 Focus Topic - MR Beyond Trends: Fact-checking MR

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Magnetic Resonance Imaging (MRI) plays a key role in modern radiology with at least 100 million diagnostic scans performed annually across the globe. However, besides its undeniable value, the (multivariate) biophysical mechanisms underlying MRI contrast generation are rather unclear and subject of current research. Furthermore, with the advent of AI into all areas of medical imaging, MRI users now tend to employ black-box models in image reconstruction, segmentation, and disease classification, which in turn introduces an additional challenge in trust and interpretation of the results. Therefore, as part of this focus topic, we believe it is paramount to also shed light on the application of AI for MRI data interpretation, emphasizing the importance of explainable AI (xAI) in validating and understanding the obtained results. In addition, the educational sessions will cover the use of postmortem MRI studies to validate tissue models and the innovative approaches in biomarker discovery that rely on accurate and validated quantitative MRI techniques. Moreover, dedicated sessions will discuss the emerging applications of low-field MRI, and the vital role of validation.

Plenary Session: From MR Views to MR Facts

Margaret Hall-Craggs will delve into the intricacies of MRI biomarkers and their pivotal role in deriving clinical insights. Her presentation will focus on the transformative impact of advanced MRI technologies on the precision and reliability of medical diagnoses. Following her, Nikolaus Weiskopf will shed light on the critical aspects of modeling and validating quantitative MRI. His talk will emphasize the rigorous validation processes necessary to understand MRI signal generation and discuss how these models can accurately link complex imaging data to the underlying histological structures and elements. Concluding the session, Christoph Lippert will explore the applications of xAI. He will discuss the development and implementation of AI-driven

models designed to predict disease outcomes, highlighting the potential of xAI for diagnosis and treatment planning in cancer care.

Education Session 1: Low-field MRI: Emerging Opportunities
In this session, Luc Darrasse will start by exploring the physics behind low-field MRI regimes, discussing how these principles can be applied to generate new contrasts, mitigate noise or bring added flexibility in the use of new low-field MRI technologies. Karyn Chappell will follow, highlighting the adaptability of MRI technologies to various medical and research settings, emphasizing innovation in design and functionality with the potential to bring more cost-effectiveness and accessibility in the next generations of MR systems. Finally, Mara Cercignani will talk about the emerging applications of low-field MRI, particularly in areas where high-field MRI is unsuitable or too costly, paving the way for broader clinical and research usage.

Education Session 2: Understanding AI
Roser Sala will open the session with an exploration into deep neural networks, focusing on their applications in diagnosing and understanding neurological diseases. Sinem Sav will then discuss the development and importance of privacy-preserving federated learning, which is crucial for maintaining patient confidentiality in expansive, multi-center studies. Simon Hofmann will conclude the session by presenting on xAI and its specific toolboxes for MRI analysis, along with methodologies like heatmapping, which help interpret AI decisions in medical imaging.

Education Session 3: Why Go Postmortem? Practical Challenges and Opportunities
Kathrin Yen will start this session by addressing the practical challenges and opportunities of postmortem MRI studies, discussing why such approaches are vital for forensic research, but also clinical forensic questions in-vivo. Christoph Birkl will then discuss non-MRI methods for validating quantitative MRI, focusing on preparation and histology. Evgeniya Kirilina will explore the validation and modeling of tissue including elemental distributions, to better understand tissue properties. Finally, Marco Palombo will discuss the innovative use of brain organoids in MRI to simulate living tissues, providing a bridge between in-vivo and ex-vivo research methods.

Education Session 4: MRI Techniques for (Biomarker) Discovery
George Thomas will kick off the session by detailing how population studies can aid in discovering new biomarkers, focusing on the role of MRI techniques in these large-scale studies. Jessica Bastiaansen will discuss the steps required for preclinical translation, emphasizing the methodological rigor needed to move from research to clinical application. Clemens Diwoky will wrap up the session by explaining the use of X-nuclei and spectroscopy methods in validating MRI biomarkers, which are essential for enhancing the specificity and sensitivity of MRI diagnostics.

With this focus topic on fact-checking MR we aim to emphasize the increasingly discussed importance of validating MRI methods that will ultimately be used for medical diagnostics and treatment decision making. We also explore the integration of xAI to refine MRI data interpretation and highlight the significance of postmortem studies for validating imaging

techniques, and methods for biomarker discovery using MRI. Together, these efforts underscore the community commitment to making MRI an accurate, reliable, and understandable tool for healthcare and research.