Have Your Cake and Eat It Too: Artificial Intelligence and Tailored Cardiac MRI Protocols

We read with interest the Point/Counterpoint articles debating use of focused versus comprehensive cardiac MRI protocols [1, 2]. Focused examinations deliver efficiency, whereas comprehensive protocols ensure thoroughness. In this Letter, we explore how artificial intelligence (AI) offers a solution to resolve this dilemma.

Deep learning models can help predict which sequences are needed, analyzing clinical data from multiple sources to guide examinations' planning and execution. Such sources include referral requests, cardiologist notes, echocardiograms, laboratory values, nuclear studies, CT scans, and catheterization results. AI can also identify redundant sequences, reducing overlap and potentially waste [2, 3]. For example, rest perfusion imaging may be unnecessary if late gadolinium enhancement imaging is planned.

Implementation of AI for examination protocoling will need to follow a phased approach. First, AI will learn to automatically assign protocols, using natural language processing to analyze clinical indications, matching patients to optimal scanning strategies [4]. AI systems will later integrate directly into scanners, allowing real-time protocol adjustments during acquisition. For example, AI may respond to patient anatomy, motion artifacts, and pathologic findings detected on images as they are acquired. Ultimately, AI will seamlessly combine comprehensive evaluation with targeted efficiency; examinations for routine indications will use streamlined protocols, whereas complex indications will receive additional sequences as needed.

Successful use of AI to protocol cardiac MRI examinations will face implementation challenges requiring training with large annotated datasets and greater standardization for implementation into an institutions' PACS and radiology information system. Nonetheless, if this aim is achieved, then technologists could focus more on patient care than protocol details, and radiologists could interpret tailored imaging sets. This vision extends beyond efficiency gains. AI enables personalized medicine at scale. Each examination will be adapted to the patient's clinical presentation and specific diagnostic needs. Use of uniform protocols will become a historical artifact [5].

Full AI integration with the EHR would amplify these capabilities if AI could access clinical data concurrently during scanning. For example, laboratory results could influence contrast media timing, and clinical notes and prior imaging results could guide real-time sequence selection.

AI could monitor image quality continuously, providing automated quality control. Technical failures could prompt immediate correction, and diagnostic adequacy could be verified before the examination's completion.

AI researchers overestimate health care changes within the next 2–3 years, whereas radiologists underestimate the radiology transformation over the next 10 years. Within this mindset, the future of cardiac MRI will embrace smart and adaptive protocols, guided by AI.

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Reply to "Have Your Cake and Eat It Too: Artificial Intelligence and Tailored Cardiac MRI Protocols"

We sincerely appreciate the interest in our Point/Counterpoint articles [1, 2], in which we focused on the current state of practice of cardiac MRI and the associated advantages and challenges of focused versus comprehensive cardiac MRI protocols. Stallman and Vegter [3] invite us to imagine the future of cardiac MRI, in which artificial intelligence (AI)-driven tools are integrated within health systems, the EMR, and MRI scanners. This use of AI hints at a future of true personalized medicine in which cardiac MRI is tailored to efficiently and effectively address the patient's unique clinical scenario.

The authors acknowledge that the AI community likely underestimates, and imagers tend to overestimate, the time and resources required to achieve this vision. Nevertheless, both groups must be clear-eyed about the challenges to be overcome to achieve this future state. First, efficient and accurate tools for mining the EMR must be developed and adapted specifically for the purpose of imaging protocol generation. The author highlights early progress in this space, and we believe such data mining to be an important (and nontrivial) target for further research and development. Second, consensus and trust must be built within the cardiac MRI community to instill confidence that AI-defined protocols provide the information that clinicians need to make accurate diagnoses and appropriate decisions. Implementation of algorithms that map into an accepted set of protocols seems feasible as a first step. However, for algorithms to make decisions to add or subtract sequences, the community will need to see strong data, including outcomes data, supporting this approach. Third, inline integration of protocols onto scanner

consoles must be further developed. Early efforts have shown that AI-driven protocol manipulation is possible but still needs significant refinement [4]. Finally, all of these developments will presumably be commercialized and come at a cost to health systems. The tools, integration support, and maintenance of these workflow enhancements will need to be cost-effective.

These challenges can be overcome, and we view this Letter as a call to action to the cardiac MRI community. This effort will require major collaboration between historically siloed industries (like EMR and scanner vendors), health systems, and scientists and physicians both within and outside of academic institutions. Cardiac MRI has a long track record of leading technologic developments. We hope the community considers these ideas as we continue to build a brighter future for our patients and the next generation of cardiac MRI practitioners.

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