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Energy Efficient MRI: Shortened Scan Protocols, Deep Learning and Magnet Cooling

The rise in energy costs, especially in regions like Europe, has put pressure on radiology departments, where magnetic resonance imaging (MRI) scanners consume significant amounts of energy. Given that radiology contributes about 4.2% of a hospital's total energy consumption, there is a pressing need to explore solutions that can optimise energy usage without compromising the diagnostic capabilities of MRI scans. Adopting sustainable practices is essential not only for cost savings but also for reducing the environmental footprint of medical facilities. A recent article published in European Radiology explores strategies to reduce energy consumption in musculoskeletal MRI, focusing on three key areas: shortening scan protocols, incorporating deep learning (DL) techniques, and optimising magnet cooling systems.

Optimising MRI Scan Protocols

One of the most straightforward approaches to reducing energy consumption in MRI is by shortening scan protocols. Shorter scan times reduce the time the MRI scanner is in use, directly translating into lower energy consumption. In musculoskeletal MRI, economic protocols were implemented by slightly reducing the imaging resolution and increasing acceleration factors in imaging. These protocols, designed to maintain diagnostic quality while using fewer resources, resulted in substantial energy savings. For instance, optimising protocols led to an average reduction of scan time by 18%, contributing to a 31% reduction in energy consumption across various body regions. Although there is a slight compromise in imaging resolution, the protocols were tailored to maintain the diagnostic capability necessary for clinical use. This approach is particularly useful in outpatient settings where MRI scanners are typically operated for 8–12 hours daily.

Incorporating economic protocols has the added advantage of being relatively easy to implement. It does not require significant investment in new technology and can be adapted to existing equipment with minimal disruptions to operations. By enhancing workflow efficiency, radiology departments can achieve quick wins in energy savings, particularly in settings where high patient throughput is essential.

Leveraging Deep Learning for Accelerated Acquisitions

While optimising protocols offers substantial energy savings, deep learning (DL) techniques push the boundaries of what can be achieved in terms of both speed and energy efficiency. DL-accelerated sequences significantly reduce the acquisition time without sacrificing image quality. In musculoskeletal MRI, DL was used to reconstruct high-quality images from undersampled data, allowing faster scan times and reducing the demand for energy-intensive components such as the gradients and radiofrequency (RF) pulses.

The use of DL in musculoskeletal MRI demonstrated a 71% reduction in scan time and a 72% reduction in energy consumption compared to traditional protocols. These results underscore the potential of DL to transform medical imaging, not only by improving patient throughput but also by reducing the environmental and financial burdens of MRI operations. For example, in knee imaging, DL protocols reduced energy consumption by 89%, highlighting the impressive efficiency gains that can be achieved.

Moreover, the computational demands of DL for image reconstruction, while initially raising concerns about energy use, were offset by the reduced scan times. This balance between computational intensity and shortened acquisition times is a critical factor in the success of DL implementations. As more radiology departments adopt these advanced algorithms, the potential for widespread energy savings becomes increasingly attainable.

Optimising Magnet Cooling Systems

Optimising the magnet cooling system is a third critical factor in reducing MRI energy consumption. MRI scanners rely on superconducting magnets, which require constant cooling to remain operational. Even when the scanner is idle, the cooling system remains active, consuming approximately 31–38% of the total energy used by the machine annually. By optimising the cooling cycles and integrating technologies like the Eco Power Mode (EPM), substantial energy savings can be achieved during non-scanning periods.

The EPM optimises the cooling system by turning off the helium pump during idle times and reactivating it based on temperature and pressure conditions. This reduces the energy consumption during non-scanning hours by 30%, a significant reduction given MRI scanners' high baseline energy consumption. Over the course of a year, this can translate into savings of approximately 4881 euros ($5287) per scanner. Combining the EPM with DL-accelerated protocols leads to even more significant savings, totalling up to 11,913 euros ($12,904) annually per scanner.

Integrating optimised magnet cooling systems offers a relatively low-cost solution that can be implemented alongside protocol and DL optimisations. This ensures that MRI scanners operate more sustainably without impacting image quality or clinical workflow. These savings become even more impactful in high-throughput or 24/7 operational environments, such as inpatient settings, where energy usage is a continuous concern.

Conclusion

Combining shorter scan protocols, deep learning-accelerated acquisitions, and optimised magnet cooling offers a comprehensive strategy for reducing energy consumption in musculoskeletal MRI. These innovations can potentially transform radiology departments' sustainability profile by significantly lowering operational costs and reducing the environmental impact. In outpatient settings, where energy consumption is a significant cost driver, adopting these techniques can result in substantial financial savings. Even in continuous operation environments like hospitals, the benefits of DL acceleration and optimised cooling are clear.

As energy prices continue to rise and as healthcare institutions seek to improve sustainability, the strategies discussed in this article provide a practical roadmap for energy optimisation in MRI. Radiology departments that implement these strategies will not only contribute to cost reduction but also align themselves with broader environmental goals. Future research and development in this field will likely focus on refining these methods further and expanding their applicability to other types of MRI scans, paving the way for a more energy-efficient future in medical imaging.

Source: European Radiology

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