

The spectrum of new hardware and how it's changing clinical management, a neuroradiologist's perspective

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Demographic trends in developed countries are well established. Life expectancy will continue to rise and the most rapidly growing segments in the population will continue to be the oldest age brackets. The consequences of these inevitable demographic trends for health care are clear. In the coming decades there will be an inexorable shift in the nature of health care to a system that is increasingly dominated by the needs of chronic (as opposed to acute) medical conditions. This will require adaptations in the health care delivery system at many levels including medical imaging. It is reasonable to ask, how will MRI adapt to meet these changing demands?

The latest hardware advances will clearly produce improvements in SNR and efficiency. This will have the obvious beneficial effect of improving clinical throughput. Perhaps more importantly these developments will bring into routine clinical practice some applications that have been largely limited to academic sties, for example perfusion imaging. However, it is reasonable to ask, will hardware improvements enable techniques that bring new insight into disease that is clinically useful. Or stated differently, what will the value added be to the clinical neurosciences, beyond improved throughput of applications already in clinical use?

A reasonable place to start is to ask, what clinically relevant questions are not being adequately addressed by currently available technology and how might this change with improvements in hardware? Modern MRI has revolutionized the clinical neurosciences. However once the capability of MRI to answer a certain set of clinical questions has been integrated into clinical practice, a new and biologically more subtle set of questions emerges. For example, in the area of dementia, a decade ago, the role of MRI was largely limited to identification of potentially treatable causes of dementia – e.g. tumor, hydrocephalus, subdural hematoma, or infarction(s). Once the ability of MRI to effectively answer those questions was apparent, a new more subtle set of potential applications emerged. These included – use of MRI to assist with early diagnosis prior to clinically evident dementia, prediction of the future risk of developing dementia, differential diagnosis of dementia and pre dementia syndromes, and measuring longitudinal disease progression on serial imaging studies. This paradigm is not unique to dementia but rather is generalizable throughout the clinical neurosciences.

In order to address these more subtle questions, MRI should come to resemble a quantitative laboratory instrument, rather than primarily an instrument for visualization. And when treating MRI as a quantitative laboratory instrument, standard considerations of accuracy and precision must be addressed; particularly the latter because some of the most important questions that must be addressed by imaging in the era of chronic disease are related to measurement of subtle changes over time on serial imaging studies.

One can envision three major sources of data variability in imaging. One is data variability across subjects due to the effect of disease itself, this is the desired component of variability one would like to capture. Second is data variability due to biologic variation which is unrelated to disease. And third is data variability due to technical or engineering related features. In order to optimize the utility of MRI as a quantitative instrument, efforts should be made to minimize engineering related variability while maximizing the variability due to disease itself. Hardware developments that improve the precision of anatomic, diffusion, perfusion, spectroscopy and other applications would provide material value-added to clinical MRI.