The Role of Biomedical Imaging in Future Healthcare Scenarios

a report by

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Biomedical imaging makes up approximately 10% of the total device industry and is showing a steady growth of 5–10% per year. At present, in terms of market potential, biomedical imaging is used primarily as a diagnostic tool in the clinical practice arena. In addition, it is being used increasingly in research settings for both clinical and animal imaging.

While imaging diagnostics have been in use for decades – the X-ray has been used for more than 100 years – it is in the last 35 or so years that there has been an explosion in its use due to the development of imaging modalities such as ultrasound (US); computed tomography (CT) scans; magnetic resonance imaging (MRI); positron (positron emission tomography, PET) and photon (single photon emitted computed tomography, SPECT). Additionally, a limited number of contrast reagents have been developed which have significantly helped to improve the signal to noise ratio of the acquired image. MRI and PET were originally developed for use in brain research; however, in terms of clinical use, CT and US have had major impacts on diagnosis of cardiovascular (CV) related disorders and CT and PET in oncology. The use of imaging in diagnosis of brain disorders using MRI is most significant in the diagnosis of multiple sclerosis and is also shown to be important in stroke recovery.

There are two major imaging paradigms that the various modalities fall into – structural and functional. These two terms are self-explanatory. The strength of imaging is that the same imaging modality can be used to gather both structural and functional imaging during the same scan sequence. For example, MRI can be used to quantitatively determine the three-dimensional structure of a tumour mass and by using the contrast reagent, gadolinium, it is also possible to monitor the blood flow which is an indication of the functional state of the tumour.

Over recent years there has been increased activity in the development of 'molecular imaging' approaches. The goal of molecular imaging is to develop technologies and assays for imaging molecular/cellular events in living organisms. Molecular imaging is expected to have a significant impact on the diagnosis of disease state and therapeutic response, particularly in oncology, and is also being developed as a combination diagnostic/therapeutic. There are very high expectations that it will become possible to visualise the disease site using imaging and subsequently specifically target it with the use of this combined reagent. Nanotechnology has a potential role to play in this area with the development of nanoparticles that may contain the therapeutic and then using specific antigen/antibody-coated particles to visualise their localisation. This allows targeting of the particle to the disease site.

While MRI, CT scans and US are part of everyday clinical practice in many disease areas, many of the applications used are significantly lagging in terms of advanced technologies. These modalities have undergone considerable advancement in academic and certain industrial environments. The information provided has been important in further understanding disease process, but the impact on clinical practice remains relatively unfelt. This is due in part to the fact that there are no therapies associated with the specific measures that have been developed. In addition, the imaging is usually the responsibility of the radiologist and not the specialist, which sometimes leads to delays in adoption of new technological approaches. Generally, the most innovative approaches to clinical imaging are limited to those facilities with relevant leading researchers and associated equipment.

The use of bio-imaging in animal research is increasing. A number of smaller imaging manufacturing companies have emerged which focus on designing instruments specifically dedicated to animal studies. The importance of such animal scanning imaging systems is that they exploit of one of the strengths of imaging – that the same technology can be used for both pre-clinical (animal) and clinical studies. Thus permitting the possibility of translating the animal findings directly to clinical research studies. This has significant implications for both technology and drug development. Additionally, imaging technologies are increasingly being used to advance veterinary treatment.

There has been considerable expectation for several years that biomedical imaging will play a major role in drug development. The utilisation of imaging has, more recently, been integrated into the drug development process in a manner that parallels the augmentation of biomarkers into these procedures. There is an increasing recognition by both the therapeutics industry and its regulators that biomarkers are essential to future development. Biomarkers are endpoints that are used to measure or quantify some form of biological, biochemical or pathological response. Imaging endpoints provides visual biomarkers that can then be quantified. Thus, their value is noteworthy and is influential in the drug development process. In addition, imaging endpoints has the added characteristic that the technology is translatable in certain cases from the pre-clinical to other settings. The expectations for imaging and translational medicine have been overrated, not due to limitations of the technology, but rather to unrealistic expectations of the animal models.

exclusivity. The challenge is for the regulators to accept this new surrogate endpoint.

The required standards for regulatory approval of a new device are not sufficient for acceptance as a surrogate for approval of a new chemical therapeutic. However, during the last two years there have been a number of volumes that have been released on the exclusive use of imaging in drug development. This is indicative of the rapid assimilation of the various technologies into numerous therapeutic areas. Most of the major pharmaceutical companies have internal animal imaging facilities. However, clinical studies are usually outsourced to leading academic facilities. There also exist consortia of imaging sites. In addition, there are a number of imaging Contract Research Organisations that will facilitate the standardisation of these technologies for clinical trials applications. Government regulators, government research institutions, leading academics, device companies and pharmaceutical companies are working together to create the standards for clinical

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In terms of clinical imaging and drug development, imaging is having its greatest effect in the development of oncological therapeutics. PET, MRI and CT are being seen as essential to the early development, full development and commercialisation of new drug approval. In central nervous system therapeutics, MRI was essential to the approval of the first and subsequent multiple sclerosis therapeutics and it is considered that for future Alzheimer's Disease treatments, imaging – both MRI and PET – will play a critical role. An interesting case relates to the development of a new therapy for atherosclerosis, being developed by Pfizer. Traditionally, agents for atherosclerosis require massive phase III trials involving over 10,000 subjects and lasting five years where efficacy is expressed in terms of cardiovascular events, including strokes and death. The phase III program for this new therapy includes three pivotal ultrasound imaging studies of significantly shorter duration and with few patients. While the costs of these studies are still very significant, if the imaging data is positive and accepted by regulators, this could gain as much as three extra years for commercialising the product before loss of patent

trials – specifically the critical phase III studies – which will lead to the incorporation of the technology into the therapy label and into the use of the same procedure in clinical practice.

With changes in the healthcare environment due to rising costs, which do not necessarily equal improved care, there is a need to alter the present business models for all the various components that make up healthcare. The imaging industry continues to grow globally. In the US, almost every hospital must have its own multi-slice CT scanners, and now there is a very rapid integration of the new 3.0 Tesla MRI scanners. All this equipment costs millions of dollars. The challenge is whether healthcare can continue to incur such increasing costs. It is widely stated that new medical technologies will cause increased healthcare costs. The solution is for the various sectors - pharmaceutical, biotechnology, device and health information technologies – to converge in terms of their strategies. This is a significant challenge as the financial drivers and value principals are different for each industry. However, the future of healthcare cannot afford to be based on the present cost-reduction focused business practices. ■