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Molecular Imaging

modern-day diagnostic miracle

Molecular imaging enables the visualisation of the cellular function and the follow-up of the molecular process in human body without perturbing it. Thus it was quickly adopted by the medical fraternity, given the clarity and non-invasive method. This technique helps improve the treatment of diseases such as cancer, and neurological and cardiovascular diseases by optimising the pre-clinical and clinical tests of new medication. They are also expected to have a major economic impact due to earlier and more precise diagnosis.

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When a hospital plans to buy a multi-crore, hi-tech equipment, the initial few months of planning are typically spent over the question, "What return on investment (ROI) can we expect?" Most imaging equipment have gone through this phase and have matured in terms of both utility and viability. Molecular Imaging, the latest technology wave in diagnostic imaging is not an exception.

But for a diagnostic consultant like me return on investment is measured differently. How many times is a life saved due to timely diagnosis? How many times was the quality of life after the treatment dramatically improved with accurate predictions and visualisation of the disease? Answers to these questions are the basis for real ROI. Let us have a look at this clinical case.

Figure 1 shows a fusion image of 18FDG uptake in malignant cells and fusion of the image with a CT scan, which helps in accurate understanding of the location of cancer cells in lymph nodes (A), bones and other soft tissues (B).

Treatment for cancer is traumatic as the disease grows and inaccurate or partial diagnosis often leads to more trauma. Molecular Imaging can be very useful not only in oncology but in many more Clinical areas.

Diagnostic Imaging - how far we have come?

Diagnostic imaging has come a long way. The aim of diagnostic imaging has been to visualise pathology non-invasively. Ever since the invention of X-rays, clinicians started directly visualising the anatomy of the body. More sophistications in the technology led to accurate visualisation of structural part. CT provided thinner slices at a faster rate of scan. Faster processing and better software for Doppler machines made real time 3D a reality!

Figure: 1A

Figure: 1B

Figure 1a & 1b: This patient who was clinically known as having stage I malignancy, that is beginning of the Cancer, underwent whole body PET CT scan, which showed extensive spread of disease - Stag IV. Generally stage I disease may need surgery as primary line management for local disease along with Chemo added to it for Stage I, on the other hand Stage IV disease would need Aggressive chemotherapy for long period.

The end result is that, we now can see the face of a fetus in the mother's womb non-invasively; one can diagnose minor calcification in the coronary arteries that supply blood to the heart without any invasive procedure; we can have a sub millimeter level measurement of body detecting hairline fracture, or even a small stone in bladder etc.

Functional imaging of cellular processes started with MRI and MR spectroscopy and has now reached up to Nuclear Medicine and fusion imaging. Current Reality is measurement of the disease processes primarily using nuclear medicine, PET & SPECT fusion with CT.

131 Iodine, MIBG, HIDA, Octreotide are some of the conventional Molecular Imaging agents. In the present scenario functional imaging talks about 18F-FDG for Malignant pathology imaging, Tissue Hypoxia imaging, Dopaminergic activity (Alzeimer's disease), Caudate / putamen degeneration (Parkinson's disease).

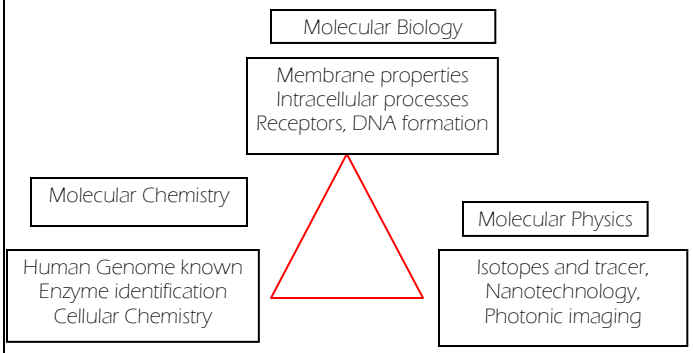
Understanding Molecular Imaging

Molecular Imaging: What is it?

The Society of Nuclear Medicine defined the term molecular imaging as "The visualisation, characterisation, and measurement of biological processes at the molecular and cellular levels in humans and other living systems"

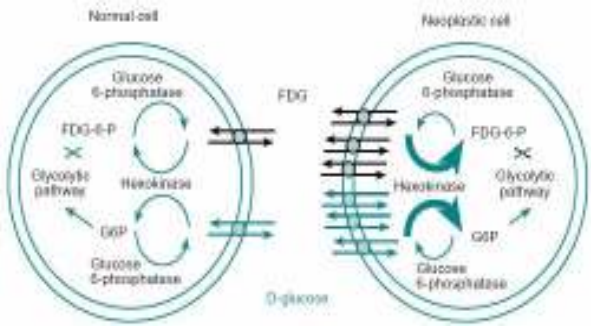
When one talks about biological processes at cellular and molecular level, all the three major streams of sciences, namely, molecular Physics, Molecular Biology and Molecular Chemistry have to join hands to translate these processes into visible image.

Figure 2



The differential metabolism in cancer cells permits intense Radioactive Glucose (18F-FDG) concentration in these cells and takes the first step of the current Molecular Imaging (PET scan).

Figure: 3



MI: Is there a better future?

Molecular imaging is a key component of 21st century cancer management. The global efforts are on for quantitative imaging of tumor that can lead to a more robust and effective monitoring of personalised molecular cancer therapy.

The American College of Radiology has recently set practice guidelines for [90Y] Zevalin and [131I] Bexxar, which are approved by the FDA for radio immunotherapy of non-Hodgkin's lymphoma. Both antibodies are directed against the CD20 antigen, which is found on the surface of normal and malignant B lymphocytes.

Targeted Imaging for Breast cancer will be available in India in the near future. Trastuzumab (A recombinant antibody against HER2) for HER2 Imaging study is available with Ab fragment to match the Ga-68, which is a Positron Imaging agent.

Molecular Imaging - Hospitals and Healthcare providers' role

Multidisciplinary approaches and cooperative efforts from many individuals, institutions, industries, and organisations are needed to quickly translate multimodality molecular imaging into multiple facets of cancer management. Not limited to cancer, these novel technologies can also have broad applications for many other diseases.

Molecular Imaging and Information Technology

High end imaging modalities need better image management and archival systems. The diagnostic outcome of molecular imaging is necessary to be made available to clinicians treating the patients. Healthcare IT and Molecular Imaging go hand in hand. If one wishes to exploit the real advantage of these systems, one should ensure effective distribution of these images to clinicians and integration with electronic medical records. We have "time-of-flight" PET CT scanner from Philips with Advanced Imaging solution for archival and Tele-radiology from 21st Century Health Management Solutions at Molecular Imaging Centre, Ruby Hall Clinic.

Conclusions

The future of Molecular Imaging is very promising and the Hospitals and other Healthcare providers will need to prepare themselves for this futuristic technology. The investments in infrastructures as well as technology are definitely worth it. Acquiring basic technologies like PET CT scanners can be immediate actions, as this fusion Molecular Imaging has already shown its unprecedented growth in cancer diagnosis and management.

But there should be provisions for expansion of this into a more promising Radioimmuno-based imaging and individualised therapies. Setting up small peptide synthesisers and use of Positron emitter generators like 82Rb, 68Ga will prove its worth in the next five years. These are modules required for Molecular Imaging of Gastro-neuro-endocrine tumors, cardiac perfusion and metabolic imaging.

Molecular imaging will assume an ever more important role in furthering our understanding of human disease and patient care in the future. Strategic planning for investment on MI modalities is key to success.■

ACR (American College of Radiology) primer describes Molecular Imaging in glossary of terms used.
"A growing research discipline aimed at developing and testing novel tools, reagents and methods to image specific molecular pathways in vivo, particularly those that are key targets in disease processes."

Novel tools	**Scanners, coils, hardware etc.**
Reagents	**Paramagnetic materials, radiopharmaceuticals, DNA or peptides.**
Methods to image	**Imaging protocols that make use of TOOLS & REAGENTS to demonstrate cellular functions and processes.**
Disease process	**This is based on assumption that we know Normal in vivo cellular processes.**