The importance of hybrid image

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Introduction

Hybrid image is defined as the merging of two or more imaging technologies into a single, new image form. Typically, this new form is synergistic - that is, more powerful than the sum of its parts. Although some modalities of hybrid images can be used simply to describe anatomy, the most distinctive feature of hybrid images is its potential to show in vivo molecular processes within the anatomical context. Existing hybrid imaging modalities include ultrasound (US) / magnetic resonance imaging (MR), MR imaging / angiography, computed tomography (CT) / angiography, photon emission computed tomography (SPECT) / CT, positron emission (PET) / CT. Most of these modalities have the potential to aid in the development of personalized molecular medicine.

Objectives

This article focuses on some key points, focusing mainly on positron emission tomography / PET / CT computed tomography. Global trends in the acquisition, use and image interpretation practices of hybrid imaging equipment and the introduction of new requirements for medical staff training and clinical prioritization are reviewed. It also highlights the current benefits of hybrid imaging for patient care and continuity of work and the potential of hybrid imaging to advance the development of personalized drugs and molecular medicine.

Hybrid Imaging: A Vital Tool for Molecular Imaging and Personalized Molecular Medicine

Molecular imaging has become an important tool for preclinical as well as clinical research in a wide range of disciplines, including oncology, cardiology, neurology, psychiatry, and pharmacology. Molecular imaging shows a promising future as a tool to accelerate laboratory discoveries in clinical practice and the application of personalized, molecularly targeted drugs.

Molecular imaging can be performed in many different modalities, including CT, MR, MR, SPECT, PET, and optical imaging. With the exception of diffusion weight MR images and MR spectroscopic images, which utilize the image of water molecules and metabolites, respectively, all molecular imaging techniques depend on the use of exogenous probes to provide the image signal or contrast. Probes usually consist of an "affinity" component that interacts with the target and a "signaling" component that provides image contrast. While radiolabeled probes are used for PET or SPECT, the signaling component may be a fluorochrome in the optical image or a chelate containing a paramagnetic atom in the MR image. Regardless of their composition, molecular imaging probes are designed to reveal specific properties that distinguish normal from pathological tissue.

Of the molecular imaging techniques available, PET is currently the most powerful and versatile. Not only does the special physics of PET images make it extremely sensitive and quantitative, but the wide range of radionuclides it emits positrons (e.g., fluorine 18 [18F], carbon 11 [11C], nitrogen 13, iodine 124 [124I], copper 64 [64Cu], gallium 68 [68Ga] and zirconium 89) allow the power of the tracer principle to extend to research and discovery that is relevant to most human diseases and the development of medicine. Essential for the development and implementation of new tracers - and thus for the advancement of molecular imaging - is the extensive biodistribution and biosafety testing of tracers, a process that requires a team effort. As new trackers enter clinical evaluation, the use of hybrid equipment that combines nuclear medicine and anatomical imaging becomes essential. Therefore, the future of molecular imaging will depend on the availability of radiation chemists, radiation pharmacists, and nuclear physicists, as well as physicians whose training combines nuclear medicine, molecular biology, and diagnostic radiology. It is essential to foster a strong working relationship between nuclear medicine and the radiology communities, so that knowledge from both specialties is combined into a rich matrix that supports continuous innovation and optimal patient care.

Although the PET / CT hybrid already has a number of clinically important applications, many more are expected to come to light over the next decade. The increased use of PET / CT is expected to stem not only from greater use of 18F fluorodeoxyglucose (FDG) but also from the introduction of a new radiotherapy army that will enable the discovery of previously hidden properties of human disease and the delivery of “roadmaps” for patient, therapy and disease management.

Promising new PET tracers now range from metabolic substrates, hypoxic agents, neuromechanical transporters, and drugs that utilize the specific metabolism mediating normal and pathological tissue function to monoclonal antibodies, peptides, and molecules that have fine molecular surface specificity detection. and those expressed in disease. In research centers around the world, the number of labeled radiotherapy trackers used for patient care is increasing. For example, from 2005 to 2008 at Ludwig Maximilian University in Munich, Germany, the percentage of all PET and PET / CT studies performed each year with 18F-FDG decreased from 93% to 73%, while the total number of trackers labeled on the radio in use increased from three to nine. The table lists some of the radio trackers that are now being used in clinical research programs around the world.

Radiotracer	Function or Molecular Target
Phenotypic probe	
^{18}F-FDG	Glycolysis
^{11}C-methionine	Amino acid transport
^{18}F-fluorocyclobutane-1-carboxylic acid	Amino acid transport
^{18}F-fluoro-L-thymidine	Cell proliferation
^{18}F-fluorodihydrotestosterone	Androgen receptor
^{18}F-fluoroestradiol	Estrogen receptor
Sodium ^{124}I	Sodium iodide symporter
^{11}C acetate	Krebs cycle, fatty acid synthesis
^{18}F-fluoromisonidazole	Hypoxia
Targeted probe	
^{68}Ga-Fab'2 Herceptin	HER2
^{124}I-cG250	Carbonic anhydrase IX
^{124}I-A33	A33 antigen
^{124}I-3F8	GD2
^{64}Cu-Herceptin	HER2
Reporter gene imaging probe	
^{124}I-2'-fluoro-2'-deoxy-1-β-D-arabinofuranosyl-5-iodouracil	Thymidine kinase (herpes virus)

Although oncology dominates the use of PET images, applications for molecular imaging are also growing in other areas. In a recent survey of members of the European Association of Nuclear Medicine (EANM) (2), 60%, 54% and 40% of respondents reported that their institutions used PET or PET / CT for applications in neurology, infection and / or inflammation, and cardiology, respectively. In these areas, as in oncology, new PET trackers are expected to change the way disease processes are understood and managed. For example, a recent study showed that PET imaging in patients with Dementia with amyloid plaques or receptor ligands may help detect some cases of Dementia earlier than MR imaging, PET, or conventional neurological testing. In many countries, a growing number of neurologists, cardiologists and oncologists are being trained in nuclear medicine because they see the potential of PET / CT imaging and theragnostic to dramatically improve patient care.

Global distribution and use of equipment

Trends in equipment purchase and distribution confirm that PET / CT is globally accepted as a vital clinical imaging tool and a valuable improvement over standalone PET. Today, the highest concentrations of PET and PET / CT units per capita are in the United States (approximately 4 units per million inhabitants) and Japan (approximately 3 units per million inhabitants), followed by Belgium, Luxembourg, Denmark and Switzerland (each with approximately 2 units per million inhabitants). Austria, the Netherlands, Italy and South Korea have between 1.5 and 2.0 units per million inhabitants.

In the past 10 years, installations of PET / CT hybrid systems have virtually replaced those of standalone PET scanners. This trend has been observed globally (Figure 1), and many large equipment manufacturers no longer offer standalone PET scanners. A trend towards the inclusion of multi-section CT scanners in PET / CT systems has also been observed.

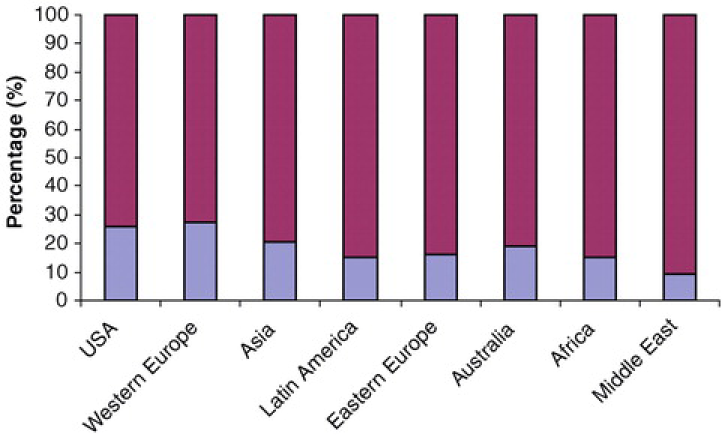
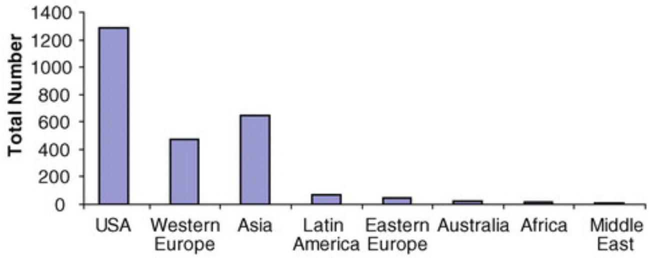


FIGURE 1A: Bar graphs show (a) the percentages of independent PET scanners (blue strips) versus percentages of PET / CT scanners (purple stripes) worldwide and figure 2 (b) the total number of PET and PET scanners / CT worldwide. Data also provided by Maurizio Dondi, MD, PhD, International Atomic Energy Agency, Vienna, Austria, in February 2010, based on surveys from 2009.



From 2001 to 2008, the percentage of PET units installed per year in the United States that were independent PET scanners fell from 60% to 0%. Until 2008, independent PET units accounted for only 26% of all fixed PET units in the United States. Concordantly, from 2005 to 2008, the percentage of PET studies conducted using independent PETs dropped from 30% to 13%.

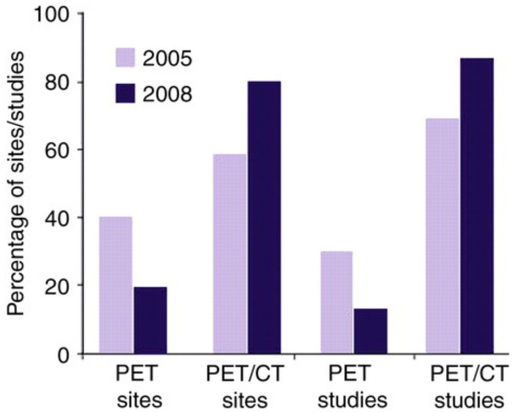


FIGURE 3: The bar graph shows the percentages of PET-only countries and studies versus PET / CT countries and studies in the United States, 2005–2008.

Overall, in the United States, the use of PET and PET / CT has grown at an extraordinary rate in the last 10 years. Surveys conducted by market research firm IMV (Greenbelt, Md) showed an average annual increase of 10.4% in the number of patient studies conducted from 2008 to 2015 in PET and PET / CT in the United States.

The need for comprehensive training in Nuclear Medicine and Radiology

To make optimal use of hybrid images in patient care, the healthcare team must be fully trained in the operation of nuclear medicine and standard radiological ingredients for completing hybrid images. In addition, physicians should be trained to fully interpret the anatomical and molecular data obtained. This section examines global trends in accreditation, training, and prioritization in hybrid images.

Radiology and nuclear medicine are distinct imaging specialties with different areas of applicability. Although training in radiology emphasizes anatomy and pathology, training in nuclear medicine emphasizes biochemistry and pathophysiology. As a survey of members of EANM and the European Society of Radiology (ESR) showed, specialists in both fields generally agree that more comprehensive training is needed to facilitate the optimal use of hybrid imaging.

In training radiologists, subjects particularly in need of greater attention include the radiolucent principles of molecular imaging, the biometrics of tracer use (e.g., separation modeling and dosimetry), and image physics. Such subjects will become increasingly important as radio-based molecular image approaches are integrated into personalized medicine. In contrast, nuclear medicine physicians need more extensive training in cross-sectoral imaging. For example, 4 months - the minimum amount of time devoted to cross-sectoral imaging at nuclear medicine residences in the United States - may not be enough to gain a true skill in modern CT imaging, let alone the full range of studies of cross-cutting images

Financial Aspects

Global Hybrid Image Market Analysis

The research report studies the Hybrid Images market using various methodologies and analyzes to provide accurate and in-depth information about the market. For a clearer understanding, it is divided into several parts to cover different aspects of the market. Researchers have used primary and secondary methodologies to gather information in the report. According to the report, the global market value of Hybrid Images is projected to reach USD 7090.3 million by 2026, from USD 5734.6 million in 2020, with a CAGR of 3.6% during 2021-2026.

This increase in investment that is expected to have in this area still supports the great importance of the Hybrid image in Medicine and patient care.

Conclusion

To realize the full potential of hybrid imaging, different disciplines of clinical and technical expertise must come together. Because the use of PET / CT is growing faster than that of any other hybrid imaging technique, it is particularly important for diagnostic radiologists and nuclear physicians to establish new avenues of collaboration within institutions, nationally, and internationally. Issues to be addressed together include:

- When should hybrid image be used?
- How to ensure quality image and optimal interpretation, clinically important?
- How best to train staff and secure credentials in hybrid image for future practitioners, practitioners, technicians and other healthcare professionals.

Moreover, recognizing that globalization is inevitable, leaders in both specialties need to work towards global standardization of hybrid images to promote rapid information exchange in preclinical research, clinical trials, and patient care.

References

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**This article is a review of several articles speaking out the importance of Hybrid Imaging*