Fusion Imaging: The Current Trends

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***Abstract**: In the present era of multimodality imaging of human body, the present emphasis is on the fusion of information achieved from different imaging modalities. It involves structural as well as functional information about the human body parts and various physiological / patholical processes related to it. The fusion imaging information is ulitimate and it allows not only better understanding of various physiological and diseases process but also helps in monitoring & predicting the course of the treatment and predicting the prognosis. The present article discusses the importance of fusion imaging in detail.*

INTRODUCTION

With the advent of many imaging modalities which assess different parameters of any disease process, fusion of these data has become inevitable for the best understanding of the concerned pathophysiology. Nuclear medicine studies like positron emission tomography (PET scan) primarily assess the functional aspects of the organ and disease process. Similarly, though conventional computed tomography (CT scan) and magnetic resonance imaging (MRI) are considered best in delineating the morphological information about the human body and various disease processes but the newer technical advancements have expanded their scope due to innovations in functional imaging including perfusion, diffusion, spectroscopy, etc. Hence, fusion of functional and morphological information would probably give us the best information. The current article is focused on latest trends, particularly involving PET-CT and PET-MRI. Though, the major impact of these fusion imaging techniques is on oncology patient management yet multiple non-oncological applications that have recently come up are also discussed in the article.

Diagnostic contrast enhanced CT scan (CECT) has become an essential part of PET-CT scans in the current times, unlike in the past, when, only a noncontrast localizing CT with low dose mAs was used. Diagnostic CECT images fused with PET scan images provide both the anatomical as well as functional aspects of the disease process.

MRI with its exquisite soft tissue resolution is the ideal choice for morphological imaging of many tumors, particularly in the central nervous system (CNS) and musculoskeletal system (MSK). Routinely performed technique is to achieve PET and MRI scans [obtaining isometric MR images with as thin a slice thickness as possible (current achievable slice thickness is 0.9 mm)] and fusing them with PET images using various softwares. This technique has limitations including changes in patient's position and different scanning parameters (like FOV, slice thickness) with separate MRI and PET scanning, resulting in erroneous fusion images. Till recently, no vendor was able to achieve a model to acquire data of MRI and the PET on a single table. The General Electric Company has a model where a PET scan is performed on the patient. The table with the patient is transferred to another gantry to acquire MRI data. This appears to be a crude method of PET-MRI scanning and misregistration due to patient movement cannot be countered. However, Siemens has come out with a novel technique of obtaining PET and MRI data simultaneously, so that the misregistration will be countered maximally.

APPLICATIONS OF FUSION IMAGING

PET-CT / PET-MR have multiple applications that can be broadly categorized in to oncological and non-oncological applications as follows:

- Oncological diagnosis & staging
- Non-oncological conditions
  - Ø Neurological diseases
  - Ø Infection & Inflammation especially in PUO
  - Ø Myocardial viability assessment
  - Ø Guiding percutaneous interventions

ONCOLOGICAL APPLICATIONS

Ø F18-FDG used for detection of osseous metastases is more sensitive than MDP bone scans. It gives an extra-advantage of detecting occult primary and associated visceral & unsuspected metastases in addition to osseous metastases (figure 1)[1].

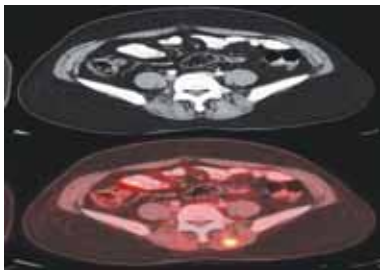

***Figure 1:** PET-CT (lower two images) show unsuspected metastatic lesions with corresponding CT images (upper two images).*

Ø F18-FDG is used to assess the metabolic activity of malignant lesions. Many non-malignant conditions like infection and inflammation can be evaluated by this technique. This can also be used for evaluation of treatment response[2].

Ø Ga68-DOTA-NOC scan is used to identify tumors expressing somatostatin receptors, most common among them being neuroendocrinal tumors[3].

Ø F18-choline is used to identify any lesion with high choline (which is a cell membrane proliferation marker) content, similar to MR spectroscopy. Latter has several technical limitations[4].

Ø F18-angiography can be used for assessing the neovascularisation of the tumors, similar to CT and MR perfusion. CT and MR perfusion scans are technically limited as whole body scan is not possible.

Ø PET-MRI has applications mainly in head and neck imaging especially in CNS tumors (figure 2)[5, 6].

NON-ONCOLOGICAL APPLICATIONS

Ø **Neurological applications:** Apart from neuro-oncology, fusion imaging has applications in epilepsy and dementia imaging[7]. Among the neurological diseases, CT and MR studies detect unsuspected clinically significant lesions in only 5% of patients of dementia. However, PET-CT has been found useful in evaluating patients with multi-infarct

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