Molecular Oncologic Imaging

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Evolving Nuclear Medicine; Changes in Daily Practice and Future Outcomes

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ABSTRACT

The Nuclear Medicine practice is based on diagnostic and therapeutic directions which are always prone to the improvements due to close interaction with technology. The revolutions in Nuclear Medicine brought recent advances day by day to the daily practice and becomes the way it is. Today Nuclear Medicine preserves the role in the treatment of Differentiated Thyroid carcinoma by I-131 as well as new treatment options by new radiopharmaceuticals like Lu-177 and Ra-223 exists. Imaging of Tc-99m labelled compounds preserves their role in imaging as well as the growing role of F-18 FDG PET/CT is supported and re-directed by recent advances on FAPI and FDG PET/MR in the field of Oncology. While sentinel lymph node imaging during oncologic surgery becomes the standard procedure recent advances provides intraoperative gamma imaging by real time imaging procedures.

1. Introduction

Nuclear Medicine studies are always informative imaging modalities and reasonable therapeutic options in Clinical practice. In the recent years increased distribution of the PET/CT scanners provided accurate management of the Oncology patients and Nuclear Medicine Imaging became the cornerstone of Oncology. The introduction of the recent Coronavirus infection in routine practice brought some drawbacks as it is in all the field of Medicine to the Nuclear Medicine. Elimination of some of the imaging modalities in daily practice forced the Nuclear Medicine physicians a new understanding of the routine imaging modalities. Despite the pandemic issues recent advances takes place with an expected speed.

FDG

The oncological imaging by means of PET/CT depend mostly on the Fluorodeoxyglucose (FDG) PET/CT imaging. This modality has become the reference imaging method in determination of primary tumor, staging-restaging of a known primary malignancy as well as treatment response evaluation. There are some non-FDG avid tumors including prostate cancer and Hepatocellular carcinoma but most of the malignant tumors do accumulate FDG. This tumor specific agent unfortunately is also accumulated in inflammation and infection. Although this property is a problem in oncologic imaging, specific precautions (delay of the imaging after operations or after treatment of infections) prevents these false positive interpretations. Today PET/CT scanners are almost mandatory for cancer imaging.

Ga-68 PSMA

Since FDG has low affinity for certain cancer types new radiopharmaceutical had to be employed in those tumors imaging including prostate cancer. The introduction of Ga-68 prostate specific membrane antigen

(PSMA) imaging by means of PET/CT is the gold standard imaging modality in prostate cancer patients. Ga-68 PSMA PET/CT and additional Lu-177 treatment brought the common methodology (teranostic approach) in the prostate cancer management. Teranostic approach existed in the treatment of Differentiated Thyroid Cancer by I-131 treatment for many years before. This means the previous observation of the possible treatment of the radiopharmaceutical before the treatment with specific imaging agents. Thus, both diagnostic and therapeutic options have become the standard for the prostate cancer. The guidelines recommend to use Ga-68 PSMA imaging in biochemical recurrence, primary staging of high-risk patients (Gleason score>7, PSA>20ng/ml and T2c-3a), before the radionuclide therapy, targeted biopsy and treatment response evaluation (13).

Neuroendocrine Tumors

Somatostatine reseptor targeted imaging (SSTR) has been used for the Neuroendocrine tumors for many years by means of gamma cameras. Adaptation of this imaging modality to PET/CT as Ga-68 DOTA-SSR radionuclide imaging improved the effectiveness of the method. Teranostic approach was also applicable to the Neuroendocrine tumors as well. The SSTR PET/CT imaging has changed patients' management significantly according to previous reports (3). However recent studies in Neuroendocrine tumors showed that FDG PET/CT as well as Ga-68 DOTA-SSR imaging might be complementary because the FDG and DOTA affinity of the tumors depend on their Grade (10).

FAPI

Fibroblast activation protein-α (FAPα) has been determined to have increased expression in the surface of multiple malignant cell types. This protein associated imaging options (FAPI PET/CT) is another promising imaging modality according to recent studies (9). Previous studies have shown superiorities over FDG PET/CT in many cancer types except myeloma and lymphoma (4). Recently Rathke et al. reported preliminary results of the first treatment with Y-90 FAPI in metastatic breast and colorectal cancer patients (7).

PET/MR

PET/MR imaging systems are newly introduced however promising imaging modalities. The recent guidelines and the expectations of longer survey related to new drugs in the field of oncology brought some concerns about the radiation damage of the current imaging modalities especially of children. PET/CT related doses were not problematic because of the option to decrease/adjust doses of the CT component which produce significantly lower doses compared to the contrast enhanced conventional CT imaging. However, the cumulative effect of the multiple scans during the lifetime of an oncology patient was some kind of issue in especially young adults and children. Additional advantages of the PET/MR systems were especially imaging of the certain organs like brain and liver.

The MR images of the PET/MR systems are no different compared to the single MR devices (6, 2). Previous researchers determined significant advantages and improvement of patient management in 8% of the patients by PET/MR compared to PET/CT especially alterations of the diagnosis in brain and liver parenchyma (5). Although the superiority of PET/MR over MR alone is obvious (1) there uncertain results overall significance of the change in patient management by PET/MR in comparison with PET/CT (8). PET/MR has significant improvement in characterization of gynecologic malignancies (12).

Treatment response evaluation

The most important aspects of Nuclear Medicine is the evaluation of treatment response in Oncology. Recent advances in drug development like generation of immunotherapy needs special response evaluation methods including anatomic and metabolic imaging and special attention in estimation (14).

Novel treatments

The Ra-223 treatment for metastatic castration resistant prostate cancer has documented to improve both overall survival and patient quality of life according to recent studies (11). However, there is a significant need for the proper treatment response evaluation criteria for this new treatment modality.

Research Interest

There is significant improvement in the variability of radiopharmaceutical thus there is a plenty of research interests exists in Nuclear Medicine. However due to the radiation exposure related to the imaging modalities the prospective studies are limited. The retrospective studies are prone to selection bias as well as improper patient

follow up results. The robust scientific information might be obtained by animal studies in order to verify or exclude possible advantages and disadvantages of the new radiopharmaceuticals and imaging modalities in the future as it is previously.

Author contributions:

Zehra Pınar Koç: Conceptualization, Methodology, Software, Data curation, Writing-Original draft preparation, Software, Validation, Visualization, Investigation, Writing-Reviewing and Editing.

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