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The Technical Principle of the Combination of Positron Emission Tomography and Multi-slice Spiral CT and its Role in Tumor Therapy

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Abstract

This paper systematically and comprehensively analyzes the composition, characteristics and technical advantages of positron emission tomography and CT. Through its application in clinical practice, it further highlights the combination of the advantages of positron emission tomography and CT.

Keywords

PET; CT; Tumor Therapy.

1. Introduction

According to the detection structure, the positron coincidence detection equipment is divided into two types: the ring structure positron coincidence detection equipment (PET) and the single photon detection function (SPECT). The attenuation correction using X-ray CT can significantly improve the imaging speed and image quality. The use of multi-row CT images to perform image fusion on the same machine can improve the accuracy of clinical diagnosis, which represents the development direction of nuclear medicine imaging equipment.

2. PET Composition and Advantages

The detector is an important part of the positron compliance detection equipment. The detector is usually composed of a filter, an isolator, a crystal, a photomultiplier tube (PMT) and a subsequent electronic processing system. The crystal of different materials has different effects on the performance of the detector. , different crystals have their own advantages. The biggest advantage of NaI is that the light output is the largest, and a small-diameter PMT can be used to improve the inherent resolution of the system; BGO has the largest crystal density, which can improve the count rate or sensitivity of the system; LSO crystal has the shortest light afterglow, which can improve the count rate and shorten the imaging time. time; GSO crystal has better energy resolution, which can effectively eliminate scattering and improve image quality.

Positron coincidence detection devices have two detection modes: two-dimensional (2D) and three-dimensional (3D) acquisition modes. During 2D acquisition, a collimation grid is added in front of the detector. The application of the collimation grid enables the detected electron pairs to be calculated in a small field of view , and the quantitative analysis is more accurate. 3D is the calculation of electron pair coincidence in the full field of view, which increases the detection count rate and is suitable for clinical applications during fast scanning, but the scattering fraction increases significantly. With the development of hardware and software technology, the shortcomings of 2D and 3D acquisition will be improved to varying degrees.

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3. Structural Characteristics of PET/CT and the Role of CT in PET/CT

The characteristics of nuclear medicine imaging or the biggest advantage over other imaging diagnostic techniques such as CT and MRI is that nuclear medicine imaging reflects the function of organs, the biochemical metabolism of tissues (including intracellular), and the density of cell receptors and other functional molecules. However, the biggest deficiency of nuclear medicine imaging or the bottleneck affecting its clinical application and development is that nuclear medicine imaging cannot accurately locate lesions or reflect the anatomical structure of human tissues and organs. In other words, various imaging techniques have commonalities and also have their own characteristics or advantages. Imaging in the 21st century is moving towards integrating the advantages of all imaging techniques to form a new type of imaging. There is no doubt that nuclear medicine imaging in the new century will be an era of fusion of functional molecules and anatomical structures.

Positron coincidence detection imaging has the characteristics of high sensitivity and high specificity, and is mainly suitable for functional metabolism and molecular imaging, but the image resolution is low and lacks clear anatomical structures; while multi-slice spiral CT can provide accurate morphological and anatomical image details ,The combination of positron coincidence detection equipment and high-resolution X-ray multi-slice spiral CT can combine their respective advantages to achieve complementary advantages at a higher level. The integrated positron coincidence detection device with multi-slice spiral CT Including PET/CT and SPECT/CT two categories. As far as the technical structure of PET/CT is concerned, it is actually an organic combination of PET and multi-slice spiral CT systems through the same gantry . In addition, the CT data can be used to perform attenuation correction for positron imaging, and more importantly, the two-dimensional, three-dimensional and four-dimensional image fusion of online PET and CT can be freely realized on the same computer image acquisition and processing platform. During one scan, the patient does not need to move. After one scan, two images of anatomical structure and functional metabolism can be obtained at the same time. The two data do not need to be converted. The anatomical structure information provided by CT can be accurately matched with the PET image. Fusion is not only extremely convenient, but also very accurate, and the image diagnostic information provided is also more complete and accurate.

The basic functions of multi-slice spiral CT scanning in PET/CT are as follows: (1) The CT value is converted through a specific mathematical model to perform attenuation correction on the PET image, which significantly shortens the inspection time of positron detection imaging and enables the equipment to work. The efficiency is significantly improved, and the quality of PET imaging is improved; (2) CT images are used for anatomical localization and differential diagnosis of radioactive concentrated lesions, which significantly improves the detection rate of small lesions and reduces the false positive rate of positron detection imaging. , and distinguish normal variation or physiological radioactive uptake phenomenon, avoid the problems of underdiagnosis and overdiagnosis that may occur in conventional PET, and enhance the accuracy of PET diagnosis; (3) Use PET/CT fusion images on the same machine to perform biological target detection (4) Under the real-time guidance of low-dose CT, perform needle biopsy and interventional treatment for abnormal radioactive concentrated lesions seen by PET.

4. Application Advantages of PET/CT Fusion Technology

4.1 The Role of PET/CT in Precision Radiotherapy of Tumors

Modern precise tumor radiation therapy technology makes full use of modern accelerator technology, computer technology and imaging technology to accurately locate and quantify the tumor treatment range and radiation dose. "Conformal" requires a sharp reduction of radiation dose beyond the edge of the tumor biological target volume to reduce normal tissue damage, while "intensity modulation" requires a reasonable distribution of radiation physical dose within the target volume according to the requirements of tumor radiobiological effects. The application of PET/CT technology combined with

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a variety of positron electron tumor imaging agents (such as reflecting tumor hypoxic metabolism, protein metabolism, nucleic acid metabolism, receptor distribution and oncogene or tumor suppressor gene expression, etc.) Diversified or multi-dimensional tumor bioimaging information from the structure to the microscopic cellular and molecular level, including the spatial location of tumor tissue and the demarcation of normal tissue,

The characteristics and invasiveness of tumor angiogenesis, the heterogeneity of cancer cells and cell cycle regulation, the difference of radiobiological effects of tumor tissue in the target area, the root cause of tumor residue and metastasis during treatment, etc., especially for PET/CT. Precision radiation therapy planning can closely combine the physical conformity and biological conformity of radiation therapy dose distribution, which meets the requirements of modern tumor precision radiation therapy technology, and achieves precise positioning, precise planning and precise planning at the level of tumor tissue morphology and molecular biology. Precise exposure.

4.2 CT Tumor Perfusion Imaging Combined with PET Tumor Functional Metabolic Imaging

Conventional CT enhanced examination shows the richness of the lesion vascular structure or blood supply (and the integrity of the blood-brain barrier in the brain), which is not accurate enough for judging the nature of the lesion. Multi-slice CT perfusion technology can display various parameters (not only morphological information), and reflect the biological characteristics of the vascular structure of lesions or organ parenchyma in more detail. Blood flow velocity, blood flow, average transit time, etc. These indicators are helpful for tumor diagnosis, prognosis judgment and selection of treatment methods. If multi-slice CT perfusion technology and PET function are combined

Combined with metabolic imaging, it can significantly supplement and confirm functional molecular imaging of nuclear medicine such as hypoxia imaging, metabolism and receptor imaging; for example, tumor CT perfusion is low and FDG imaging is concentrated, reflecting the poor blood supply of tumor. This kind of multi-level functional metabolic information integration and analysis idea has great clinical value in improving the specificity and accuracy of disease diagnosis.

In addition, the surface penetration imaging system is a new multi-slice CT information display technology. Conventional CT enhancement examination shows the inflow and elimination information of contrast agents in the tissue or diseased vascular structure. Surface penetration imaging adopts the method of delayed scanning. , compared with images of different phases, it reflects the exudation of contrast agent on the surface of tissue or lesions. This kind of information combined with dynamic and delayed imaging of organ nuclide has great clinical diagnostic value.

References

[1] Analysis of the diagnostic value of PET/CT comprehensive analysis method combined with density ratio in NSCLC with mediastinal lymph node metastasis [J]. He Tao, Li Yufeng, Wang Huan, Sun Jiangming, Yao Yutang. Journal of Medical Imaging. 2020(09).

[2] The value of 18F-FDG PET/CT in differential diagnosis of benign and malignant hilar and mediastinal lymph nodes with different densities in patients with non-small cell lung cancer [J]. Zhang Yuyi, Yao Zhiming, Xue Qianqian, Chen Congxia, Li Xu, Liu Xiuqin. Chinese Journal of Nuclear Medicine and Molecular Imaging . 2020(09).

[3] Interpretation of the update of the 2020 V1 "NCCN Clinical Practice Guidelines for Non-Small Cell Lung Cancer" [J]. Zhang Jiahao, Zhang Yajie, Li Hecheng. Chinese Journal of Thoracic and Cardiovascular Surgery. 2020(06).

[4] Application of 18F-FDG PET/CT quantitative analysis of various parameters in the identification of mediastinal lymph node metastasis in non-small cell lung cancer [J]. Li Xiaodong, Zheng Xiaomeng, Fan Ruyi, Dong Xi, Cao Yanxia. Hebei Medicine. 2020(07).

[5] The value of 18F-FDG PET/CT primary tumor metabolism parameters and mediastinal lymph node SUVmax in predicting mediastinal lymph node metastasis in non-small cell lung cancer [J]. Li Xuerong, Xiao Xiong, Feng Hongyan, Bu Lihong. Journal of Practical Medicine. 2019(23).

ISSN: 2414-1895 DOI: 10.6919/ICJE.202205_8(5).0083

[6] Application value of 18F-FDG PET/CT image texture analysis in non-small cell lung cancer [J]. Zhang Bin, Ma Yubo, Geng Yanfang, Zhou Bing. Journal of Clinical Radiology. 2019(10).