REVIEW

Clinical Imaging Technology and the Diagnosis in Patient-centered Interdisciplinary Care

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Abstract : Clinical imaging examinations and the diagnosis of their findings play an important role in patient-centered interdisciplinary care. Clinical imaging tests, such as X-ray, computed tomography (CT), magnetic resonance imaging (MRI) and nuclear medicine scans, are performed both in the initial diagnosis to identify the disease and at follow-up with the radiology team. Imaging technology is advancing day by day, both the hardware and software. CT and MRI are useful for confirming the size and location of lesions, providing what is known as morphologic images. CT can perform whole-body imaging very quickly, and the huge data are reconstructed in many ways with advanced computer systems. Three-dimensional CT, such as virtual colonography and bronchography, is useful for planning the approach before surgery or endoscopic study. MRI is useful for detecting acute cerebral infarction and evaluating brain perfusion or brain metabolites using MR spectroscopy. Fluorodeoxyglucose-positron emission tomography (FDG-PET)/CT is a molecular imaging modality mainly used in oncology for the initial diagnosis, staging and detection of recurrence or metastasis after treatment as well as the evaluation of the treatment response. The focus of this paper was to elucidate the types and use of clinical imaging technologies, with a focus on CT, MRI and FDG-PET. J. Med. Invest. 66 :31-34, February, 2019

Keywords : *clinical imaging technology, CT, MRI, FDG-PET/CT*

INTRODUCTION

Clinical imaging examinations and the diagnosis based on their findings play important roles in patient-centered interdisciplinary care. Three topics are described : team radiology, advances in diagnostic systems, and clinical imaging examinations and its diagnosis such as MRI, CT and FDG-PET. Team radiology consists of many members. When patients come to the radiology reception area, medical clerks welcome them with smiles. They make them feel calm. Subsequently, nurses participate as team members by directly caring for the patient before and after radiological examinations, whereas radiological technologists perform the most accurate examination, pertaining to time duration, decreased radiation exposure, and better image quality. For Positron Emission Tomography (PET) scan, medical engineers and pharmacists generate fluorodeoxy glucose every morning.

Advances in diagnostic system

In the practice of radiological imaging about 25 years ago, the product of the examination was a print out of the object using film processing. The film view box was used to peer through the film and hand-written reports were made. These processed films were kept and stored in a film jacket. However, today, scanning process has allowed a shortened time frame and, images are displayed on the computer monitor almost instantaneously and saved as an electric data within the hospital information system (HIS) server. Huge data are saved in these computers.

Radiologists interpret these images on the monitor which are connected to patient medical records via the HIS making electronic reporting easy and less cumbersome. Consequently, through technological advancements, Radiology has changed from a fully film-based practice of patient care record to a filmless and paperless HIS system.

Clinical imaging examinations and its diagnosis

Computerized Tomography (CT) or Magnetic Resonance Imaging (MRI) are continually being referred to as types of "morphologic imaging," demonstrating the size and location of a lesion with adequate density or intensity. However, PET is a molecular imaging modality that can clarify the metabolism, function or activity of the lesion. Some images of a pancreatic cancer exhibit in Figure 1. The pancreatic cancer appears as a low density nodule on CT and as a signal defect on magnetic resonance cholangio-pancreatography. This pancreatic cancer shows a very intense FDG (fluorodeoxy glucose) uptake, indicating that the tumor's metabolic activity is very high. However, MRI machines are themselves a huge magnet with a cylindrical cavity at the center. Any magnetic items such as scissors, hair pins, cardiac pacemaker, coins or credit cards need to be put off before entering the MRI scan room.

For patients with stroke, the selection of an optimal imaging examination is very important. Images produced by CT and MRI of a patient's brain with left hemiplegia two hours before hospital admission is exhibited on Figure 2. The sequence of the MRI data are called "diffusion weighted image (DWI)" and shows the lesion of impaired water molecule movement as high intensity. On the other hand, identifying the abnormal lesion on CT is a little difficult. This patient was diagnosed with acute cerebral infarction in the territory of the right middle cerebral artery. Figure 2-c is an image called MR angiography. This sequence data can show the artery as high intensity without a contrast material. The stenosis of the right middle cerebral artery is clearly demonstrated, while the blood supply decreased and the area is found to be ischemic, and the brain infarcted. MRI is very useful towards diagnosing acute cerebral infarction, especially with diffusion weighted images and

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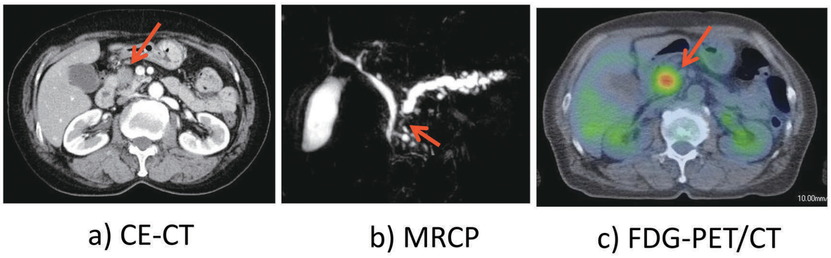

Fig. 1 Pancreatic cancer

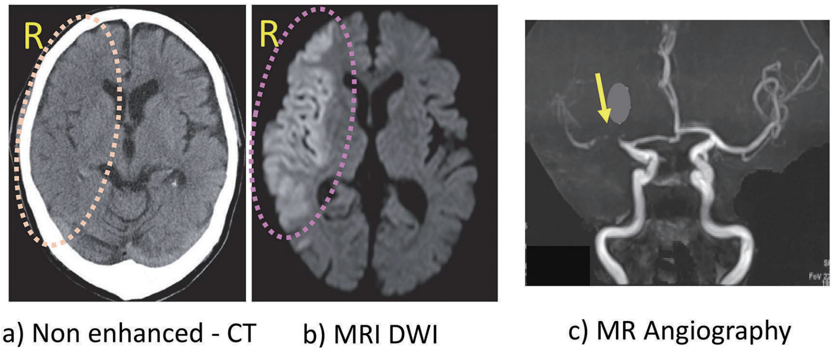

Fig. 2 Acute cerebral infarction. Right middle artery stenosis.

MR angiography.

What about the usefulness of CT in patients with stroke? Figure 3 exhibits the images of a patient with severe headache. Figure 3 exhibits abnormally high density images of the left thalamus and left lateral ventricle. The patient is diagnosed with acute cerebral hemorrhage. CT can demonstrate acute hemorrhage so clearly.

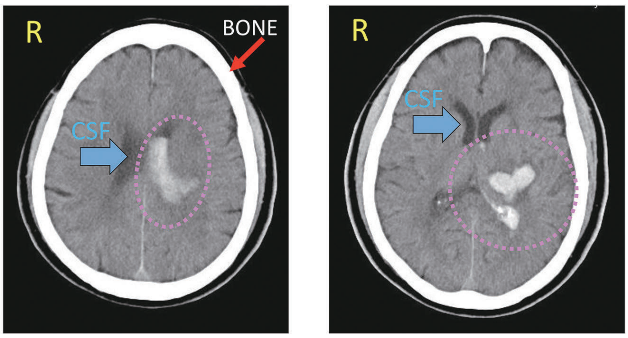

Fig. 3 Hemorrhage in thalamus

A CT scanner is shaped like a doughnut. Contrast material is used in some kinds of diseases. A CT scan can diagnose a variety of common and uncommon conditions in the physical body. Today, modern CT scanners can move quickly and can take images of a patient in well under a minute.

CT scanners have an x-ray tube and detectors are set inside the CT scanners directly opposite each other. The x-ray tube and detectors continuously spin around the patient while scanning. In some disease conditions, Iodine contrast material is intravenously injected to evaluate tumor vascularity, vessel disease, such as aneurysm and many other conditions. In this situation, the nurse inserts a small catheter into the patient's arm vein and contrast media is injected. The Radiology technologist scans and reconstructs many images. Both the nurse and the technologist care for the patient during the entire examination. One caution when using contrast media is to check the patient's renal function as these are excreted through the kidneys in the form of urine.

Figure 4 shows three CT images signifying hepatocellular carcinoma (HCC). It is difficult to pick up the tumor without contrast media, but HCC shows contrast enhancement and is clearly

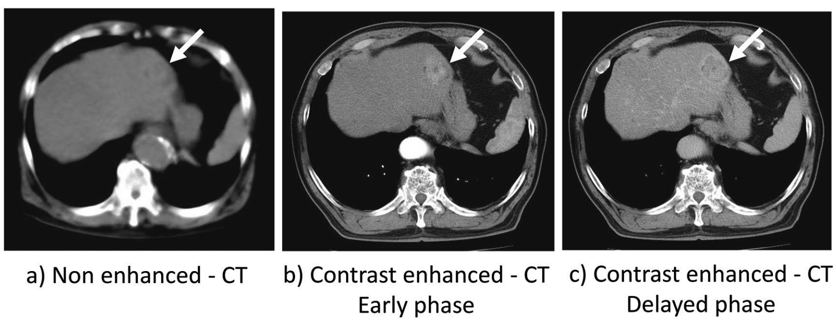

Fig. 4 Hepatocellular carcinoma

demonstrated as high density on the early phase of dynamic CT image.

Figure 5 shows images of the lung cancer patient. This was a 60-year old male patient with an abnormal lesion on the left lung found on chest x-ray examination. The tumor was located at the left lung upper lobe, size 3.9 cm in diameter, attached to the chest wall, thereby the suspicion of invasion to the chest wall. With heterogeneous contrast enhancement, this showed a lesion consistent with necrosis or a degenerative change. After scanning, Radiology technologists produced many kinds of 3D-images. Figure 5-c,d are 3D-images of the left lung. The red vessel is the pulmonary artery, blue one is the pulmonary vein, and the light green is the trachea and bronchus. And purple section is the lung cancer. Anatomical location of the lung cancer, relationship between the tumor and vessels, and bronchus are clearly visualized and allows observation of the tumor from any directions.

Figure 5-d is called virtual bronchoscopy imagery. This image gives much information prior to the bronchoscopy procedure and preoperative planning. It illuminates the best way to approach the tumor. Evaluation of the tumor can use both virtual bronchoscopy and 3D-image movie. To produce these images, do not require additional radiation exposure. The reconstruction time is about a minute. This patient had FDG-PET/CT scan for further examination.

Clinical indications of FDG-PET in Oncology

FDG is the abbreviation for fluoro-deoxy glucose, an analogue of glucose containing a positron-emitting radioactive isotope, fluorine-18, substituted for the normal hydroxyl group at the 2' position. PET is the abbreviation of positron-emission tomography. Clinical indications of FDG-PET in oncology focus on the initial diagnosis / staging and follow up as re-staging. These factors are critical information in order to select the best treatment option such as surgery, chemotherapy, radiation therapy and their combinations.

FDG-PET is useful to detect the recurrence or metastasis after some treatment, and to monitor the treatment effect such as chemotherapy for malignant lymphoma. FDG-PET has an advantage in differentiating malignant lesion from benign. Malignant tumor needs much more glucose compared to benign lesion. The patient is asked to fast for at least six hours to avoid exercise on the day before PET and if the patient is diabetic, to skip treatment for diabetes mellitus on the day of the examination. Before FDG injection, the blood glucose level is examined. The presence of a high glucose level (> 150 mg/dl) may lead to underestimation of the lesion.

Physiology of FDG Uptake

After FDG injection, the patient rests on a bed or sofa for one hour. During this resting period, the FDG gradually accumulates in normal organs and in the disease sites with high glucose uptake. Both glucose and FDG enter the cell via the glucose transporter expressed on the cell membranes and are phosphorylated by hexokinase. Glucose-6-phosphate is metabolized to energy via metabolic pathways. However, FDG is not metabolized from FDG-6-P and stays in the cells. This is called metabolic trapping. FDG is a glucose analogue, so it is physiologically taken up by tissues such as the brain, heart, liver and so, and is excreted in the urine. Malignant lesions require more glucose than normal tissues, and exhibit more intense FDG uptake as a result. Inflammatory lesions also utilize more glucose than normal tissues, and inflammation and malignancy must be differentiated in clinical practice, but sometimes it is difficult.

After voiding, the patient goes into the scan room and lies on the couch. The scanner moves toward the patient. This part shaped like a donut is the CT scanner, and the square shaped part is the PET scanner. The scan starts with a localized image, and the CT imaging follows. The CT part takes less than 1 min. The PET scan follows the CT and takes about 20 min. Both CT and PET scans are obtained under free-breathing conditions, and the total examination time is less than 30 min.

Determining and Describing the Imagery

PET/CT machine is a hybrid system comprising a PET scanner and CT set in line with the scanner. Both biological and morphological information during a single session can be obtained and can the two images can be fused on the monitor to more comprehensively understand the location and activity of the lesion. Benign lesion utilizes less glucose than malignant lesion, showing faint to moderate FDG uptake. Both glucose metabolism and morphologic findings of this nodule in a single image (PET/CT fusion image) can be visualized. FDG-PET is a powerful tool to differentiate malignant from benign.

As to the imagery produced by PET/CT, the left lung cancer of the aforementioned patient showed very intense FDG uptake and bilateral hilar lymph nodes were shown as bright spots. No other distant images suggesting metastases were suggested. However, physiological brain high uptake of glucose may mask abnormal lesions such as brain metastasis, therefore, it is important to include brain MRI with contrast agent. In lung cancer, the tumor can show very intense FDG uptake with SUVmax22.1. SUV is an abbreviation of standardized uptake value, and the larger the number, it signifies that the glucose metabolism has increased dramatically. Intense uptake is appreciated as malignant. However, when using the gadolinium-enhanced MRI, no brain metastasis was evident.

Summary

Correct diagnosis and tumor staging with the combination of some clinical imaging examinations such as CT, FDG-PET and brain MRI can be reached for the purpose of determining accurate diagnosis and prognosis of patient condition. Described were the utilization of clinical imaging technologies for the diagnoses and appropriate treatments of tumor conditions. The focus of this paper was to elucidate the types and use of clinical imaging technologies, with a focus on CT, MRI and FDG-PET. At the Tokushima University Hospital, the radiology team does its best to support patient care through the competent use of advancing clinical imaging technologies in order to know persons more fully as persons.

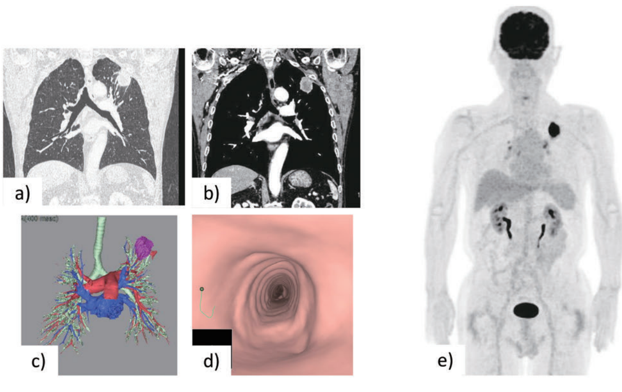

Fig. 5 Lung cancer d) Virtual bronchoscopy

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CONFLICT OF INTEREST

None

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