

Analysis of radiation measurement of FDG radiopharmaceuticals and the development of medical image processing techniques

Chenghui Shao¹, Shuangshuang Xu¹, Yang Song² and Dong Zhu^{3*}

¹College of Mechanical Science and Engineering, Jilin University, Jilin, China

²School of Mechanical Engineering, Tianjin University of Technology, Tianjin, China

³The First Hospital of Jilin University, Jilin, China

Abstract: This paper based on the theory of radiopharmaceuticals and the theory of radiation risk prediction, the author mainly studies the dose distribution of F-FDG and its radiation risk. Through the assessment of the risk of radiation carcinogenesis, the effective dose range was 4.61mSv to 8.97mSv, and the range of radiation carcinogenic risk was 1.57×10^{-3} - 3.14×10^{-3} . Also, we reviewed the development trend of medical image processing techniques, and the development of medical imaging processing in three-dimensional (3D) medical imaging visualization and PACS-based medical imaging compression is introduced.

Keywords: Radiopharmaceuticals, medical image, 3-D medical Image visualization.

INTRODUCTION

Positron emission tomography-computed tomography (PET/CT) has realized the integration of PET and CT two kinds of devices with the integration of the two kinds of images, and has formed the advantage of the complementary of the two advanced technologies. F-FDG is widely used in clinic as the imaging medicine, and the patients are injected into the human body, so that the examinee becomes an open source, which brings the radiation influence to the recipient, the family member and the related staff. From the domestic and foreign literature reports, the research on the diagnosis of the more, but for the prosecution, family members and medical staff to accompany the reported dose of less. Based on the experimental data, the distribution of FDG in vivo was studied, and the corresponding risk of radiation carcinogenesis was estimated. F-FDG, as a non tumor specific imaging agent for glucose metabolism, has a certain degree of false positive and false negative. As a single tumor imaging agent, F-FDG is still the most widely used in clinic at present, and no other imaging agents can replace its position in the development of tumor imaging.

The medical image can be roughly classified into two categories, one is to provide the normal anatomy and pathology and disease information as the representative of the anatomical image, such as X-ray, CT and ultrasound classic; the other is the physiological information and to provide information about the molecular and functional imaging as a representative, such as the radionuclide imaging and functional MRI. In the past two decades, medical image has become one of the fastest developing fields in medical technology (fig. 1, fig. 2). It allows

clinicians to observe lesions within human body in a more direct and clearer way and to make more accurate diagnosis (Divani *et al.* 2015; Duzagac *et al.* 2015). In the early 1970s, the invention of CT triggered a revolution in the field of medical image. Meanwhile, magnetic resonance imaging was also undergoing progressive development. Computer and medical image processing techniques, as the foundation for the development of these imaging techniques, have brought a profound reform in modern medical diagnosis. With the clinical application of various new medical imaging methods, great progresses have been made in medical diagnosis and treatment technology. In addition, the complementary information obtained from various imaging techniques provides a solid scientific basis for clinical diagnosis and biomedical research (Dagher *et al.*, 2015; Damyanov *et al.* 2015; Pergialiotis *et al.* 2015; Pistevou-Gombaki *et al.* 2015). Therefore, medical image processing techniques have always been the research area that is highly regarded by domestic and foreign experts.

F-FDG is a complex process in vivo metabolism, its distribution directly affects the radiation level of the subject's size, which has been widely used SUV semi quantitative analysis of radionuclide FDG in different subjects of drug metabolism and distribution in vivo. Differences in the distribution of drugs in various tissues and organs is the main cause of tissues and organs in different SUV, then SUV is also related to a variety of factors, such as height, weight and blood sugar level subjects. Subjects and healthy subjects of the main tissues and organs with lung cancer SUV to study F-FDG in tumor. Patients and healthy subjects distribution in vivo, and analyze the effect of body weight, height and blood glucose concentration on SUV has important significance, has a certain reference value for clinical diagnosis.

*Corresponding author: e-mail: zhudongcn@126.com

MATERIALS AND METHODS

Clinical experiment

During the ten months of clinical trials, we measured 45 cases of lung cancer subjects and 22 healthy subjects of the cerebral cortex, basal ganglia, brain matter and normal lung tissues, lung tissue (lung cancer subjects), SUV and CT in renal cortex, renal pelvis, bladder, muscle and bone values. Height, body weight and blood glucose concentrations of subjects were measured, and the net activity injected into the body of the radioactive drug F-FDG. Among the 45 cases of lung cancer, among them, the male was 32, and the female was a total of 13 people, aged from the age of 25 to the age of 84. Among the 22 healthy subjects, there were 9 male and female subjects, aged from 34 to 60 years old. The experimental instrument is Discovery STE16 PET/CT, which is produced by GE company of America. It is composed of three parts: the platform, the worktable and the operator console.



Fig.1: Anatomical imaging

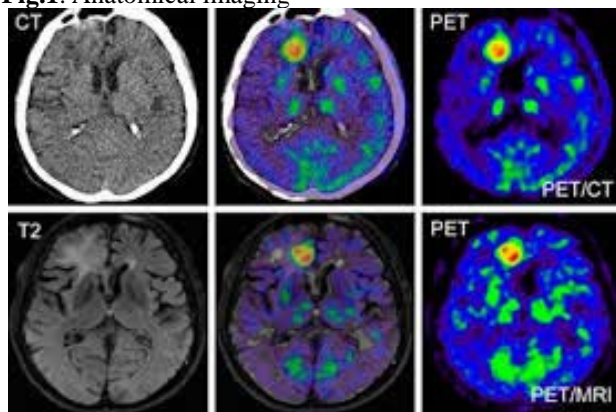


Fig.2: Functional imaging image

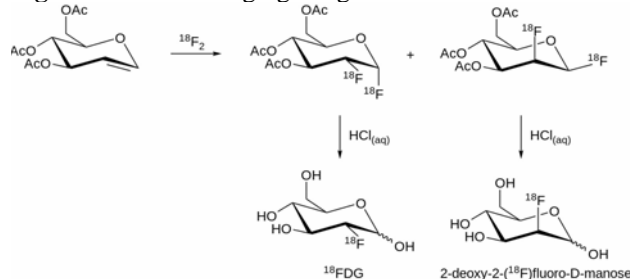


Fig.3: Fludeoxyglucose F 18 Injection.

Dose rate measurement

Approved by the ethics committee of the hospital, all patients signed informed consent before surgery. The subjects underwent PET/CT examination in the injection of radioactive drugs for half an hour or so, the experimental subjects in 12 cases of PET/CT after F-FDG injection, 10minutes, 20minutes and 30minutes, the distance for air dose of 2meters 2.5meters and 3meters under the condition of the subjects surrounding rate measurement in choice a separate room. The measuring instrument used in the experiment is nano SPEC Pro multi channel analyzer produced by Target company of germany. The spectrometer consists of a scintillator (Na I crystal), photomultiplier tube, high voltage, nuclear electronics, touch palm computer (also can choose external computer), power adapter, wire, data wire, etc.

Pathway of the radiopharmaceutical

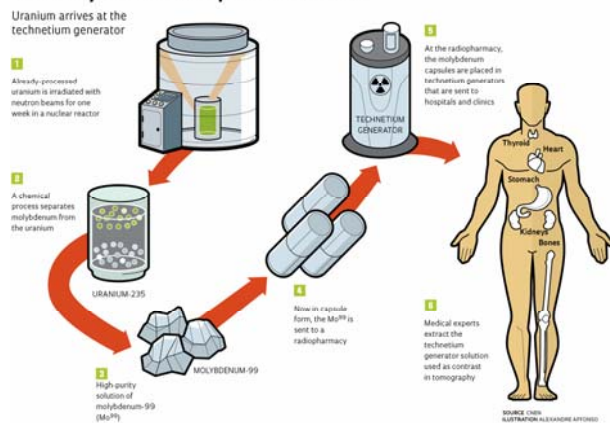


Fig. 4: Path way of radiopharmaceuticals

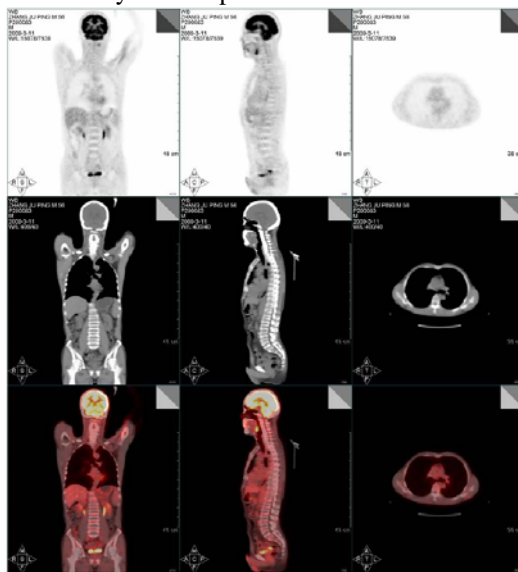


Fig. 5: Distribution of F-FDG in healthy subjects after half an hour of injection.

Medical image processing technology

Medical image processing technology includes many aspects. This paper mainly introduces the application and

development of image segmentation, image registration and fusion, pseudo color processing technology and texture analysis in the field of medicine (Antonova *et al.*, 2015; Avci *et al.*, 2015; Babacan *et al.*, 2015; Baikoussis *et al.*, 2015; Bal *et al.*, 2015; Bozkurt *et al.*, 2015). Image segmentation is the process of partitioning an image into multiple areas according to their special properties (Cetinkunar *et al.*, 2015; Chapoy-Villanueva *et al.*, 2015; Chen *et al.*, 2015; Cirak *et al.*, 2015; Cvetanovic *et al.*, 2015; Dagher *et al.*, 2015; Damyanov *et al.*, 2015). The result is that each of the disjoint area conforms to the characteristics of special region. Many different image segmentation algorithms have been put forward aiming at specific problems and there is also good analysis conclusion on the effects of image segmentation. But due to the particularity of filed image segmentation facing, a satisfactory and universal solution has not been reached. Up to now, the image segmentation has been further developed on the basis of gray thresholding, edge detection and region tracking combined with the specific theory tools (Antonova *et al.*, 2015; Apostolakis *et al.*, 2015; Aldeas *et al.*, 2015). For example, 3D visualized system combined with Fast Marching algorithm and Watershed transformation medical image segmentation can get a rapid and accurate segmentation results. Image segmentation is also the basis of 3D reconstruction, and its result directly affects precision of the 3D reconstruction model. Segmentation can help doctors to extract the objects of interest (diseased tissue, etc.), so that doctors could qualitatively and quantitatively analyze the diseased tissue, so as to improve the accuracy and scientificity of the diagnosis (Divani *et al.*, 2015; Duzagac *et al.*, 2015; Gao *et al.*, 2015; Gatzidou *et al.*, 2015).

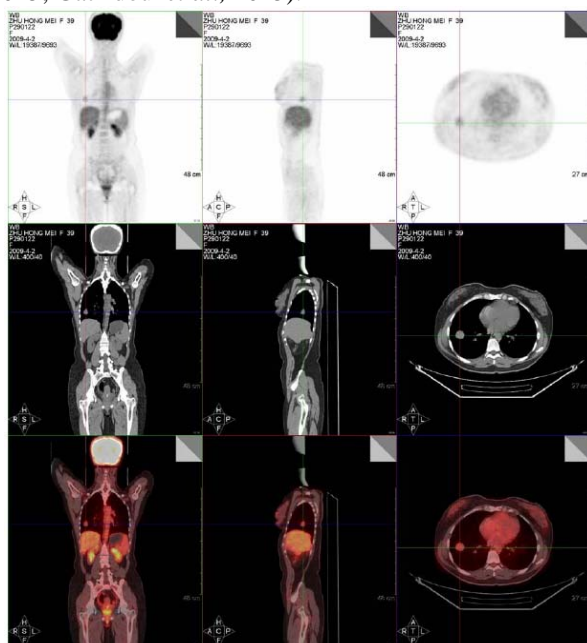


Fig. 6: Distribution of F-FDG in Lung cancer patients after half an hour of injection.

It has been an important and urgent topic of medial image processing that how to comprehensively utilize the information from multiple imaging method or from a variety of imaging equipments, to make up the defects caused by incomplete information, or part of inaccurate or uncertain information, so as to get a more accurate clinical diagnosis and treatment, radiotherapy positioning, planning design, surgery and curative effect evaluation. Medical image registration is the process that corresponding pixels of two images are transformed into same space location and anatomical structure by certain spatial alternation. It is required that all the anatomical pixels, or at least all the pixels with diagnostic significance and all the pixels of the operation area on the two images should be matched. The existing medical image registration methods include image registration (with framework) based on the external characteristics and image registration (without framework) based on the internal characteristics. The latter has become the research spot of registration algorithm due to its non-invasive and retrospective features (Manzat-Saplacan *et al.*, 2015; Mammias *et al.*, 2015; Milosevic *et al.*, 2015). The elastic deformation model based on mutual information has also gradually become a research hotspot. Mutual information is a measure of the mutual dependence between two random variables. Image registration with the mutual information as a measure of the similarity of two images is based on the following principles that: when the two images based on the common anatomical structure achieve the best matching, the mutual information of their corresponding image characteristics is maximized. Image registration is the premise of image fusion, which is also recognized as a difficult image processing technology and a key technology to determine the development of medical image fusion technology (Gkialas *et al.*, 2015; Guan *et al.*, 2015; Gunaldi *et al.*, 2015; Guo *et al.*, 2015; Gu *et al.*, 2015; Han *et al.*, 2015; Hou *et al.*, 2015; Jia *et al.*, 2015; Kertmen *et al.*, 2015). Image registration has been greatly researched in the foreign countries in recent years, such as the geometric moment registration, similarity measure for image registration, and spline interpolation polynomial transformation, etc. Researcher in China also put forward some corresponding algorithms: consistency image registration refers to a new image registration that estimates the positive and negative transformation of images based on their common part; pyramid multi-level image registration refers to the image registration with pyramid segmentation to realize multi-grid and multi-resolution image registration; and in addition, the method based on mutual information could also be used to improve the precision of 3D registration and fusion of CT, MRI and PET multimodal medical images (Murat *et al.*, 2015; Naumovic *et al.*, 2015; Nayir *et al.*, 2015; Ostojic *et al.*, 2015; Okasov *et al.*, 2015; Ozgur *et al.*, 2015; Panton *et al.*, 2015; Parau *et al.*, 2015).

Table 1: F drug induced organ absorbed dose

Radiopharmaceuticals	Effective dose (m Sv/GBq)	Maximum absorbed dose	Maximum absorbed dose
Fluoride	2.4	Bones	40
F-fluorodeoxyglucose	19	Bladder	170
Dopamine fluoride	25	Bladder	300

Table 2: Estimation of cancer risk in 12 subjects

Number	Effective dose (mSv)	Cancer risk	Injection dose (MBq)
1	4.61	1.57×10^{-3}	190.18
2	7.69	2.70×10^{-3}	304.51
3	4.89	1.71×10^{-3}	193.51
4	6.81	2.39×10^{-3}	269.73
5	8.97	3.14×10^{-3}	390.72
6	8.22	2.89×10^{-3}	344.10
7	8.72	3.41×10^{-3}	384.80
8	6.54	2.30×10^{-3}	273.80
9	7.02	2.46×10^{-3}	277.87
10	7.57	2.66×10^{-3}	317.09
11	8.74	3.06×10^{-3}	345.95
12	5.21	1.83×10^{-3}	206.46

In terms of image registration, while endeavoring to improve the matching accuracy, the existing various methods are also put forward to avoid human intervention, and ensure the whole process automation. This results in complex and time consuming algorithm (Breitenbuecher *et al.*, 2015; Bruera *et al.*, 2015; Bulut *et al.*, 2015; Buyukhatipoglu *et al.*, 2015; Carvajal *et al.*, 2015; Caziuc *et al.*, 2015; Cetean *et al.*, 2015). Literature has been studied to try to find a rapid image registration algorithm based on human-computer interaction, and at the same time, it is also important to choose the appropriate registration measure according to the different imaging modes.

Different medical images provide different information of relevant organs, and the potential of image fusion is to obtain new information in favor of clinical diagnosis by integrated processing the information from these imaging equipments. Image fusion of images with a variety of modes by visualization software, can accurately determine the space location, size and geometry shape of lesions, and its spatial relationship with the surrounding biological tissues, so as to timely and accurately diagnose diseases; it can also be used in surgical planning, tracking on pathological changes and the evaluation of treatment effect, etc. In radiotherapy, MRI image is used to draw the contour of tumor, namely the tumor size; and CT image is used to calculate the radiation dose and distribution, to correct the treatment plan (Kong *et al.*, 2015; Kouloulia *et al.*, 2015; Lee *et al.*, 2015; Liapis *et al.*, 2015; Li *et al.*, 2015; Luo *et al.*, 2015; Lykoudis *et al.*, 2015). The understanding on the lesions and surrounding tissues is the key to the success of the operation during operation scheme formulation; therefore, fusion of CT and MRI

images is a favorable evidence for surgery and even provides new opportunity for further tumor development and early diagnosis. In CT imaging, since the bone tissue has larger absorption coefficient to X-ray, CT is sensitive to bone tissue; while in MR imaging, bone tissue contains lower proton density, so MRI has weak signals to bone tissue and calcification point, and fused images are of great help for definition and positioning of the lesions. Due to the different imaging mechanisms of various medical imaging equipments, there are great differences in the image quality, space and time characteristics. Therefore, the realization of medical image fusion, image data transformation, image data-related content, image database and data understanding are key technologies to be solved (Saglam *et al.*, 2015; Sandri *et al.*, 2015; Sahin *et al.*, 2015; Sheng *et al.*, 2015).

Human eyes can only distinguish the gray level of 4 to 5 bits generally to a black-and-white image, but can distinguish hundreds of different colors. Aiming at this characteristic, people tend to turn black and white images into color image, and give full play to the visual ability of the human eye to color, to obtain more information from the images, called pseudo color image processing technology. Medical images are mostly black and white images, such as X-ray, CT, MRI and B ultrasound images. The recognition of image characteristics is improved through pseudocolor processing technology, namely the density segmentation technology. X-ray, CT, MRI and B-ultrasound and SEM images are given pseudo color technology in clinical researches, and good effects are achieved. Some pictures show hidden lesions after processing. Pseudo color processing on X-ray images, for example, could identify cystic, benign and malignant

tumor in mammary gland imaging; and at the same time, barium meal images and X-ray images could also get good diagnosis effect.

Texture is an important part of human vision. It is difficult to properly model texture so far. Experts carried out extensive research, but failed to get the effective explanation on analysis, classification, segmentation and comprehension of texture. A research adopted gray gradient co-occurrence matrix, aiming at the liver disease that is difficult to eradicate and harms extensively, to respectively extract the texture features of CT images in fibrosis liver tissue and normal liver tissue, propose parameters based on gray gradient co-occurrence matrix (WSga, WGys, WHe) as the image texture characteristics. Significant differences can be seen between normal group and abnormal group by the chosen texture parameters, to provide a basis for the clinical diagnosis of fibrosis CT images (Sideris *et al.*, 2015; Siyar *et al.*, 2015).

RESULTS

SUV and drug dose distribution

Lung cancer is one of the most serious malignant tumors that threaten human health and life. Differential diagnosis of solitary pulmonary nodules in peripheral lung cancer by single CT or PET. MRI can not distinguish between some of the CT visible small pulmonary nodules, and even can be missed in the contralateral lung metastases. Therefore, it is of great practical significance to study the dose of PET/CT in patients with lung cancer. At present, there are two methods of visual analysis and semi quantitative analysis for F-FDG PET/CT imaging standard. Visual analysis was based on the size and shape of the lesion. Usually at the tumor site is increased or radioactive concentration, but there are also many benign lesions also showed increased metabolic activity, therefore, just look at the lesion metabolism degree is not enough, morphological characteristics of F-FDG PET/CT imaging on the uptake in the range is also very important. Standardized uptake value (SUV) is benign and malignant lesions most commonly used semi quantitative index to lung cancer, for example, the average standard uptake value (SUV mean) is generally over 2.5 as the standard for diagnosis of lung cancer.

Distribution of radiopharmaceuticals in vivo

Fig. 5 shows a relatively high level of brain, kidney and bladder uptake. Lower skeletal muscle uptake. The kidney itself uptake by FDG level is not very high, but the F-FDG can not completely after glomerular filtration and tubular reabsorption by urinary excretion (unlike glucose metabolism), so F-FDG uptake in urinary tract is very high. The incidence of F-FDG in the head and neck was more complicated, and the F-FDG uptake was mild in the lips, tongue, the whole nasopharynx mucosa and throat. The uptake of F-FDG in the heart, gastrointestinal tract

and liver showed a low level, in the fasting state, most of the normal myocardium does not absorb F-FDG, because the normal myocardium is mainly the use of free fatty acids as energy substances. At present, there are different levels of F-FDG uptake in some normal people or patients, and the mechanism and clinical significance of the uptake is not fully understood. The stomach has a small amount of F-FDG intake, in order to facilitate the PET/CT to improve the accuracy of the diagnosis of gastric lesions, usually in front of the scan, allowing the patient to drink water, so that the stomach filling. A large area of the bone and joint of the limbs with a radioactive distribution, which can be used as a marker. Fig. 6 shows the distribution of F-FDG in the lung cancer, the lesion is located in the lower lobe of the right lung, showing a circular high density shadow. Comparison of fig. 5 and fig. 6 shows that the distribution of F-FDG in healthy subjects and in the lung cancer patients in the distribution of the body in addition to the lesion tissue no significant difference, which is consistent with the results of statistical analysis.

Risk assessment of radiation induced cancer

The medical body radiation dose Committee (MIRD) is based on a number of more complex computational models, as well as the drug uptake and dynamic processes of each organ. The Oak Institute for Science and Education) calculated in detail the F-FDG of various body organs caused by the radiation absorbed dose of Ridge. At present, there are some differences between the results obtained by many researchers. Some scholars have shown that the effective dose and the dose of radiation absorbed by some organs are shown in the following table 1, which shows only a few doses of F radiation absorbed by the organ.

According to the reference data provided by ICRP103, the risk of radiation induced cancer was assessed in 12 cases. The results showed that the effective dose range of 12 cases was 4.61mSv to 8.97mSv, and the range of radiation carcinogenic risk ranged from 1.57×10^{-3} to 3.14×10^{-3} . In the table the results visible, examined the dose of F-FDG during the PET/CT injection caused cancer risk is very small, with the largest injection dose of 390.72MBq subjects for the basis of the estimated radiation cancer risk is only 3.28×10^{-3} .

DISCUSSION

Radioactive drug metabolism

The metabolism of F-FDG was similar to F-FDG because of glucose clearance pathways to the bladder excretion mainly by kidney, kidney, bladder and so absorbed dose is relatively large, be attributed to other entities because of kidney, bladder, brain category, other entities so the calculation result of a class of absorbing large dose. Although the role of radiation in all human cancers is not

as important as chemical carcinogens, more detailed experimental studies and population studies have been conducted than any carcinogen. Is to accept the deadly radiation carcinogenic health hazards caused by low dose irradiation of human has been confirmed, is to determine the human dose of radiation protection important index value, so the evaluation of radiation carcinogenic effect is the core content of radiation hazard evaluation. Due to the experiment needs to be based on clinical diagnosis does not interfere with, and to collect the required data to calculate the dose of CT has certain difficulty, therefore, the calculation of radiation cancer risk is refers to the radioactive drug tested F-FDG radiation of PET/CT caused by the risk of cancer.

Other medical image visualization techniques

Usually, in 3-D medical image visualization, the 3D morphology of human tissue is visualized using the intuitive 3D images that are converted from 3D data reconstructed from 2D imaging slices through computer processing based on human visual characteristics. The 3D medical image visualization technology can generally be cauterized into surface rendering and volume rendering. For volume rendering, the main idea is to assign opacity to each voxel by taking into the consideration of the effect of voxel on the transmittance, reflectance, and transmission of light. Visualization of medical data has become one of the most active research areas in the visualization field. There are many methods to realize 3D visualization. Typical algorithms for space domain methods include ray casting, foot printing, and Shear-Warp methods, etc. Through 3D reconstruction of 2D imaging slices, various anatomical structures of human organs and their spatial relationship with each other can thus be visualized, providing reference information for basic research, surgical planning, and surgery simulation.

PACS (Picture Archiving and Communication System) is an emerging medical image information technology both domestically and internationally in recent years. It is an integrated software & hardware system specially designed for medical image management, including image acquisition, processing, storage, display or printing. It is a product that combines medical image, digital image technology, computer technology and network communication technology (Shi *et al.* 2015). Obviously, computer networks play an important role in PACS. It is responsible for providing the underlying image transmission service, and is the software & hardware basis for PACS. It is the computer network on each level that links up various PACS functional units responsible for image acquisition, storage, display and medical data management, forming a uniform system of high performance. PACS needs to resolve data transmission and image storage issues (Stojiljkovic *et al.* 2015). In the field of medical image compression, many researchers have explored new ways for image encoding by

combining pattern recognition (Abu 2017; Fang and Ruan 2017; Liu *et al.* 2017; Takahashi 2017), computer vision, neural network theory, Wavelet Transform, and fractal theory. Meanwhile, research findings on, the physical and psychological characteristics of human visual perception have also broadened people's vision and brought new aspiration to scholars involved in image encoding technology research (Smithers *et al.* 2015; Socha *et al.* 2015; Spiliotis *et al.* 2015; Suren *et al.* 2015). However, with the wide application of network technique in medical field, more specific requirements have also been put forward. Selected lung cancer subjects and healthy subjects in the cerebral cortex, basal ganglia, brain matter and normal lung tissues, lung cancer subjects lung tumor, renal cortex, renal pelvis, bone and muscle, the correction of SUV using different methods, radioactive drug F-FDG has undergone some changes in the distribution of different organs in 12 cases, PET/CT subjects tissues organs at dose of 18F-FDG after injection respectively, patient's cancer risk have been estimated. The results showed that the highest activity was 390.72MBq, the effective dose was 8.97 mSv, and the risk of radiation carcinogenesis was 3.14×10^{-3} .

CONCLUSION

The clinical trials based on ten months, combined with radioactive nuclear medicine drug metabolism distribution theory and radiation risk prediction theory, mainly studies the radiation dose of F-FDG and the distribution of radiation and risk. With the rapid development of telemedicine technology, the requirements for medical imaging processing are getting higher and higher. With today's development of medical image processing techniques, cross-discipline is the inevitable trend of development. However, there still are many problems remain to be solved. Therefore, it becomes more and more important to effectively improve the level of medical image processing techniques, the integration of multidisciplinary theories, and the exchange between medical staff, researchers, and technicians.

REFERENCES

- Abu A (2017). Video-assisted thoracoscopic surgery for non-small cell lung cancer. *Minim. Inv. Surg. Oncol.*, **1**(1): 1-11.
- Fang W and Ruan W (2017). Advances in uniportal video-assisted thoracoscopic surgery for non-small cell lung cancer. *Minim. Inv. Surg. Oncol.*, **1**(1): 20-30.
- Han J, Lu S, Wang Z and Li Y (2015). Flax seed oil inhibits metastatic melanoma and reduces lung tumor formation in mice. *J. BUON.*, **20** (6):1546-1552.
- Hase K, Naomoto Y, Ninomiya M, Watanabe M, Omoto T and Wang H (2016). Staging of gastric cancer. *Asian Pac. J. Surg. Oncol.*, **2**(2): 75-86.
- Hatano E, Uemoto S and Kondo S (2016). Pathology and

- pathogenesis of hepatocellular carcinoma. *Asian Pac. J. Surg. Oncol.*, **2**(7): 391-416.
- Horgan P, Morrison D, McMillan D, Kondo H and Morita Y (2016). Diagnostic workup of colon cancer. *Asian Pac. J. Surg. Oncol.*, **2**(1):1-12.
- Hou L and Zhai J (2015). Aberrant expression profile of translationally controlled tumor protein and tumor-suppressive microRNAs in cervical cancer. *J. BUON.*, **20** (6): 1504-1509.
- Imada T, Yukawa N, Nakatsuji M, Tan B, Tan JY and Fock KM (2016). Lymph node dissection for gastric cancer. *Asian Pac. J. Surg. Oncol.*, **2**(2): 101-120.
- Jia W, Zhao J, Sun X, Yao Z, Wu H and Xi Z (2015). Additive anticancer effects of chrysin and low dose cisplatin in human malignant glioma cell (U87) proliferation and evaluation of the mechanistic pathway. *J. BUON.*, **20**(5):1327-1336.
- Jin X, Guo Y, Ye M, Shibasaki H and Davidson L (2016). Outcomes of gastric cancer resection in elderly. *Asian Pac. J. Surg. Oncol.*, **2**(2): 143-152.
- Kaibori M, Matsui K, Ishizaki M, Saito T, Kitade H, Matsui Y and Kwon AH (2009). Hepatic resection for hepatocellular carcinoma in the elderly. *J. Surg. Oncol.*, **99**(3): 154-160.
- Kertmen N, Babacan T, Keskin O, Solak M, Sarici F, Akin S, Arik Z, Aslan A, Ates O, Aksoy S, Ozisik Y and Altundag K (2015). Molecular subtypes in patients with inflammatory breast cancer; A single center experience. *J. BUON.*, **20**(1): 35-39.
- Kong F, Cai B, Lin S, Zhang J, Wang Y and Fu Q (2015). Assessment of radiotherapy combined with adjuvant chemotherapy in the treatment of patients with advanced nasopharyngeal carcinoma: A prospective study. *J. BUON.*, **20**(1): 206-211.
- Kouloulis V, Antypas C, Liakouli Z, Armpilia C, Zygogianni A, Floros I, Tolia M, Kokakis J and Kouvaris J (2015). The first implementation of IMRT technique for head & neck and prostate cancer patients in public sector in Greece: Feasibility, treatment planning and dose delivery verification using the delta(4PT) Pre-Treatment volumetric quality assurance system. *J. BUON.*, **20**(1): 196-205.
- Lee Y and Gyu SG (2015). Genome-wide pathway analysis in pancreatic cancer. *J. BUON.*, **20**(6): 1565-1575.
- Lee Y and Gyu G (2015). Vitamin D receptor FokI, BsmI, TaqI, ApaI, and EcoRV polymorphisms and susceptibility to melanoma: a meta-analysis. *J. BUON.*, **20**(1): 235-243.
- Li C, Yichao J, Jiabin L, Yueting Z, Qin L, Tonghua Y (2015). Methylenetetrahydrofolate reductase gene polymorphism and risk of chronic myelogenous leukemia: A meta-analysis. *J. BUON.*, **20**(6): 1534-1545.
- Li K, Wang J, Shi M, Li J, Yan L, Zhang H, Lu C (2015). Prescription consisting of Vitamin C and Baicalin inhibits tumor growth by enhancing the antioxidant capacity in vivo. *J. BUON.*, **20**(5):1368-1372.
- Liu H, Ichikawa Y, Nagano Y, Shiono S (2016). Surgery for colorectal cancer lung metastases. *Asian Pac. J. Surg. Oncol.*, **2**(3):183-192.
- Liu Z, Yang R, Shao F (2017). Anastomosis using complete continuous suture in uniportal video-assisted thoracoscopic bronchial sleeve lobectomy. *Minim Inva. Surg. Oncol.*, **1**(1): 31-42.
- Liu K, Chen X, Nakamura I, Ohki S, Eslick G (2016). Laparoscopic surgery for gastric cancer: survival outcome and prognostic factor. *Asian Pac. J. Surg. Onco.*, **2**(2):135-142.
- Li X, Liu X, Cui D, Wu X, Qian R (2015). Clinical significance of nucleostemin and proliferating cell nuclear antigen protein expression in non-small cell lung cancer. *J. BUON.*, **20**(4):1088-1093.
- Li X, Ren D, Li Y, Xu J, Liu C, Zhao Y (2015). Increased cancer risk associated with the -607C/A polymorphism in interleukin-18 gene promoter: an updated meta-analysis including 12,502 subjects. *J. BUON.*, **20**(3):902-917.
- Li X, Xu Y, Yang K, Shi J, Zhang X, Yang F, Yuan H, Zhu X, Zhang Y, Wang J, Yang Z (2015). Association of THADA, FOXP4, GPRC6A/RFX6 genes and 8q24 risk alleles with prostate cancer in Northern Chinese men. *J. BUON.*, **20**(5):1223-1228.
- Lykoudis P, Nastos C, Dellaportas D, Kairi-Vassilatou E, Dastamani C, Kondi-Pafiti A (2015). Uncommon benign lesions of the adrenal glands mimicking sinister pathologies: report of 8 cases. *J. BUON.*, **20** (6): 1630-1634.
- Manzat R, Balacescu L, Gherman C, Visan S, Chira RI, Bintintan A, Nagy G, Popovici C, Valean S, Anca C, Bintintan V, Scurtu R, Mircea P, Berindan-Neagoe I, Ciuleanu T, Balacescu O (2015). Is there a correlation between peripheral blood expression of angiogenic transcriptional factors/receptors and colorectal cancer? *J. BUON.*, **20**(5):1193-1200.
- Mammas I, Spandidos D (2015). Fighting against human papillomavirus: the 25-year old contribution of the University of Crete School of Medicine. *J. BUON.*, **20**(1):17-21.
- Mellotte G, Maher V, Devitt P, Shin V, Leung C (2015). Minimally invasive surgical oncology: State of the art. *Asian Pac. J. Surg. Oncol.*, **1**(2):101-112.
- Sheng W, Zhang B, Chen W, Gu D, Gao W (2015). Laparoscopic colectomy for transverse colon cancer: Comparative analysis of short- and long-term outcomes. *Int. J. Clin. Exp. Med.*, **8**(9): 16029-16035.
- Takahashi Y (2017). Real-time intraoperative diagnosis of lung adenocarcinoma high risk histological features: A necessity for minimally invasive sublobar resection. *Minim. Inva. Surg. Oncol.*, **1**(1): 12-19.