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FULL PAPER

Functional imaging of interstitial brachytherapy in pancreatic carcinoma xenografts using spectral CT: how does iodine concentration correlate with standardized uptake value of ^{18}F FDG-PET-CT?

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Objective: This study aimed to investigate the correlation between iodine concentration (IC) for the quantitative analysis of spectral CT and maximum standardized uptake value (SUV_{max}) of ^{18}F fludeoxyglucose positron emission tomography-CT (^{18}F FDG PET-CT) as an indicator of therapeutic response to interstitial brachytherapy in transplanted human pancreatic carcinomas in BALB/c-nu mice.

Methods: Xenograft models were created by subcutaneous injection of SW1990 human pancreatic cancer cell suspensions into immunodeficient BALB/c-nu mice. 30 mice bearing SW1990 human pancreatic cancer cell xenografts were randomly separated into two groups: experimental ($n = 15$; 1.0 mCi) and control ($n = 15$, 0 mCi). After 2 weeks of treatment, spectral CT and ^{18}F FDG micro-PET-CT scan were performed. IC values and SUV_{max} in the lesions were measured. IC normalized to the muscle tissue is indicated as nIC. The relationships between the nIC and SUV_{max} of the transplantation tumours were analysed.

Results: 2 weeks after treatment, the nIC in three-phase scans and SUV_{max} of the experimental group were significantly lower than those of the control group. The nIC values of the three-phase scans have certain positive correlation with the SUV_{max} values ($r = 0.69$, $p < 0.05$; $r = 0.73$ and $p < 0.05$; $r = 0.80$, $p < 0.05$ in the 10-, 25- and 60-s phase, respectively).

Conclusion: Spectral CT could serve as a valuable imaging modality, as our results suggest that nIC correlates with SUV_{max} of ^{18}F FDG PET-CT for evaluating the therapeutic effect of ^{125}I interstitial brachytherapy in a pancreatic carcinoma xenograft.

Advances in knowledge: Spectral CT offers opportunities to assess the therapeutic response of pancreatic cancer. This study supports the conclusion that nIC values in spectral CT could also serve as a valuable functional imaging parameter for early monitoring and evaluation of the therapeutic response of ^{125}I interstitial brachytherapy mouse models because the nIC correlates with the SUV_{max} of ^{18}F FDG PET-CT.

INTRODUCTION

Pancreatic cancer is the fourth leading cause of death due to cancer, with an overall 5-year survival rate of $< 5\%$.^{1,2} Only 20% of patients with pancreatic cancer present with localized, non-metastatic disease which qualifies for surgical resection, and there are few effective therapies for the control of local advanced or metastatic pancreatic cancer. Traditional treatment involves intravenous chemotherapy with 5-fluorouracil or gemcitabine. Patients

who do not respond to traditional treatments have to seek alternative therapies. Recently, ^{125}I seed implantation has been suggested as a safe alternative treatment for pancreatic carcinoma because of its high precision, minimal trauma, high accumulative dose and few complications.^{3,4} However, further studies are needed to confirm these results. Current studies suggest that imaging-based therapy monitoring is critical in oncologic treatment.^{5–12}

^{18}F fludeoxyglucose positron emission tomography–CT (^{18}F FDG PET–CT) has an established role in monitoring various malignancies. Studies have demonstrated that ^{18}F FDG PET–CT is an important method for the diagnosis, staging, response to treatment and prognosis of pancreatic and other cancers.^{5,8–11,13–15} The standardized uptake value, which is used for the semi-quantitative analysis of tumour glucose metabolism measured by ^{18}F FDG PET–CT, is a sensitive marker for tumour viability and biological behaviour.^{11,13,15} The maximum standardized uptake value (SUV_{max}) reflects tumour aggressiveness and is useful in monitoring the effects of treatment on pancreatic cancers.^{5,9,10,15} Previous studies reported that ^{18}F FDG PET–CT is considered superior to standard CT in assessing the therapeutic response to treatment after non-surgical intervention in patients with pancreatic cancer.^{5,9,10}

Multiphase multidetector CT of the pancreas is the preferred imaging modality for screening, detecting, staging and evaluating the therapeutic response to pancreatic cancer treatment. Spectral CT has been recently introduced as a new dual-energy CT based on the rapid alternation between two peak voltage settings (140 and 80 kVp, *i.e.* “fast switching”).^{4,6,16–18} This scanning mode enables the precise registration of data sets for the creation of accurate material decomposition (MD) images (*e.g.* water- and iodine-based MD images) and monochromatic spectral images at energy levels ranging from 40 to 140 kV.^{4,12,17–19} The use of MD technique with spectral CT showed supplements of conventional CT for quantitative contrast-uptake measurement.^{4,12,18} Significant technical progress has been made in efficiently capturing information regarding morphology and function of the pancreas.^{6,12}

In this study, we evaluated the relationship between iodine concentration (IC) for the quantitative analysis of spectral CT and SUV_{max} of ^{18}F FDG PET–CT to determine the therapeutic efficacy of interstitial brachytherapy on human pancreatic carcinomas transplanted in BALB/c-nu mice.

METHODS AND MATERIALS

All animal experiments were reviewed and approved by the institutional ethics committee and local governmental authorities. All procedures were in compliance with the current national guidelines for the use and care of laboratory animals.

Cell lines and cell culture

The human pancreatic carcinoma cell line SW1990 was purchased from the American Type Culture Collection (Manassas, VA) and was maintained in dulbecco's modified eagle medium (DMEM) (pH 7.4; Sigma, St. Louis, MO) supplemented with 10% foetal bovine serum, 100 U ml^{-1} penicillin and 10 ng ml^{-1} streptomycin at 80% humidity in 5% CO_2 at 37°C.

^{125}I seed sources

^{125}I sealed seed sources were provided by Xinke Pharmaceutical Ltd (Shanghai, China). The ^{125}I seeds were manufactured from silver rods. The silver rods absorbed ^{125}I and were enclosed in a titanium capsule. Each seed source was 0.8 mm $\times$ 4.5 mm (diameter $\times$ length) with a radioactive half-life of 59.6 d and main X-ray transmission of 27.4 keV–31.4 keV and main γ -ray

transmission of 35.5 keV. The human tissue penetration distance was only 1.7 cm, and the mean radioactivity was 1.0 mCi.

Animal Model

The mouse xenograft model has been previously described in detail.^{4,14} 30 BALB/c male nu/nu nude mice weighing 20 g (mean: 20 ± 0.6 g) at 5 weeks of age were purchased from the Chinese Academy of Sciences Shanghai Experimental Animal Center. The dorsal flank of each nude mouse was inoculated subcutaneously with SW1990 human pancreatic cells (5×10^6 cells in 0.5 ml). Tumour size was between 10 and 15 mm, following 3 weeks of implantation. Mice were separated randomly into groups receiving either ^{125}I seeds ($n = 15$, 1.0 mCi) or blank seeds ($n = 15$, 0 mCi).

Spectral CT imaging protocol

Over 2 weeks, three-phase spectral CT was performed at 10, 25 and 60 s after intravenous contrast agent administration, and imaging was carried out as previously described in detail.⁴ Briefly, three-phase spectral CT was performed using a high-definition CT (Discovery™ CT750HD; GE Healthcare, Waukesha, MI) with a single-tube, fast kilovoltage switching between 80 and 140 kVp in <0.5 ms on 30 anesthetized mice after a 24-h fast. The anatomical range examined included the whole mouse. The tail vein was injected with the non-ionic contrast media iopamidol (0.1 ml of 30 g of iodine per 100 ml, Shanghai) at a rate of 0.02 ml s^{-1} . The other CT parameters were as follows: collimation thickness of 0.625 mm at an interval of 0.625 mm, tube current of 600 mA, rotation speed (temporal resolution) of 0.5 s, helical pitch of 0.984, 20-mm detector coverage, 20-cm field of view and 512×512 reconstruction matrix. Projection-based MD software and a standard reconstruction kernel were used to reconstruct MD images using water and iodine as basis material pairs.

The spectral CT images were analysed with the Gemstone Spectral Imaging (GSI) Viewer software 4.4 (GE Healthcare), with a standard soft-tissue display window preset (WL 40 and WW 400).

^{18}F fludeoxyglucose positron emission tomography–CT protocol

Mice were imaged using PET–CT over 2 weeks. All mice ^{18}F FDG micro-PET–CT and spectral CT scans were performed within an interval of less than <24 h. After anaesthesia by inhalation of 2% isoflurane in oxygen, images were acquired on an Inveon micro-PET–CT scanner (Siemens, Knoxville, TN). Prior to micro-PET–CT imaging, all anaesthetized mice were fasted for at least 8 h. Animals were maintained at 37°C after tracer injection and during imaging. At first, a 10-min micro-CT was performed from the head to mid-thigh according to a standardized protocol with the following settings: 360 rotation steps, tube voltage 80 kV, 500 mA tube current, 4 binning and 310 ms exposure time. The pixel size was $0.091 \times 0.091 \times 0.091 \text{ mm}^3$. Following the micro-CT scan, a 20-min micro-PET scan was acquired. Emission scans that allowed the mice the same horizontal position in the micro-CT scanner as in the micro-PET scanner were then obtained at 60 min after the intravenous administration of 10 MBq ^{18}F FDG. After the data were collected, PET data were

reconstructed with ordered subsets expectation maximization two-dimensional algorithm. The voxel size was $0.87 \times 0.87 \times 0.80 \text{ mm}^3$ and the resolution in the centre field of view was 1.4-mm full width at half maximum. Attenuation correction and respiratory gating were not used.

Image analysis of spectral CT

CT data were analysed by two experienced radiologists (XZL and KMC with 17 and 33 years' experience in abdominal CT, respectively). Both have 6 years' experience in performing quantitative measurements on an advanced workstation (AW4.4; GE Healthcare) with the GSI viewer in consensus. Two types of images were reconstructed from the single spectral CT acquisition for analysis: a set of water- and iodine-based MD images and monochromatic image sets that correspond to photon energies ranging from 40 keV to 140 keV. The GSI Viewer software package automatically calculated and displayed the contrast-to-noise ratio (CNR) values for the 101 sets of monochromatic images in real time. Optimal energy level (keV) to provide the best CNR between the lesion and normal adjacent muscle tissue was determined based on the monochromatic image sets. Two circular regions of interest (ROIs) were placed in the lesion and normal adjacent muscle tissue to obtain the optimal keV images.

The quantitative measurement of IC was essential for the quantitative assessment of different lesions. The MD images were used to measure IC in the lesions and adjacent muscle tissues. The ROIs were placed over the tumour to cover the solid tumour on the monochromatic image and then copied to the iodine image. These ROIs were as large as possible to reduce noise, carefully excluding prominent metal artefacts and the necrotic area. All measurements were performed three times at different image levels to ensure consistency, and average values were calculated. The size, shape and position of the ROIs for all measurements were kept consistent at the same places in the three phases by applying the copy-and-paste function. The IC data in the ROI were exported in the Excel® (Microsoft®, Redmond, WA) form. To minimize variations between mice, the ICs in lesions were normalized to the IC adjacent muscle tissues to derive a normalized IC ($\text{nIC} = \text{IC lesion}/\text{IC muscle tissue}$).

Image analysis of positron emission tomography-CT

Image analysis was conducted by board-certified radiologists in radiology and nuclear medicine (ZMW and YL, respectively) with more than >10 years' experience in oncologic imaging. SUV_{max} was defined as the ratio of activity per millilitre of tissue to the activity in the injected dose corrected by decay and body weight. The ROI was drawn on the area of the lesion with the highest FDG uptake.

Histochemical examination

Immediately after spectral CT and ^{18}F FDG micro-PET-CT data acquisition, the mice were killed under deep anaesthesia with an overdose of intravenous pentobarbital sodium, and the tumours were excised and fixed in 10% buffered formalin, divided into 5- μm sections and then stained with haematoxylin and eosin stain (Sigma Aldrich, St. Louis, MO).

Statistical analysis

Continuous variables are expressed as mean $\pm$ standard deviation. SPSS v. 17.0 (IBM Corp., New York, NY; formerly SPSS Inc., Chicago, IL) was used to perform all statistical analyses. Independent *t*-test was used to evaluate differences in the mean nIC value and SUV_{max} of all tumours in the experimental and control groups. Pearson's correlation coefficient *r* was used to analyse the relationship between the nIC values of the three-phase CT scans and SUV_{max} of ^{18}F FDG PET-CT. A *p* value of <0.05 was considered statistically significant. The correlation coefficient *r* was interpreted as follows: 0–0.1, no correlation; 0.2–0.4, weak correlation; 0.5–0.6, moderate correlation; 0.7–0.9, strong correlation; and 1, perfect correlation.

RESULTS

To evaluate the efficacy of spectral CT and ^{18}F FDG PET-CT in monitoring therapeutic response to ^{125}I seed brachytherapy, we transplanted human pancreatic carcinomas into BALB/c-nu mice and treated them for 2 weeks. Following 2 weeks of treatment, all 30 mice of the experimental and control groups were scanned with the three-phase spectral CT (10, 25 and 60 s) and ^{18}F FDG PET-CT. Tumour growth was strongly inhibited by ^{125}I seed implantation. All semi-quantitative data, including nIC and SUV_{max} measurements for ^{125}I interstitial brachytherapy in pancreatic carcinoma xenografts, are summarized in Table 1.

Spectral CT imaging

The mean optimal keV for displaying lesions in this study was $72 \pm 4 \text{ keV}$. This voltage provided the best CNR between the lesion and muscle and removed most of the ^{125}I seed artefacts (Figure 1). Spectral CT with monochromatic imaging improved tumour visibility in the vicinity of the ^{125}I seeds and successfully reduced ^{125}I seed artefacts. Examples of optimal keV monochromatic CT images, iodine- and water-based MD and colour-scale images for mice implanted with ^{125}I and blank seeds are shown in Figures 2 and 3. In the experimental group, the lesions showed prominent central necrosis, and the necrotic cystic areas remained unenhanced during three-phase scans. After treatment, the H&E staining showed that 90% of cancer cells were destroyed around the ^{125}I seeds in the experimental group (Figure 3d). Colour-scale images were used to identify the solid components and necrotic areas of the lesions (Figures 2b and 3b).

Table 1. Normalized iodine concentration (nIC) value and maximum standardized uptake value (SUV_{max}) of pancreatic carcinoma xenograft in the semi-quantitative measurements of all tumours in the experimental and control groups

Group	CE scan—10 s	CE scan—25 s	CE scan—60 s	SUV_{max}
Experimental group	0.185 ± 0.073	0.284 ± 0.069	0.439 ± 0.127	1.509 ± 0.614
Control group	0.265 ± 0.081	0.391 ± 0.097	0.591 ± 0.105	2.925 ± 1.169

CE, contrast enhancement.

Figure 1. Selection of the best contrast-to-noise ratio (CNR) for displaying tumour visibility in the vicinity of the blank seed in a pancreatic carcinoma xenograft using the Gemstone Spectral Imaging Viewer analysis tool. (a) Region-of-interest selections for the tumour (1) and normal adjacent muscle tissues (background). (b) 70 keV was the optimal monochromatic energy for achieving the best CNR for improved tumour visibility in the vicinity of the seed and successful removal of most artefacts from the seed.

Positron emission tomography-CT imaging

The lesion in the experimental group implanted with ^{125}I seeds had decreased FDG accumulation compared with animals implanted with blank seeds (Figures 4 and 5). Prominent necrotic cystic areas in the lesions remained unenhanced during the three-phase spectral CT scans (Figure 2b,c), whereas the same necrotic cystic areas revealed an obvious decrease in the accumulation of FDG in the experimental group implanted with ^{125}I seeds (Figure 4b). In animals implanted with blank seeds,

lesions showed high glucose uptake by PET-CT imaging (Figure 5), and H&E staining revealed few small necrotic areas in the lesion (Figure 3d).

The relationship between the nIC values of the three-phase spectral CT scans and SUVmax of ^{18}F FDG PET-CT

The nIC values of mice implanted with ^{125}I seeds were significantly lower than those of mice implanted with blank seeds

Figure 2. Spectral CT images of a mouse with ^{125}I seeds implanted in a pancreatic carcinoma xenograft. (a) The monochromatic image obtained at 70 keV showed a tumour with prominent central necrosis on a coronal image at 60 s after intravenous contrast agent administration. (b) Colour overlay of the iodine-based material decomposition images on a coronal image. (c) Monochromatic image taken at 70 keV on an axial section. (d) Spectral Hounsfield unit curves (CT values in Y-axis vs keV in X-axis) of the necrotic areas (pink line) and solid components of the lesions (yellow line). (e) Gemstone Spectral Imaging scatter plot of the necrotic areas (pink) and solid components of the lesions (yellow). (f) Water-based material decomposition (MD) images for identifying the necrotic areas and solid components of the lesions. (g) Iodine-based MD images for identifying the necrotic areas and solid components of the lesions. (h) Haematoxylin and eosin staining (original magnification, 100 $\times$) of large necrotic regions around the ^{125}I seeds. For colour image see online.

Figure 3. Spectral CT images of a mouse with blank seeds implanted in a pancreatic carcinoma xenograft. (a) The monochromatic image shows tumour with less necrotic cystic areas. (b) Colour overlay of the iodine-based material decomposition (MD) images. (c) Iodine-based MD images demonstrated that the lesion had fewer necrotic cystic areas. (d) Haematoxylin and eosin staining (original magnification, 100 $\times$) of the pancreatic cancer cells lacking necrotic areas.

during the three spectral CT phases. The nIC values of the experimental and control groups were 0.185 ± 0.073 and 0.265 ± 0.081 in the 10-s scan, 0.284 ± 0.069 and 0.391 ± 0.097 in the 25-s scan and 0.439 ± 0.127 and 0.591 ± 0.105 in the 60-s scan. A significant difference in nIC was observed between the two groups at each spectral phase (10 s: $t = 2.841$, $p = 0.0083$; 25 s: $t = 3.481$, $p = 0.0017$; and 60 s: $t = 3.573$, $p = 0.0013$).

The SUV_{max} values of the experimental and control groups were 1.509 ± 0.614 and 2.925 ± 1.169 , respectively. The SUV_{max} in the control group was marginally higher than that in the experimental group ($t = 4.153$, $p = 0.0003$).

The nIC values of the three-phase scans have excellent positive correlation with the SUV_{max} values ($r = 0.69$, $p < 0.05$; $r = 0.73$, $p < 0.05$; and $r = 0.80$, $p < 0.05$ in the 10-, 25- and 60-s phases, respectively).

DISCUSSION

^{125}I seed implantation was recently reported as a safe alternative treatment and a mature technique for advanced pancreatic cancer.^{3,4} Our results demonstrate that spectral CT and ^{18}F FDG PET-CT are functional imaging techniques for monitoring and evaluating the therapeutic responses of a pancreatic carcinoma xenograft to ^{125}I interstitial brachytherapy.

Our results showed that nIC values of the three-phase spectral CT correlate with SUV_{max} values of ^{18}F FDG PET-CT during evaluation of therapeutic response to ^{125}I interstitial brachytherapy using a pancreatic carcinoma xenograft model. Our results suggest that IC obtained from spectral CT data is a feasible quantitative parameter for monitoring tumour response.

Response monitoring of therapies is currently one major challenge in imaging techniques to evaluate patient response.^{8,10,12} A reliable, practical, objective, reproducible biomarker and standardized imaging-based therapy monitoring is essential for not only clinical

research but also daily patient care. To date, Response Evaluation Criteria in Solid Tumors (RECIST) has been defined as a standardized approach for response monitoring.²⁰ RECIST is based on the sum of one-dimensional measurements of the greatest diameter of the tumour and/or metastases,²⁰ and size-based classification systems such as RECIST may not be sufficient to evaluate other indicators of disease developments, including necrosis without a change in tumour size and tumour vascularization. Additional aspects of disease progression cannot be underestimated in evaluating therapeutic response and patient outcome.^{7,8,21,22} Additional functional information on tumour vascularization can contribute to therapy monitoring.^{8,21,22} Our results suggest that quantitative imaging of spectral CT provides complementary and additional functional information for monitoring tumour response.

^{18}F FDG PET-CT is a functional imaging method that provides unique molecular and metabolic information of tissues and organs based on glucose-uptake capacity. Most malignant tumours have increased uptake of ^{18}F FDG owing to enhanced glucose utilization. Our study demonstrates the utility of micro-PET-CT using ^{18}F FDG after implantation with ^{125}I interstitial brachytherapy in monitoring changes in tumour glucose utilization in a pancreatic carcinoma xenograft model. Several studies^{8,9,11,13} reported that SUV_{max} values may be a useful parameter for the detection and evaluation of therapeutic response viability. The quantitative measurements obtained in the present study are consistent with those of the previous studies and showed that SUV_{max} values of the experimental group significantly decreased compared with those of the control group. This study showed a prominent correlation between the SUV_{max} and ^{125}I seed antitumour effects. However, the use of FDG PET-CT in monitoring tumour response is restricted because of high cost and limited availability. Compared with PET-CT, standard CT examination is fast, relatively inexpensive and extensively used for monitoring tumour response, but it includes less functional information. Spectral CT may be a solution to this problem and provides supplementary functional information from the dual-energy technique.

Figure 4. 18 F-fluorodeoxyglucose (FDG) positron emission tomography (PET)–CT images of the same lesion as in Figure 2 with 125 I seeds implanted in a pancreatic carcinoma xenograft. (a) Coronal section of a CT image. (b) A fused PET–CT image showing a distinct reduction in FDG uptake in the central area of the lesion.

Spectral CT imaging obtained with the single-tube, rapid dual-tube voltage-switching technique provides monochromatic images that depict how the imaged object would look if the X-ray source produced only single-energy X-ray photons.^{4,12,18,19,23} Spectral CT imaging technology includes acquisition of conventional CT images and the important ability to acquire monochromatic images at different energies ranging from 40 to 140 kV, which substantially reduces the beam-hardening artefact. In addition, spectral CT generates MD images (water and iodine based), which can differentiate tumours by their signal patterns. Spectral CT seems to be a promising technique to simultaneously evaluate both morphology and function.

IC is a new assessment parameter provided by spectral CT, and it is assumed to reflect vital tumour burden by measuring the IC of active tumours.^{4,6,12,19} The IC in the tumour is an indication of its blood flow because iodine is the main component of the contrast agent.^{4,12} Our research has already correlated IC measurements with histological parameters of tumour angiogenesis such as microvessel density (MVD),⁴ suggesting that IC assessment

may be a promising tool for evaluating new tumour response. The quantitative measurements obtained in this study showed that nIC values of the experimental group significantly decreased compared with those of the control group and demonstrated a prominent correlation between the nIC value and 125 I seed antitumour effects. This study also demonstrated the feasibility of using IC values to monitor and evaluate the therapeutic efficacy of 125 I interstitial brachytherapy. Semi-automatic IC quantification enables objective, easy and fast parameterization of tumour size and contrast medium uptake, thereby providing additional functional information for response monitoring applicable in daily routine.

Compared with PET–CT examinations, assessing IC values by spectral CT is fast and low cost. Future studies will correlate the nIC values of three-phase spectral CT and SUV_{max} of 18 F-FDG PET–CT and investigate whether both methods provide similar information about tumour metabolism. We found a positive correlation between SUV_{max} and nIC using spectral CT. Although tumour angiogenesis and glucose metabolism are different physiologic processes, recent advances in tumour molecular genetics

Figure 5. 18 F-fluorodeoxyglucose positron emission tomography (PET)-CT images of the same lesion as in Figure 3 with blank seeds implanted in a pancreatic carcinoma xenograft. (a) Coronal section of a CT image. (b) A fused PET-CT image demonstrating high glucose uptake by the lesion on PET-CT imaging.

provide a biological rationale for an association between these two parameters.⁸ The frequently mutated oncogenic KRAS and TP53 are often expressed in pancreatic cancer^{24,25} and are known to regulate and promote tumour angiogenesis and anabolic glucose metabolism.²⁵ Increased MVD resulting from angiogenesis leads to increased tumour perfusion and iodine enhancement, whereas increased glucose metabolism produces increased 18 FDG uptake in PET-CT.⁸ These conceptual and biological relationships between tumour angiogenesis and 18 FDG uptake are reflected in the correlation between nIC and SUV_{max} in our study.

This study has some potential limitations that must be considered. First, this investigation reflects our preliminary experience with a relatively small number of mice, necessitating larger studies for confirmation. Different animal models may reach different conclusions. Second, the IC values in spectral CT were compared with only SUV_{max} measurements. Future studies should compare IC values in spectral CT with other 18 FDG PET-CT measurements, such as mean standardized uptake value, or histological parameters of tumour angiogenesis, such as MVD. Third, spectral CT with GSI successfully removed most of the artefacts from the 125 I seeds and improved the image quality. However, spectral CT with GSI could not eliminate all of the artefacts from the 125 I seeds, which may influence the study results and require further investigation.

In conclusion, this study supports using spectral CT as a powerful tool in early monitoring and evaluation of therapeutic response to 125 I interstitial brachytherapy in mouse models with the hope of implantation in a clinical setting. The SUV_{max} and nIC values in spectral CT correlated well in a pancreatic carcinoma xenograft model and might be used as a supplement to 18 FDG PET-CT for monitoring and evaluating the therapeutic response of 125 I interstitial brachytherapy. The nIC values in spectral CT could also serve as a valuable functional imaging parameter for response evaluation.

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