Sources of Artefacts: Consequences and Solutions

5

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Content

While PET shows much promise in improving target delineation in radiotherapy planning, there are some pitfalls which must be acknowledged before adopting wholescale implementation.

State-of-the-art PET/CT scanners are recommended for radiotherapy planning. A bore size of 70 cm (accommodates RT immobilization devices and large patients) is preferred. An integrated CT scanner with flat couch and contrast facilities would permit the use of CT component of the PET for RT planning.

There are several artefacts (Table 5.1) encountered in PET/CT imaging which can mimic FDG-avid malignant lesions, and therefore recognition of these artefacts is clinically relevant and has implications when SUV is used to derive region of interest used for planning.

CT imaging with intravenous contrast, as a component of the exam, can cause challenges as it mimics intense FDG uptake [1, 2]. A simple solution to resolving the uncertainty is to inspect the non-attenuated correction PET images or to perform a low-dose non-contrast CT prior to contrast administration.

Metallic objects such as dental fillings [3], orthopedic devices, and fiducial markers can demonstrate falsely elevated tracer uptake. The high CT number of metal can result in overestimation of the SUV.

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Table 5.1 Examples of artefact in PET/CT

PET-based errors	Errors from CT-based attenuation
Calibration problems	CT artefacts
Detector failures	Non-biological objects in patients[a]
Resolution and partial volume effects[a]	Respiratory mismatch between PET and CT images[a]
Patient motion[a]	Patient motion[a]
Non-malignant FDG avidity[a]	

[a]Artifacts that can cause specific problems for RT planning

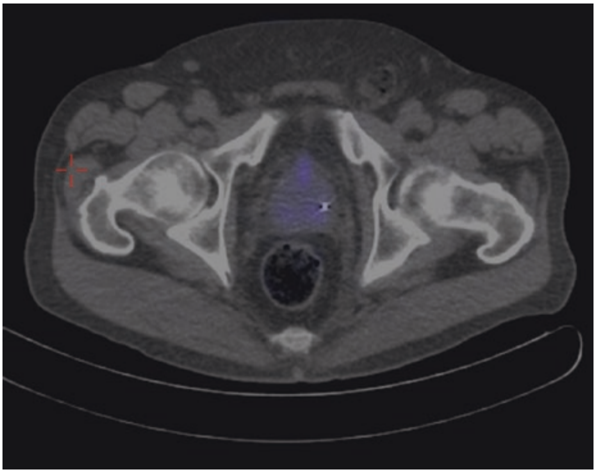

Fig. 5.1 Nonmalignant choline PET uptake in the prostate around fiducial markers

In addition, there are many nonmalignant processes which can mimic tumor on PET such as inflammation around a stent [4], benign inflammation of an organ such as prostatitis [5] (see Fig. 5.1), and postsurgical changes.

The field of view of a standard CT is 50 cm, whereas PET imagers can detect a field around 70 cm wide. This leads to truncation, a lack of ability to correct the lateral aspects of the PET for CT attenuation. This can artefactually reduce SUV.

In areas where there is a large change in attenuation over a small distance, potentially artefactual uptake can be seen with small errors in fusion. This can be reduced by scanning in a radiotherapy immobilization device and/or laser alignment. Reports on 3D displacements between CT and PET indicate a displacement error of 0.5 mm [6].

Respiratory motion remains the main challenge for RT planning of lung [7] and upper GI tract [8] malignancies. The misalignment between scans is most noticeable at the left lung and in the bases [6, 9, 10] and upper abdomen (hepatic area) [11].

In addition to image registration mismatch, respiratory motion can lead to a decrease of FDG concentration in (lung) tumors [12]. Erdi et al. describes lesion displacements of 6.4–24.7 mm when 4DCT was registered with PET which correlates with a decrease in tumor SUV of 6–24% between the extremes of the respiratory cycle [13].

Different strategies to reduce respiratory motion artifacts have been proposed including breathing coaching; exhale breathold has been suggested to be the best option as this is reproducible and permits a reduction of breathing artifacts up to 28% when compared with free-breathing scans [14]. Deep inspiratory breathold was proposed by Nehmeh et al. [15]. These techniques are all dependent on patient compliance.

4D PET/CT is discussed in Chap. 7.

Knowledge of potential sources of artefacts and awareness of the potential advantages and disadvantages of intervention has the potential to produce better quality PET/CT images that may improve the target volume delineation for PET guided RT.

Key Points

- State-of-the-art PET/CT scanners are recommended for radiotherapy planning.
- A bore size of 70 cm (accommodates RT immobilization devices and large patients) is preferred.
- An integrated CT scanner with flat couch and contrast facilities would permit the use of CT component of the PET for RT planning.
- There are several artefacts encountered in PET/CT imaging which can mimic FDG-avid malignant lesions, and therefore recognition of these artefacts is clinically relevant and has implications when SUV is used to derive region of interest used for planning.
- CT imaging with intravenous contrast, as a component of the exam, can cause challenges as it mimics intense FDG uptake. A simple solution to resolving the uncertainty is to (a) inspect the non-attenuated correction PET images or (b) to perform a low-dose non-contrast CT prior to contrast administration.
- Metallic objects such as dental fillings, orthopedic devices, and fiducial markers can demonstrate falsely elevated tracer uptake (high CT number of metal can result in overestimation of the SUV).
- The field of view of a standard CT is 50 cm, whereas PET imagers can detect a field around 70 cm wide. This leads to truncation, a lack of ability to correct the lateral aspects of the PET for CT attenuation. This can artifactually reduce SUV.
- Respiratory motion remains the main challenge for RT planning of lung and upper GI tract malignancies. The misalignment between scans is most noticeable at the left lung and in the bases and upper abdomen (hepatic area).
- Knowledge of potential sources of artifacts, advantages, and limitations of intervention can lead to better quality PET/CT images that may improve the target volume delineation for PET guided RT.

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