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FDG PET/BT'de Sık Görülen Görüntüleme Artefaktları: Ortadan Kaldırılabilirler mi?

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Özet: [18F]-2-floro-2-deoksi-D-glukoz (FDG) pozitron emisyon tomografisi (PET)/bilgisayarlı tomografi (BT) görüntülerini yorumlayan hekimlerin, teknik nedenlere bağlı sıkça ortaya çıkan görüntüleme artefaktlarını tanımaları gerekir. En sık görülenleri ve en önemlileri atenüasyon düzeltme artefaktları, metalik implantlar veya yoğun kontrast maddeler gibi yüksek dansiteli materyallere bağlı artefaktlar, solunum hareket artefaktları ve trunkasyon (kesme, budama) artefaktlarıdır. Her bir artefakt FDG PET/BT uygulamaları ile ilgili önlemler alınarak veya hasta doğru şekilde hazırlanarak ortadan kaldırılabilir veya asgariye indirilebilir.

Anahtar Kelimeler: Fluorodeoksiglukoz F18, pozitron-emisyon tomografi/bilgisayarlı tomografi, artefaktlar

Common Imaging Artifacts on FDG PET/CT: Can They be Eliminated ?

Abstract: Physicians who are in charge with interpretation of fluorine-18 fluorodeoxyglucose (FDG) positron emission tomography/computed tomography (PET/CT) images should be familiar with the imaging artifacts which occur frequently, due to technical reasons. The most common and important ones are attenuation correction artifacts, artifacts due to high-density materials such as metallic implants or concentrated contrast material, respiratory motion artifacts and truncation artifacts. Each artifact can be eliminated or minimized by taking certain measures regarding the FDG PET/CT applications or preparing the patient properly.

Keywords: Fluorodeoxyglucose F18, Positron-Emission Tomography/Computed Tomography, Artifacts

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INTRODUCTION

In today's medical era the hospital departments taking care of oncology patients are among the most dedicated ones particularly in tertiary hospitals (1, 2). Fluorine-18 fluorodeoxyglucose (FDG) positron emission tomography/computed tomography (PET/CT), is a noninvasive imaging method which is most frequently used for staging and evaluation of response to treatment in oncology cases, giving very significant qualitative and quantitative data about metabolic activity of target tissues (3–5). Expert image interpreters who are involved with FDG PET/CT, should be familiar with the frequently seen imaging artifacts which occur mostly due to technical reasons. These artifact have a high potential to cause misinterpretation of the FDG PET/CT images. The most common and important ones are attenuation correction artifacts, artifacts due to high-density materials such as metallic implants or concentrated contrast material (CM), respiratory motion artifacts and truncation artifacts (6–8). Not only recognizing these artifacts but also having sufficient experience to eliminate them or to decrease their effects are of utmost significance in daily FDG PET/CT practice.

Common imaging artifacts on fdg pet/ct and the methods to eliminate or to minimize them

Attenuation correction artifacts result from misalignment (misregistration) between the data from PET and CT components, mostly due to change in patient position (9). Referring to PET images without attenuation correction and fusion images can help discriminate them (6). Deficiencies and errors in change over of polychromatic CT energies and the annihilation radiation (511-keV) can be another source of artifact particularly in the vicinity of metallic objects (i.e. instrumentation) or concentrated oral CM such as barium. Because of their high Hounsfield unit values, intracorporeal high density objects such as metallic bone prostheses and dentistry materials cause high PET attenuation coefficients and overestimation of the activity (7, 10). PET images without attenuation correction are particularly useful in evaluation of the patients with metallic dentistry materials (11) or smaller metallic objects such as pacemakers and chemotherapy catheters (9). As a precaution, the patient should take out all the removable metallic objects before the imaging. However, large metallic bone instrumentations such as hip prosthetics also attenuate 511-keV photons causing photopenic region on PET images with and without attenuation correction (7). In such patients obtaining a detailed medical history and referring to other imaging data (i.e. plain radiographs) can help reveal large metallic bone instrumentations. Besides metallic objects, high concentrations of oral CM (i.e. barium) also leads to overestimation of the PET activity, whereas with lower concentrations this risk is avoided (12). Taking the oral CM which has been administered in previous days into account is also important, because water reabsorption from the intraluminal CM increases with time and causes higher CM concentrations. In such CM related false-positive findings PET images without attenuation correction are useful (7). A negative oral contrast agent solution

containing 0.2% locust bean gum and 2.5% mannitol dissolved in water was reported to be successfully used to eliminate oral CM artifacts in FDG PET/CT by Antoch et al (13). Utilizing proper algorithms can also help decrease the artifacts caused by both metallic intracorporeal objects and high density oral CM (6, 10, 14).

Respiratory motion artifact which was stated to be the most common FDG PET/CT imaging artifact (15), occur because of the failure of overlapping between the images of the chest on CT component and of those on PET (7) due to the extended acquisition time of the PET component when the patient breaths liberally (16). Respiratory motion artifacts can cause a hepatic lesion to mimic a nodule at the right lower lobe of the lung (17). This artifact can also can cause difficulties in PET/CT-guided biopsies (18). Additionally, a curvilinear photopenic region at the lung–diaphragm junction may be seen when the diaphragm is at lowermost position during full inspiration (9). In order to decrease this artifact, capable patients should be instructed to hold their breath at mid-expiration or mid-inspiration (7). However, shallow-breathing method can be tried in incapable patients who fail to hold their breaths. In indeterminate cases, other imaging tools such as chest radiographs, chest CT, ultrasonography or magnetic resonance imaging of upper abdomen are helpful. New respiratory motion correction methods are being proposed to overcome this artifact during PET/CT-guided biopsies such as using registered and summed phases method (18) and to make proper diagnoses on thoracic FDG PET/CT images such as cine-averaged CT combined with shallow breathing (19).

As another important artifact, the problem of truncation which occur because of the discrepancy between fields of view (FOVs) of CT and PET components can be challenging, particularly in oversized patients and/or in the patients with the arms on their sides (i.e. in malignant melanoma cases) (20). In these cases, the region of the body which extends beyond the FOV of CT is cut and can not be seen in the reconstructed CT images which causes failure in attenuation correction for these body parts (7). As the result, truncation artifacts are demonstrated as a line of increased activity (overestimation) at the side of the truncated CT image with a neighboring region of decreased activity (underestimation) peripherally (20). The simplest way to reduce these artifacts is to place the patients at the center of FOV. Holding the arms above the level of the head in all suitable patients is also an important measure. Another recommended method is the use of truncation-correction algorithms which restore the anatomy of the imaged part as much as possible, decreasing truncation artifact with little error (3, 21).

CONCLUSION

In conclusion, imaging artifacts on FDG PET/CT are not uncommon and thorough knowledge about them is necessary for their recognition. Qualified and experienced FDG PET/CT technician is necessary for patient preparation and for obtaining ideal images. Each artifact can be eliminated or minimized by taking certain measures regarding the FDG PET/CT applications or preparing the patient properly before the imaging.

Conflict of Interests

The authors declare that they have no conflict of interests.

REFERENCES

1. Tiwari M. (2019). Profile of patients at a state-run tertiary cancer hospital in India: an audit. *Ulutas Med J*; 5(3):194–201.

2. Ari A, Buyukasik K, Segmen O, Akkus O, Tatar C. (2016). Lymph node yield in laparoscopic total mesorectal excision: our clinical experience. *Ulutas Med J*; 2(1):36–40.

3. Boellaard R, Delgado-Bolton R, Oyen WJ, Giammarile F, Tatsch K, Eschner W, et al. (2015). FDG PET/CT: EANM procedure guidelines for tumour imaging: version 2.0. *Eur J Nucl Med Mol Imaging*; 42(2):328–54.

4. Ayaz S. (2016). Letter to editor: FDG-PET/CT evaluation of breast cancer. *Ulutas Med J*; 2(3):157–8.

5. Ayaz S, Durmaz HA, Döğen ME. (2019). Comparison of the FDG PET/CT parameters of primary tumors and liver metastases in cases with gastric adenocarcinomas. *Cumhuriyet Üniv Sag Bil Enst Derg*; (4)2:25–8.

6. Delbeke D, Coleman RE, Guiberteau MJ, Brown ML, Royal HD, Siegel BA, et al. (2006). Procedure guideline for tumor imaging with 18F-FDG PET/CT 1.0. *J Nucl Med*; 47: 885–95.

7. Sureshbabu W, Mawlawi O. (2005). PET/CT imaging artifacts. *J Nucl Med Technol*; 33(3):156–61.

8. Mihailovič J, Matovina E, Nikoletič K. (2015). 18F-fluorideoxyglucose positron emission tomography/computed tomography imaging: artifacts and pitfalls. *Med Pregl*; 68(1-2):41–8.

9. Shammas A, Lim R, Charron M. (2009). Pediatric FDG PET/CT: physiologic uptake, normal variants, and benign conditions. *Radiographics*; 29(5):1467–86.

10. Martin O, Aissa J, Boos J, Wingendorf K, Latz D, Buchbender C, et al. (2019). Impact of different metal artifact reduction techniques on attenuation correction in 18F-FDG PET/CT examinations. *Br J Radiol*; 20190069. doi: 10.1259/bjr.20190069. [Epub ahead of print]

11. Kamel EM, Burger C, Buck A, von Schulthess GK, Goerres GW. (2003). Impact of metallic dental implants on CT-based attenuation correction in a combined PET/CT scanner. *Eur Radiol*; 13:724–8.

12. Cohade C, Osman M, Nakamoto Y, Marshall LT, Links JM, Fishman EK, Wahl RL. (2003). Initial experience with oral contrast in PET/CT: phantom and clinical studies. *J Nucl Med*; 44(3):412–6.

13. Antoch G, Kuehl H, Kanja J, Lauenstein TC, Schneemann H, Hauth E, Jentzen W, et al. (2004). Dual-modality PET/CT scanning with negative oral contrast agent to avoid artifacts: introduction and evaluation. *Radiology*; 230(3):879–85.

14. Dizendorf E, Hany TF, Buck A, von Schulthess GK, Burger C. (2003). Cause and magnitude of the error induced by oral CT contrast agent in CT-based attenuation correction of PET emission studies. *J Nucl Med*; 44(5):732–8.

15. Li TR, Tian JH, Wang H, Chen ZQ, Zhao CL. (2009). Pitfalls in positron emission tomography/computed tomography imaging: causes and their classifications. *Chin Med Sci J*; 24(1):12–9.

16. Beyer T, Antoch G, Blodgett T, Freudenberg LF, Akhurst T, Mueller S.

(2003). Dual-modality PET/CT imaging: the effect of respiratory motion on combined image quality in clinical oncology. *Eur J Nucl Med*; 30:588–96.

17. Osman MM, Cohade C, Nakamoto Y, Wahl RL. (2003). Respiratory motion artifacts on PET emission images obtained using CT attenuation correction on PET-CT. *Eur J Nucl Med Mol Imaging*; 30:603– 6.

18. Zhang R, Zukić D, Byrd DW, Enquobahrie A, Alessio AM, Cleary K, et al. (2019). PET/CT-guided biopsy with respiratory motion correction. *Int J Comput Assist Radiol Surg*; 14(12):2187–98.

19. Changlai SP, Huang CK, Luzhbin D, Lin FY, Wu J. (2019). Using cine-averaged CT with the shallow breathing pattern to reduce respiration-induced artifacts for thoracic cavity PET/CT scans. *AJR Am J Roentgenol*; 1:1–7. doi: 10.2214/AJR.18.20606. [Epub ahead of print]

20. Mawlawi O, Erasmus JJ, Pan T, Cody DD, Campbell R, Lonn AH, Kohlmyer S, et al. (2006). Truncation artifact on PET/CT: impact on measurements of activity concentration and assessment of a correction algorithm. *AJR Am J Roentgenol*; 186(5):1458–67.

21. Beyer T, Bockisch A, Kühl H, Martinez MJ. (2006). Whole-body 18F-FDG PET/CT in the presence of truncation artifacts. *J Nucl Med*; 47(1):91–9.