Head and Neck

Normal Variations and Benign Findings in FDG Positron Emission Tomography/ Computed Tomography Imaging

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KEYWORDS

• Head and neck • Positron emission tomography • Computed tomography • Imaging
• Physiologic uptake • Benign tumors

KEY POINTS

- Physiologic uptake and other benign findings on positron emission tomography (PET)/computed tomography (CT) with FDG for the head and neck increase the risk of misinterpretation.
- PET/CT should be performed with diagnostic quality CT, including intravenous contrast media and with PET and CT interpreted by experts in both modalities to secure the highest quality.
- Knowledge of the anatomy in the head and neck region as well as the medical history of the patient is crucial.

INTRODUCTION

The head and neck region is typically included in every whole-body 18F-fluro-deoxyglucose (18F-FDG) positron emission tomography (PET)/computed tomography (CT) scan.

The anatomy of the head and neck region is complicated, with many small structures close together and delicate structures. Interpretation of small lymph nodes and detection of small primary tumors are challenges.

The high physiologic FDG uptake in various benign structures, especially in the head and neck area, increases the risk of misinterpretation, and it is therefore mandatory to have knowledge about the pitfalls.

This article will guide the reader through these problems by discussing scanning procedures and normal findings as well as benign tumors with FDG PET/CT in the head and neck area.

PET/CT SCANNING PROTOCOLS

It is recommended that PET/CT is performed with diagnostic quality CT, including intravenous contrast media and with PET and CT interpreted by experts in both modalities to secure the highest quality. Time and effort should be spent on protocols for acquisition and image reconstruction. In a clinical setting, the CT part with intravenous contrast media can be used for PET attenuation correction, because the contrast media induced artifacts are rare and easy to detect.[1] In clinical trials, a standardized protocol including a noncontrast CT is often recommended, reducing the risk of measuring attenuation-caused false increased standardized uptake value (SUV) in relevant foci.

The patient should be well prepared with sufficient information about preparations and scanning procedures. FDG uptake in brown fat is a common

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finding in the head and neck area, especially in children and young adults, and especially during winter. Often the uptake is symmetric, but unilateral foci do occur. Fortunately, fat tissue is easily depicted on the CT scan. The fat tissue uptake can be reduced by letting the patient rest in a warm environment or tucked under warm blankets. In children this procedure is often sufficient. Adults can be prepared with a beta-blocking agent or muscle relaxing treatment (eg, diazepam) given 1 hour before the FDG injection followed by the same warm and comfortable rest period, although this procedure is still debatable.[2–4]

FDG

Patients must be fasting at least 6 hours prior to FDG injection; children need 4 hours fasting. In patients with diabetes, it is important that they are scheduled early in the morning for the first scans, and that special diabetes protocols are followed.

The recommended FDG dose is 4 MBq/kg body weight, maximum 500 MBq; children should receive 3 MBq/kg body weight until 16 years. Children older than 16 years should be dosed as adults.[5]

It is crucial that the patients are lying still and quietly between FDG injection and scan.

Activated brown fat tissue in the head and neck area can be decreased or even completely avoided by pretreatment with beta-blocking agents or diazepam.

Radiation Doses

Adults will receive approximately 5 mSv (0.019 mSv/MBq), and children will receive approximately 4 mSv[5] due to the FDG injection. The radiation dose from a whole-body CT scan of diagnostic quality is approximately 10 mSv, but the new CT scanners with iterative reconstruction possibilities can reduce the dose even further. In children, the radiation dose is approximately 1 to 4 mSv from the CT scan. So in total, the adult radiation dose for an FDG PET/CT whole-body scan with diagnostic quality CT is approximately 15 mSv, and in children, the dose is 5 to 8 mSv.

Scanning Protocol

For the diagnostic CT, it is important to have a meticulous preparation of both scan protocol and intravenous contrast media. The diagnostic CT parameters should be 80 to 120 mA, 120 to 140 kV, and 2 to 3 mm slice thickness. The patient should be positioned with the arms down and special immobilization devices for the head and neck area. It is recommended to give the intravenous contrast media with an automatic intravenous pump. The delay must be set to show the contrast media in the head and neck region depending on the scanner characteristics. The reason for using intravenous contrast media in PET/CT is to discriminate the vessels from other structures more than to get enhancement in the tumor.

Patient Positioning

The patient must be positioned comfortably to avoid motion during scanning and should prior to this be asked to remove metal in area of scanning (eg, jewelry, piercings, or metal in clothes).

Acquisition Protocol

After the CT scan, the PET scan is performed, preferably in 3-dimensional mode, with an acquisition time of 2 to 4 minutes per bed position depending on the patient's size and weight.

Image Reconstruction

CT images are reconstructed with a 70 cm field of view (FOV) and a slice thickness of typically 2 mm. Attenuation and scatter-corrected PET data are reconstructed iteratively using a 3-dimensional attenuation weighted ordered subset expectation maximization (AW-OSEM) reconstruction including point spread function (PSF), and, if available, time of flight (TOF). The settings are 3 iterations, 21 subsets, and a 2 mm Gaussian filter. The images are reconstructed on a 336 $\times$ 336 or 400 $\times$ 400 matrix (scanner dependent) with a pixel size of 2 mm $\times$ 2 mm and a slice thickness of 3 mm.

PET/CT IMAGE INTERPRETATION

The quality of the PET/CT interpretation is increased, if it is done in collaboration with a specialist in nuclear medicine and a specialist in diagnostic radiology, and preferably done simultaneously. In some countries, physicians have competence in both nuclear medicine and radiology, and therefore can do the interpretation alone. However, 4 eyes see more than 2 eyes. Taking the overall costs of the PET/CT, including isotope, into account makes the costs of double-reading minor.

Knowledge of the anatomy in the head and neck region (**Fig. 1**) as well as the medical history of the patient, especially prior surgery or radiotherapy in the relevant region, is of course crucial.

PHYSIOLOGIC FDG UPTAKE

FDG is a glucose metabolism tracer; therefore physiologic uptake is seen in normal tissue as well as in malignant tumors. The degree of uptake