Patterns of 18F-FDG PET images in patients with uncomplicated total hip arthroplasty

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Abstract

Objective: This retrospective study was carried out to determine the typical patterns of 18F-FDG uptake in uncomplicated total hip arthroplasty (THA). **Subjects and Methods**: 18F-FDG PET images of 62 asymptomatic THA patients who had undergone whole body scanning were evaluated for this retrospective study. The uptake was assessed qualitatively as positive or negative in the head/neck and the stem of the prosthesis. There were 76 hip prosthesis scans (34 left side and 42 right) and the average time following surgery was 75 months (range from 40 days to 372 months). Furthermore, the time course after surgery was subdivided into 3 time interval groups: Group I less than 2 years, Group II between 2 to 5 years, Group III more than 5 years. The regions of assessment were: head region including acetabulum and femoral head, femoral neck, trochanter, and femoral shaft. **Results**: In patients who demonstrated increased peri-prosthetic 18F-FDG uptake (59 of the 76 hip scans), the activity was confined to the femoral neck and proximal femoral shaft with the majority in the neck regions alone: 68% (40 of 59). Majority of the uptake was noted in the femoral neck, proximal shaft and trochanteric regions. **Conclusions**: Uptake of 18F-FDG in the asymptomatic patients with THA is commonly visualized and appears to be confined to the proximal segment of the prosthesis with minimal or no activity in its femoral segment.

Introduction

Total hip arthroplasty (THA) has become a mature procedure for patients who are in need of joint restoration. This surgical intervention is commonly employed because of its high success rate and for improving quality of life in the rapidly aging population around globe. Despite advances in surgical techniques and perioperative patient care that have decreased the incidence of deep periprosthetic sepsis, infection remains a common cause of painful and failed total hip arthroplasties which leads to subsequent revision surgery [1-4].

The differentiation between loosening alone and superimposed infection of hip prosthesis is a major challenge to the attending orthopedist. The recommended treatment options differ significantly between these two complications. Arriving at an accurate diagnosis is essential for successfully planning revision surgery [5].

The management of these complications is associated with some morbidity and relatively high cost, and there is a dire need for a single test that is highly sensitive, specific and also cost effective. In spite of advances made in recent years, there is no validated gold standard diagnostic modality for determining whether an infection is present [1, 3, 4]. It is often difficult to choose among various preoperative and intraoperative tests which are available in a given clinical situation. Conventional nuclear medicine imaging, including bone scintigraphy, gallium scanning and labeled white blood cell studies, are widely used [6-11]. They can be used for this purpose but they are commonly inconclusive and have significant limitations.

Recently, 18F-FDG PET imaging has been proposed as a potential alternative to the existing imaging modalities in assessing hip prosthesis and other infections [12-16]. However, there is a need to establish certain diagnostic criteria for the detection of infection based on validated normal patterns of 18F-FDG uptake after THA. These expected patterns and the time course of non-specific 18F-FDG uptake following THA are being defined as the approach to be adopted in the daily practice of this technology. In this report, we have determined the normal patterns of 18F-FDG uptake in uncomplicated THA and there time course following surgery.

Subjects and Methods

This retrospective study was carried out by reviewing patient's medical and surgical history from available sources and the standard questionnaire. The ^{18}F-FDG PET images were reviewed by two experienced readers. The patients were referred to the institution for whole-body ^{18}F-FDG PET scans to evaluate a variety of malignant disorders and were included in this study if he/she had undergone THA. Those with painful arthroplasties were excluded from this analysis. Based on these inclusion criteria, 62 patients (29 male and 33 female), average age of 67.3 years (32 to 92 years) were selected with adequate follow up information. Selected patients were asymptomatic for the hip arthroplasty at the time of the scan and were followed for a minimum of 3 months after PET study for any symptoms and/or additional studies. Clinical and radiological correlations were performed whenever necessary and possible. In the final analysis, the patterns, location, time course, and the degree of ^{18}F-FDG uptake were determined around various segments of inserted prostheses.

PET images were obtained on a dedicated whole body PET scanner (Allegro Philips Medical System, Philadelphia, PA or C-PET, ADAC UGM, Philadelphia, PA). The patients had fasted for at least 4h and the serum glucose levels were <140mg/dL in all subjects. PET scanning was initiated 50-60min after intravenous administration of ^{18}F-FDG. Transmission scans for attenuation correction were performed by using a Cs-137 point source, which were interleaved between the multiple emissions scans. The final PET images were reconstructed by employing an iterative reconstruction algorithm. The analysis included both attenuation and non-attenuation corrected scans.

The analysis scheme included two parameters: the level of uptake and its location, and the time course of THA. The uptake assessment was qualitative as positive or negative, and the locations included head, neck, and the rest of the prosthesis. We examined 76 hip prosthesis scans (34 left side and 42 right side) and the average time interval between PET imaging and surgery was 75 months (range from 40 days to 372 months) for the population. We then subdivided the patients into 3 groups: Group I had hip placement for less than 2 years; Group II between 2 to 5 years; and Group III more than 5 years. The patterns and the degree of uptake were then evaluated in each scan. The observers interpreted the scans jointly, and a consensus decision was used for the final analysis.

Results

In this population of asymptomatic THA, 77.6% (59 of 76) showed varying degrees of peri-prosthetic ^{18}F-FDG uptake in three regions: femoral head/acetabulum region; femoral neck/proximal femoral shaft/trochanter region; and both head and neck regions. There were 22.4% (17 of 76) studies which did not reveal any increased peri-prosthetic uptake.

In the patients who demonstrated increased peri-prosthetic ^{18}F-FDG uptake (59 of the 76 hip scans), the activity was localized in the femoral neck and proximal femoral shaft with majority of them in the neck regions alone: 68% (40 of 59). Figures 1 and 2 demonstrate the patterns of uptake clearly as described. Based on inclusion and exclusion criteria for selecting patients for this study, no significant abnormalities were noted in the remaining segment of the inserted prosthesis.

With regard to the effects of time course of prosthesis insertion and ^{18}F-FDG PET imaging, we noted the following in the designated groups: Group I (less than 2 years of placement) with 23 patients (12 male and 11 female, mean age of 62 years, range 32 to 79 years) with 29 hip studies (15 on the left and 14 on the right). In this group, 79% (23 of 29) showed increased uptake in the hip prosthesis, while 21% (6 of 29) did not. In Group II, 15 patients (8 male and 7 female, mean age of 74 years, range 69 to 83 years) with 18 hip studies (10 on the left and 8 on the right) were examined and 77.8% (14 of 18) showed uptake around the head and neck while 22.2% (4 of 18) did not. Group III included 24 patients (13
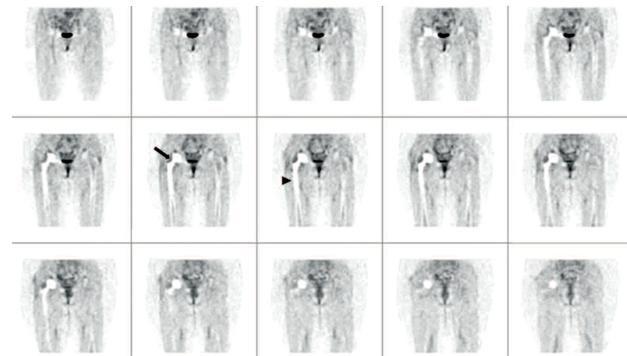

Figure 1. A 47 year old woman had right hip prosthesis for 10 months. ^{18}F-FDG PET images showed increased peri-prosthetic ^{18}F-FDG uptake in femoral head, acetabulum region, femoral neck, proximal femoral shaft and trochanter region (arrow). Please note no detectable uptake in the bone-prosthesis interface, indicating lack of inflammation in this location (arrow head).
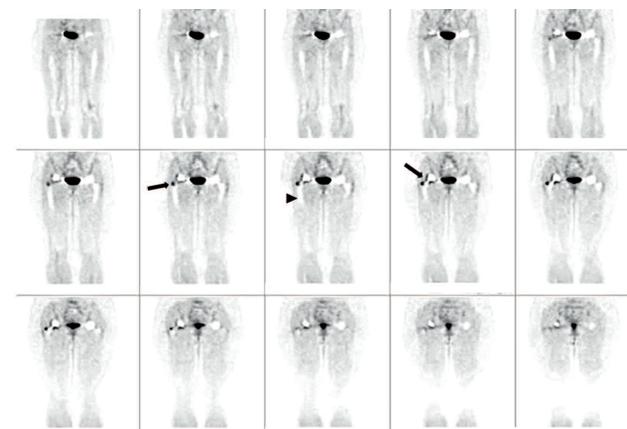

Figure 2. A 56 year old woman with bilateral hip prostheses for 38 months. The ^{18}F-FDG PET image demonstrates increased uptake at right hip especially major trochanteric and the neck regions (arrows). Please note no detectable uptake in either right or left sides of prosthesis stem region, indicating uncomplicated THA (arrow head).

male and 11 female, mean age of 69 years, range 32 to 85 years) with 29 hip studies (9 on the left and 20 on the right). This group demonstrated uptake in 72% (21 of 29) of the hips and was negative in 28% (8 of 29).

Discussion

With the rapidly aging population around the globe, THA is performed frequently. Complications following surgery are relatively common and limit the life of the device. The incidence of infection rises from less than 1% for the initial insertion of prosthesis, up to 30% following the revision of the prosthesis [3, 4]. Since the incidence of infection in uncomplicated prostheses is very low, specificity of diagnostic techniques is critical for early detection of this serious complication. Therefore, it is critical to make a distinction between septic and aseptic loosening for optimal management of these patients. Patients with infected hip prosthesis are treated differently than those with aseptic loosening. Patients with aseptic loosening require one step procedure that includes replacement of the failed prosthesis. In contrast, infection THA requires multiple surgical interventions and antimicrobial therapy. Accurate diagnosis of infection before revision surgery can significantly simplify the planning of the surgery.

Diagnosis of infected joint prosthesis is often made based on clinical, laboratory, radiographic and conventional nuclear medicine procedures. Laboratory findings (e.g. erythrocyte sedimentation rate and C-reactive protein levels) are not often conclusive, because they may be abnormal in both settings [17-19]. Clinical history and physical examination can result in accurate diagnosis in only 25% of patients with infected prostheses [20]. There is an incidence of false-negative results by relying on standard clinical assessment. Over the years, joint aspiration has been relied upon for patients with failed hip replacement. However, the role of joint aspiration as a basis for detection of infection is debated, its overall sensitivity and specificity range from 50% to 93% and from 82% to 97%, respectively [21-23]. The wide range of sensitivity is not sufficiently enough to diagnose infection with optimal certainty [22]. Conventional radiographic images are of limited value in the diagnosis of infection. Clinical signs along with bone changes on plain x-rays do not become evident for days or weeks. Furthermore, several radiographic features, such as periprosthetic radiolucency, osteolysis, and migration, are also observed in both infection and aseptic loosening [24]. Thus, there is substantial overlap between the two diagnoses based on these structural imaging criteria [9]. Computerized tomography and MRI are also limited by the presence of metallic artifacts and for differentiating scar tissue from active inflammation [10].

Conventional nuclear medicine studies have long been employed for the diagnosis of infection in THA. An alternate nuclear medicine test for detection is bone scintigraphy which shows positive results regardless of the underlying cause, and therefore, it cannot distinguish infection from other entities [11]. The use of autologous white blood cells (WBC) labeled with technetium-99m or with indium-111,

along with bone marrow imaging, has been claimed to have a relatively high specificity and sensitivity but its role as a viable modality in this very complicated setting is questionable at this time [3,4]. Furthermore, this preparation requires specialized equipment and is quite labor intensive. The labeling procedure can result in potentially contaminated blood and lead to transmission of pathogens such as HIV and HBV.

In addition, conventional nuclear medicine imaging suffers from two major shortcomings: the time needed to complete the procedures and also the cost of the test [12]. The ^{18}F-FDG PET scan is an accepted modality in clinical imaging. Over the years, it has been shown to be very effective in the diagnosis and management of patients with a variety of suspected infections. The ability to image glucose metabolism, which is commonly abnormal in many disorders and diseases, is the key to the current success of PET in many fields of medicine. The ^{18}F-FDG PET scan has been extensively used in oncology for the detection of multiple malignancies. However, ^{18}F-FDG is not a specific tracer and it is taken up by both malignant and inflammatory cells. Similar to cancer cells, inflammatory cells also can show increased ^{18}F-FDG uptake [25-27], particularly when they are activated at the inflammatory sites. In the early years of clinical use of ^{18}F-FDG PET imaging in cancer patients, false-positive results were noted with many infections. Although at first this was thought to be a disadvantage, it has actually proved to be of great value for imaging a variety of infectious and inflammatory processes [28-31]. A typical whole body examination can be completed in 90 minutes, but is shorter if the area of interest is spatially limited.

In this study, we have noted that various degrees of uptake in patients with asymptomatic THA are very common and are seen on the average in 4 out of 5 hip arthroplasties. Majority of the uptake is in the femoral neck, proximal shaft and trochanteric regions. It appears that there is no apparent difference between the percentage of visible uptake and the time interval between the prosthesis placement and imaging. This demonstrates that after hip arthroplasty, non-specific ^{18}F-FDG uptake persists in the femoral neck, proximal shaft and trochanteric regions for many years, in patients without proven complications. The data generated showed that non-specific ^{18}F-FDG uptake following THA is not only frequent, but also long-lasting.

There are several other published reports from our department. In the first study [12], it is reported that increased tracer uptake along the shaft portion of the prosthesis (interface bone and prosthesis) should be considered suggestive of infection. If the ^{18}F-FDG uptake is limited to the femoral head or neck regions and does not extend to the bone prosthesis interface, there is a low probability of infection. Furthermore, the intensity of uptake at the bone-prosthesis interface is of limited value in making the diagnosis of infection.

The second report [32] concerns non-specific inflammatory reaction in the soft tissues surrounding the head or neck region of the prosthesis which persists for an extended period of times, even in subjects without known complications. In this study we found that following total hip replacement, this non-specific uptake frequently persists for many years,

even in patients with no evidence of infection or loosening. This inflammatory reaction is limited to the head and neck segments of the prosthesis. The research further confirms that these findings should not be considered as evidence for periprosthetic infection and should be managed accordingly.

The results from this study support the previous findings. Accurate diagnosis of infection is necessary for effective management of patients with either (please explain "either') THA. Based on multiple scientific reports in the literature, ^{18}F-FDG PET will replace the existing methodologies and become the standard in this setting.

In conclusion, various degrees of uptake in the patients with asymptomatic THA are very common and the majority of the uptake is in the femoral neck, proximal shaft and trochanteric regions. There appears to be no apparent difference between uptake and the time interval between prosthesis placement and imaging. Recognizing this well established pattern will allow physicians to employ ^{18}F-FDG PET imaging as an effective modality in the management of patients with suspected THA

The authors declare that they have no conflicts of interest.

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