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Original

The role of PET/CT in evaluation of Facet and Disc abnormalities in patients with low back pain using ^{18}F-Fluoride

Sherief Gamie[1, 2], Tarek El-Maghraby[3, 4]

[1]Department of Radiotherapy, Alexandria University, Alexandria, Egypt
[2]Department of Radiology, Stanford University/Veterinary Affairs Palo Alto Medical Center, Stanford, California, United States
[3]Department of Nuclear Medicine, Cairo University, Cairo, Egypt
[4]Nuclear Medicine Section, Saad Hospital, Al-Khobar, Saudi Arabia

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Abstract

BACKGROUND: Bone scintigraphy including Single Photon Emission Computed Tomography (SPECT) is known for its role in the diagnosis of low back pain disorders. Positron Emission Tomography (PET) with ^{18}F (Flouride-18) as a tracer can be used to carry out bone scans with improved image quality. With the addition of CT, simultaneous PET/CT fused images provide more accurate anatomical details.

The objectives of this work are to assess the use of ^{18}F-PET/CT in patients with back pain and suspected facetogenic pain, and to find the frequency of facet arthropathy versus disc disease abnormalities.

MATERIAL AND METHODS: 67 patients who presented with back pain underwent routine X-ray, CT and/or MRI, which failed to identify a clear cause, were referred to ^{18}F-PET/CT. Among the main group, a subset of 25 patients had previous spine surgery consisting of laminectomy or discectomy (17 patients) and lumbar fusion (8 patients). The PET/CT scan was acquired on a GE VCT 64-Slice combined scanner. Imaging started 45–60 minutes after administration of 12–15 mCi (444–555 MBq) of ^{18}F-Fluoride. The PET scan was acquired from the skull base through the inguinal region in 3D mode at 2 minutes/bed. A low-resolution, non-contrast CT scan was also acquired for anatomic localization and attenuation correction.

RESULTS: The ^{18}F-PET/CT showed abnormal uptake in the spine in 56 patients, with an overall detection ability of 84%. Facet joints as a cause of back pain was much more frequent (25 with abnormal scans). One-third (36%) of the patients showed multiple positive uptake in both facet joints and disc areas (20/56). The patients were further divided into two groups. Group A consisted of 42 patients (63%) with back pain and no previous operative procedures, and the ^{18}F-PET/CT showed a high sensitivity (88%) in identifying the source of pain in 37/42 patients. Group B included 25 patients (37%) with prior lumbar fusion or laminectomy, in which the PET/CT showed positive uptake in 76% (19/25 patients). ^{18}F-PET/CT showed positive uptake in all patients (100%) with a history of pain after lumbar fusion, while in the laminectomy subgroup only 11 cases (65%) showed positive focal uptake.

CONCLUSIONS:^{18}F-PET/CT has a potential use in evaluating adult patients with back pain. It has a promising role in identifying causes of persistent back pain following vertebral surgical interventions.

Key words: PET/CT, low back pain, facet arthropathy, bone scanning

Correspondence to: Tarek El-Maghraby
Nuclear Medicine, Saad Specialist Hospital
Al-Khobar 31952, Saudi Arabia PO box: 30353
Tel: (+96 63) 801 25 28, fax: (+96 63) 882 10 48
e-mail: Tarek116@hotmail.com

Introduction

The spectrum of causes for low back pain is wide and includes a variety of conditions including musculoligamentous, osteoarticular and neurologic disorders. Spinal disorders and facet joint pathology have long been considered common sources of low back pain [1]. Among the various available imaging modalities, bone scintigraphy, including Single Photon Emission Computed Tomo-

graphy (SPECT), used to be the modality of choice in patients with suspected bone abnormality, to show its physiologic and metabolic activity [2–6]. Further studies showed the efficacy of SPECT in the diagnosis and evaluation of a variety of vertebral disorders [7–9]. Positron Emission Tomography (PET) is a well-recognized tool in the management of malignancy. However, PET with ^{18}F as a tracer can be used to carry out bone scans with improved image quality. There is significantly improved sensitivity and specificity of F18-PET bone scans in diagnosing benign and metastatic bony abnormalities compared with conventional bone scintigraphy and SPECT [10].

^{18}F-PET/CT, which consists of ^{18}F-fluoride PET images fused with CT images acquired simultaneously in PET/CT hybrid scanner, provides more accurate anatomical localization of bony lesions. Recent studies demonstrated the positive potential role of ^{18}F-PET and ^{18}F-PET/CT in the diagnosis and evaluation of bone abnormalities in adolescent and young patients with back pain [11–13].

The main objective of the present work is to report our initial experience with the use of ^{18}F-PET/CT in adult patients with back pain and suspected facetogenic pain. In addition, the aim is to assess the frequency of suspected facet arthropathy versus disc disease abnormalities in regular patients with back pain and in postoperative patients with persistent back pain.

Material and methods

This study included 67 patients presented with suspected facetogenic back pain or disc pain and seen initially in the neurosurgery clinic in Palo Alto Veterinary Affairs (VA) Hospital/Stanford University Medical Center, Stanford, California. This group of patients went through the routine practice of obtaining X-rays followed by CT and/or MRI, which failed to identify obvious causes of back pain such as herniated discs, spondylolistheses and lumbar stenosis. Accordingly, they were referred to the Nuclear Medicine Lab for ^{18}F-PET/CT studies. The group of 67 Patients consisted of 63 males and 4 females with mean age of 60 years (range 40–85 years). Among the main group, a subset of 25 patients had previous lumbar spine surgery consisting of laminectomy or discectomy (17 patients) and lumbar fusion (8 patients). The study proceeded after approval from the Palo Alto VA Institutional Review Board.

PET/CT scintigraphy

The PET/CT scans were acquired on a GE VCT 64-Slice combination of Positron Emission Tomography and volume Computed Tomography (PET/CT) scanner. The Discovery VCT 64-slice combines the high-speed, high-resolution capabilities of GE's volumetric CT with the high sensitivity imaging capabilities of the GE Discovery PET system. The 67 patients were imaged 45–60 minutes after intravenous injection of 12–15 mCi (444–555 MBq) of ^{18}F-Fluoride. The whole PET scan duration was 12–16 minutes and was acquired from the base of the skull through the inguinal region in 3D mode at 2 minutes/bed. A low-resolution, non-contrast enhanced CT scan of the same area was also acquired for anatomic localization and attenuation correction of the PET data and image registration. All the images were displayed in three window settings of PET alone, CT and fused PET/CT images. The interpretation was carried out after reviewing all the images in the transaxial, coronal, and sagittal planes.

Results and Discussion

A total of 67 patients were evaluated in the current study. The ^{18}F-PET/CT showed abnormal foci of uptake in the spine in 56 patients, while in 11 patients there was no abnormal tracer uptake. Accordingly, the overall detection ability (sensitivity) was 84%. Facet joints as the cause of back pain was much more frequent (25 with abnormal uptake) compared to 11 cases only with disc lesions that showed abnormal ^{18}F uptake (Table 1). One-third (36%) of the patients with back pain showed multiple positive uptake in both facet joints and disc areas (20/56). The numbers of single versus multiple levels of facet or disc abnormalities are variable and illustrated in Table 2. The findings in ^{18}F-PET/CT were further divided into two groups. Group A consisted of 42 patients (63%) with back pain and no previous operative procedures in the spine (Figures 1 and 2). Group B included 25 patients (37%) with prior lumbar fusion or laminectomy for the vertebrae, but presenting with persistent back-pain.

Group A — no prior spine operative procedures

As indicated in table 1, the ^{18}F-PET/CT scanning showed high sensitivity (88%) in identifying the source for pain in 37 out of 42 patients, while it showed no abnormal uptake in 5 cases only. Cases of positive uptake were more prevalent in the facet joints (n = 14) as seen in figure 1, compared to 9 cases in which the source of pain as identified by ^{18}F-PET/CT was related to discogenic pathology (Figure 2). In 38% of the cases, there were abnormal scintigraphic features in both facet and disc areas.

Group B — persistent post-operative pain

This group comprised 17 patients with prior laminectomy for assumed disk pathologies and 8 cases with previous lumbar fusion. The ^{18}F-PET/CT scanning showed positive areas of uptake in all patients (100%) with a history of pain after lumbar fusion, as in the ex-

Table 1. ^{18}F-PET/CT findings in all included patients

	Total (n = 67)	Group A Non-operative (n = 42)	Group B Post-operative (n = 25)
+Ve ^{18}F-PET/CT	56 (84%)	37 (88%)	19 (76%)
Facet joint alone	25	14	11
Disc and facet joint	20	14	6
Disc alone	11	9	2
–Ve ^{18}F-PET/CT	11	5	6

Table 2. Prevalence of single versus multiple level facet and disc abnormalities

	Number
Disc Lesions	
Single Disc	15
Multiple Discs	16
Facet Lesions	
Single Facet	12
Multiple Facets	33

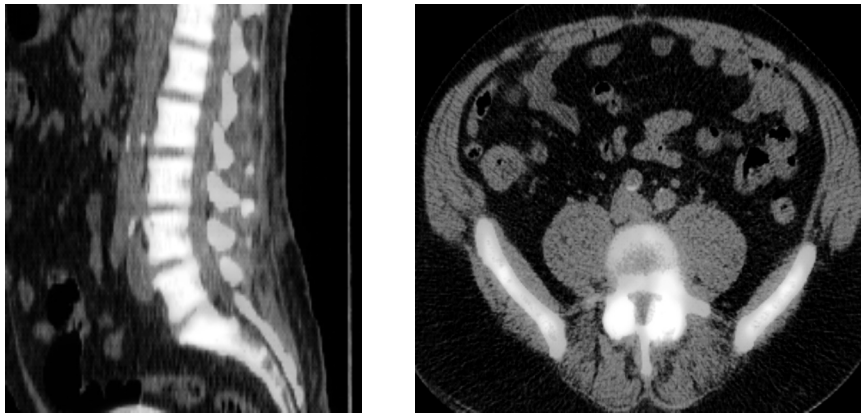

Figure 1. 62-years-old male presenting with 2 years history of severe low back pain. The CT and MRI failed to show exact cause or level of pathology. The Fusion ^{18}F-PET/CT images show bilateral intense uptake in both facet joints at L4-L5 level. The pathological uptake is more on the left side.

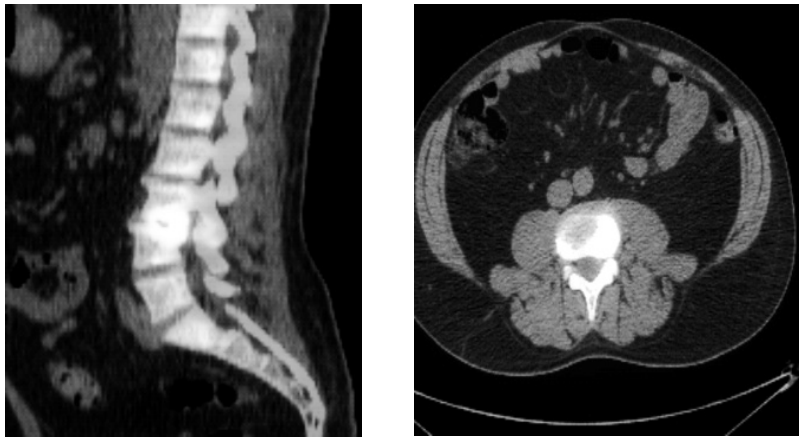

Figure 2. Chronic low back pain with no localized cause by CT and MRI. ^{18}F-PET/CT showed intense uptake at the left aspect of the disc area at levels of L3-L4 vertebrae.

Figure 3. Previous discectomy in the lumbar region with persistent pain. The ^{18}F-PET/CT fusion images show intense pathological uptake in the L3/4 disc.

ample in Figure 3. On the contrary, in the laminectomy subgroup, 6 patients showed no pathological ^{18}F uptake while the remaining 11 cases (65%) showed positive focal uptake (Table 3, Figure 4). This may denote that the probability of persistent back pain following lumbar fusion is much higher than in the case of laminectomy. In

Table 3. ^{18}F-PET/CT findings in Patients with post-operative pain (Group B)

	Total (n = 25)	Lumbar fusion (n = 8)	Laminectomy (n = 17)
+Ve ^{18}F-PET/CT	19 (76%)	8 (100%)	11 (65%)
Facets alone	11	3	8
Disc alone	2	1	1
Facets and Discs	6	4	2
–Ve ^{18}F-PET/CT	6/25	0/8	6/17

group B, the prevalence of pathological ^{18}F uptake was more in facet areas (58%), compared to only 2 cases (10%) that showed uptake at the level of the discs. The remaining 6 cases (32%) showed multiple areas of uptake in both disc and facet areas.

Discussion

This study demonstrates the potential efficacy of ^{18}F-PET/CT in diagnosing abnormalities of facets and discs in adult patients who present with back pain. Eighty-four percent of patients had abnormalities of discs or facets. Forty-five percent had abnormalities of

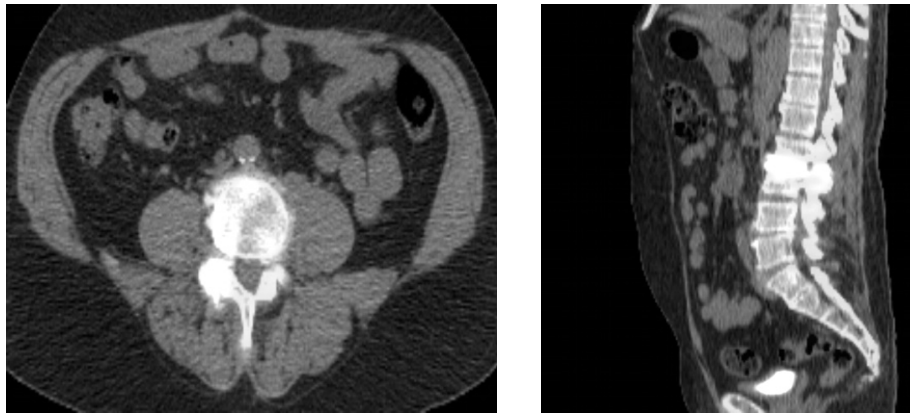

Figure 4. Male patient with persistent pain after previous laminectomy. The ^{18}F-PET/CT images showed positive uptake at L3–L4 and in the right facet joint as well.

facet joints alone, 36% had abnormalities of both discs and facets, and 20 % had abnormalities of discs only. Seventy-six percent of patients who had persistent pain after previous surgery had focal abnormalities in facets and/or discs.

This is a novel study to report the use of ^{18}F-PET/CT in the evaluation of facetogenic and discogenic pain in adults. Two previous studies reported on ^{18}F-PET findings without concurrent CT in younger patients. Lim et al. [13] performed ^{18}F-PET in 94 young patients (mean age 15 years) with back pain. Focal abnormalities were present in 52/94 (55%) patients. Of these, 34% had abnormalities suggestive of pars/pedicle stress, 16% spinous process, 14% vertebral body and 3% related to Sacro-iliac joint abnormality. Ovadia et al. [12] performed ^{18}F-PET/CT scans on 15 adolescents (mean age 14 years) with severe back pain. The patients had undergone several imaging studies including x-rays, and in some cases 99mTc-MDP bone scan with SPECT; however, all of these failed to delineate the causes of back pain. In their study, 10/15 (67%) patients showed abnormal uptake in the ^{18}F-PET/CT and proved to have bony abnormalities that include osteoid osteoma (2 patients), spondylolysis (4 patients) and fractures (4 patients). The 5 patients with negative ^{18}F-PET/CT studies had no bony pathology and recovered spontaneously. In contrast to the findings in adolescents and young patients, the current study suggests that adults who present with back pain are more likely to have abnormalities of facet joints or discs rather than pars defects or fractures.

We found that a significant number (76%) of patients with persistent postoperative back pain after spine surgery had abnormalities of the facet joints and/or discs. Two previous ^{99m}Tc-MDP bone SPECT studies reported similar findings [14, 15]. Gates et al. [15] performed SPECT in 63 back pain patients. All patients had a history of previous surgery (28 patients underwent laminectomy, 28 laminectomy with fusion, and 7 discectomy). Abnormalities of facet joints were present in 51/63 (81%) patients after surgery and 28/63 (44%) had disc space abnormalities. Likewise, Lusins et al. [14] also identified a high number of facet abnormalities (75%) in patients with persistent back pain after multilevel lumbar laminectomy. They concluded that abnormalities of facet joints in patients with persistent post-laminectomy pain are suggestive of increased stress in facet joints caused by instability after multilevel laminectomy.

There have been several previous studies on the utility of ^{99m}Tc-MDP bone SPECT in diagnosis and evaluation of back pain [1, 4, 14, 15]. Ryan et al. [2] performed ^{99m}Tc-MDP bone SPECT studies in 80 patients (median age 44) with back pain. Sixty percent had spinal abnormalities on SPECT scanning. Of these, 50% involved facet joints. In a similar work, SPECT was performed in 43 patients with suspected facetogenic disease and showed that 44% of patients had SPECT abnormalities in facet joints [3]. Similarly, Dolan et al. [4] identified facet abnormalities in 22/58 (38%) patients with suspected facetogenic pain, and Pneumaticos et al. [1] identified 15/31(48%) patients who had facet abnormalities on bone SPECT scanning. None of these studies reported disc abnormalities. Our study reports a higher percentage of facet joint abnormalities (67%) compared to abnormal disc activity (46%). Our findings are consistent with the demonstrated superior sensitivity, specificity and spatial resolution of ^{18}F-PET/CT over ^{99m}Tc-MDP bone SPECT in imaging bone activity [16, 17]. We believe that ^{18}F-PET/CT with its superior resolution has the advanced ability to evaluate the exact cause of back pain by showing discogenic as well as facetogenic abnormalities.

Conclusions

^{18}F-PET/CT has a potential use in evaluating adult patients with back pain, especially when the exact pathology cannot be identified by anatomical tomographic modalities (CT and/or MRI). In addition, ^{18}F-PET/CT has a promising role in identifying causes of persistent back pain following surgical interventions for the vertebrae. Further large-scale studies are recommended to establish the clinical significance of ^{18}F-PET/CT in assessing the wide spectrum pathologies for back pain and to show its further potential in monitoring and predicting response to therapy.

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