Original Article Clinics in Orthopedic Surgery 2010;2:167-172 • doi:10.4055/cios.2010.2.3.167

Evaluation of Shoulder Disorders by 2-[F-18]-fluoro-2-deoxy-D-glucose Positron Emission Tomography and Computed Tomography

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Background: Although flourine-18-flourodeoxyglucose (FDG) positron emission tomography (PET) has a limitation for localizing anatomical structures, combining it with computed tomography (CT) has made it more efficient for overcoming such limitations. This study aims to evaluate the efficacy of PET/CT for evaluating diseases of the shoulder.

Methods: Retrospective examination was performed on 25 patients who underwent FDG-PET/CT scanning. All the patients were over 60 years of age, and they were evaluated both clinically and radiologically for shoulder pain. The study period was from May, 2006 to May, 2008. One of the patients had metastatic lesion in a shoulder and this patient was excluded from the study, so the total number of subjects in the study was finally 24 patients.

Results: PET/CT showed 67% sensitivity, 73% specificity, a positive predictive value of 60%, a negative predictive value of 79%, 27% false positivity and 33% false negativity concerning shoulder pain. PET/CT showed negative finding in 4 cases that were successfully treated by operative treatment (rotator cuff tear [RCT], 3 cases; impingement syndrome, 1 case). Negative findings were also noted in 6 cases in which the pain subsided after conservative treatment (RCT, 1 case; suspected RCT, 2 cases; impingement syndrome, 3 cases). All the patients with osteoarthritis and rheumatoid arthritis had positive findings on PET/CT scanning.

Conclusions: PET/CT is a useful adjunct to the existing imaging modalities to assess functional and pathophysiologic processes and at a very early stage, and so PET/CT can help physicians make better preoperative and postoperative decisions on treatment.

Keywords: *Shoulder, Positron emission tomography, Computed tomography, Fluorodeoxyglucose F18*

Shoulder pain is a common musculoskeletal problem and it is noticed in 7% to 20% of the adult population.[1] Rotator cuff disorders that can cause shoulder pain are one of the most common disorders affecting the musculoskeletal system and so rotator cuff disorders are becoming more important in today's aging society.[2,3] It is also reasonable to think that incidence rate of other shoulder diseases is on the rise as the geriatric population is increasing. Generally, in the early stage, simple physical examination and radiographs are commonly used to analyze shoulder disorders. Nowadays, these simple examinations are complemented by ultrasound and magnetic resonance imaging (MRI), which both make more detailed evaluation possible.[3-12]

Recently developed flourine-18-flourodeoxyglucose (FDG) positron emission tomography (PET) is an imaging modality that can detect the metabolism rate of glucose, which is especially high in tumor and inflammatory cells. This is a better examination, when compared to MRI, for detecting the symptomatic lesions among various lesions that present simultaneously within a particular region. This is because FDG PET reflects the difference

Received December 22, 2008; Accepted November 10, 2009
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in the uptake of the FDG between the various tissues and bones based on their activity so that it can detect osteoblast activity or increased vascularity of the clinically abnormal tissue. It also it has an advantage of detecting any pathological lesion at a very early stage,[13-16] yet it is difficult to accurately localize the lesion anatomically with this modality.

On the other hand, computed tomography (CT) or MR imaging provides accuracy for the morphologic aspect, such as the lesion location, size, etc, but it has a limitation to provide functional, physiologic imaging.

By combining the CT and PET scan (PET/CT) it is possible to obtain the functional, physiological, anatomical and pathological imaging that can help physicians make better treatment decisions.[17]

This study aims at finding a relation, if any, between PET/CT imaging and the presence or absence of shoulder disease, and also we assessed the efficacy of PET/CT for diagnosing such disease.

METHODS

This retrospective study was performed on 25 patients who underwent FDG-PET/CT examination. All the patients were over 60 years of age, and they also were evaluated radiologically for shoulder pain. The study period was from May, 2006 to May, 2008. One of the patients had metastatic lesion in a shoulder and this patient was excluded from the study, thereby reducing the final study group to 24 patients. Of these 24 subjects, 18 were males and 6 were females with the mean age of 65. PET/CT imaging was performed to determine a cancerous or metastatic condition (18 cases), for health screening (3 cases) and for analysis of pulmonary tuberculosis or pneumonia (3 cases). The presence of a shoulder disorder or shoulder pain at the time of the PET/CT examination was determined from the simple radiographs, MR imaging and the clinical examination records of the hospital.

Twenty-four cases of shoulder disorders were classified into six groups; rotator cuff tear confirmed by MRI and clinically suspected rotator cuff tears that are not confirmed by MRI (7 cases), impingement syndrome (7 cases), calcific tendinitis (1 case), osteoarthritis and rheumatoid arthritis (3 cases), adhesive capsulitis (2 cases), bruise and others (4 cases).

The PET/CT examination was done by intravenous injecting F-18-FDG and then the PET scan and a non-contrast CT scan were done after 1 hour, to correct the attenuation, from the head and neck to above the knee joint. The timing of the PET/CT exam, the simple radiographs and the MR imaging was analyzed as before, after or at the same time. For example, when the respective examinations (PET/CT exam, simple radiograph and MR imaging) were performed within a week, they were considered to be performed at the same period. If they were not done within the same week, then they were considered as being performed either before the PET/CT or after the PET/CT, based on the timing of the examinations.

If any case had simple radiography and MR imaging before PET/CT, then we analyzed whether if there was any disease or not and whether there was any increase or decrease in activity on PET/CT. If simple radiographs and MR imaging were done after PET/CT, then we analyzed whether or not disease activity existed. The increased uptakes in the shoulder regions on PET/CT scanning were analyzed thrice by nuclear radiology reports and by three orthopedic doctors who specialized in shoulder surgery.

RESULTS

On the PET/CT exam, 9 patients showed increased uptake around the shoulder, but no uptake was seen in 15 patients. Ten patients complained of shoulder pain due to a shoulder disorder, but 14 patients were without symptoms on the day of the PET/CT study.

On the analysis of the timing of PET/CT, the simple radiographs and MR imaging, 11 patients had a basic exam (simple radiographs and MR imaging) before the PET/CT study, 3 patients had it the same time (within the same week) as the PET/CT study and 10 patients had the basic exam after PET/CT study. For the cases with increased uptake, 6 patients complained of a shoulder pain and 3 patients did not. For the cases with no increased uptake, 4 patients complained of a shoulder pain, but 11 patients did not complain of shoulder pain (Table 1).

From these results, PET/CT showed 67% sensitivity, 73% specificity, a positive predictive value of 60%, a negative predictive value of 79%, a false positive value of 27% and a false negative value concerning shoulder pain of 33% (Table 2). PET/CT showed negative findings in 4 cases that underwent operative treatment and among them, it was negative in 3 out of 4 cases of surgically repaired rotator cuff tear and in 1 out of 7 cases of impingement syndrome (Fig. 1). Also, negative findings were noticed in 6 cases in which the pain subsided after conservative treatment, and out of the 6 cases, one was rotator cuff tear in which the pain subsided after conservative treatment, 2 cases were those with suspected rotator cuff tear and 3 cases were of impingement syndrome. The patients with symptomatic osteoarthritis and rheumatoid arthritis all

Table 1. Patients' Profiles

No.	Age/ gender	PET/CT finding	Shoulder symptoms	Shoulder lesions
1	60/M	-*	No	Acromial spur
2	61/M	-	No	Cuff tear
3	68/M	+†	Yes	Acromial spur
4	66/M	-	No	Cuff tear
5	69/F	+	Yes	Rheumatoid arthritis
6	63/M	-	No	Contusion
7	64/M	-	No	Acromial spur
8	64/M	-	Yes	Acromial spur
9	69/M	-	Yes	Acromial spur
10	65/M	+	Yes	Osteoarthritis
11	69/M	-	No	Cuff tear
12	67/M	+	Yes	Osteoarthritis
13	68/M	+	No	Frozen shoulder
14	62/M	-	No	Acromial spur
15	68/M	-	No	Suspected cuff tear
16	60/F	-	No	Others
17	67/F	+	Yes	Cuff tear
18	60/F	-	Yes	Suspected cuff tear
19	63/F	-	No	Others
20	62/M	+	No	Calcific tendinitis
21	66/M	+	Yes	Frozen shoulder
22	68/M	-	Yes	Acromial spur
23	64/M	-	No	Suspected cuff tear
24	78/M	+	No	Acromial spur

*Negative positron emission tomography (PET) / computed tomography (CT) scan findings, †Positive PET / CT scan findings.

Table 2. Results

Symptom \ PET/CT	+	-	Sum
+	6	4	10
-	3	11	14
Sum	9	15	24

PET: Positron emission tomography, CT: Computed tomography.

showed positive finding (Fig. 2).

DISCUSSION

PET was invented by Ter-Pogossian in 1974, and it is a functional imaging modality in nuclear medicine and PET is rapidly developing. PET makes an image of the intravenously injected radiopaque material distributed in the body by taking advantage of the radiopaque material emitting positrons.

PET is a specialized imaging modality that can quantify functions of internal organs and biochemical and physiologic responses. So, PET offers unique and important information about disease processes and so it is useful for making the diagnosis and prognosis of disease and analyzing treatment.

With PET it is possible to quantitatively and qualitatively analyze the physiologic or biochemical responses of internal organs. Usually, as biochemical change precedes anatomic change, PET can detect the disease even before any anatomic alteration is noticed. However, PET study alone can't reveal the accurate location of the disorder. Fluorine-18 is a radionuclide that has an affinity for musculoskeletal tissue, and fluorodeoxyglucose with marked fluorine-18 shows increased uptake in tumor cells and inflammatory cells, and these cells have increased glucose metabolism compared to that of normal cell.[18,19]

PET is commonly used for diagnosing cardiac diseases, brain tumors and the others tumors, and it is also useful for determining the grade of tumor malignancy. Skeletal muscle activity has been examined in vivo by determining the FDG uptake. It is already known that there is little accumulation of FDG in the muscles.[20] So, PET/CT *i.e.*, the FDG-PET image with CT imaging helps to localize anatomic lesions and so this may increase the specificity of a diagnosis when compared with using only a PET scan or only a CT scan to make the diagnosis.[21,22] The increase in glucose metabolism is not only confined to the tumor cells, but it is also noticed in inflammatory cells such as leukocytes, granulocytes and macrophages, so that the enhanced uptake of the radionuclide helps diagnose infective and inflammatory disorders much more effectively.[19,23,24] Consequently, the effectiveness of PET/CT to accurately detect anatomic lesion will increase.

As shoulder disease and shoulder pain most often occur in older age people, we surveyed the patients over 60 years who had shoulder symptom from among those who were included in the PET/CT study. The incidence of rotator cuff tear is closely related to increasing age. It has been reported that the incidence of full-thickness

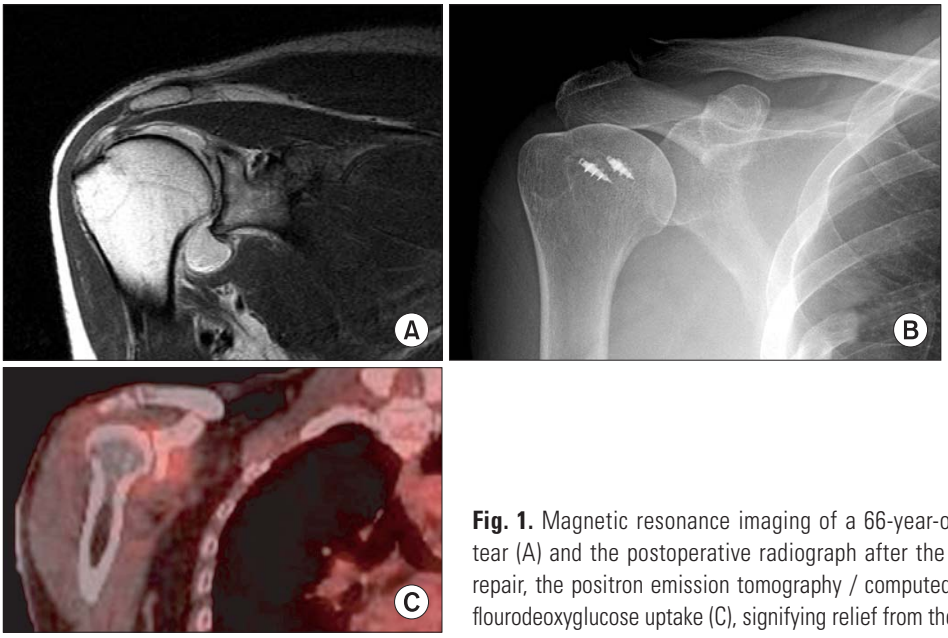

Fig. 1. Magnetic resonance imaging of a 66-year-old male with a symptomatic rotator cuff tear (A) and the postoperative radiograph after the repair (B). Fourteen month after the cuff repair, the positron emission tomography / computed tomography revealed normal flourine-18-flourodeoxyglucose uptake (C), signifying relief from the previous symptoms.

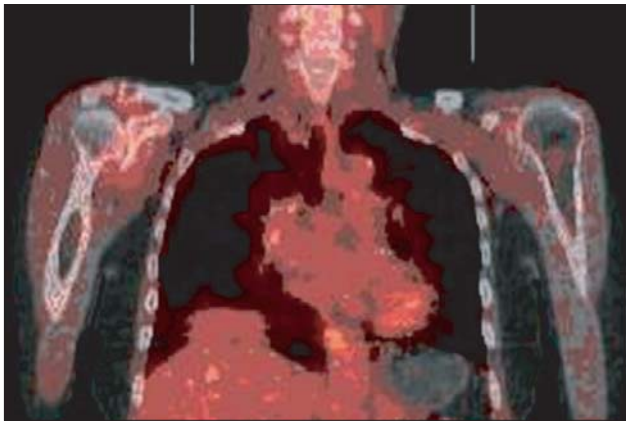

Fig. 2. A 69-year-old female patient with rheumatoid arthritis in the shoulder shows generalized increased uptake on the left side.

tear is 5% to 30% as demonstrated in the cadaver studies and the incidence of full-thickness tear is 28% in patients over sixty years old and it is 65% in patients over the age of seventy. This infers that the incidence of full-thickness tears is on the rise in the aged population.[25-27)]

But as it is an expensive test, PET/CT is mainly used for cancer detection and evaluation of the metastatic foci and follow-up; its routine use for diagnosing shoulder disorder and pain has not been established. None of the patients in our study underwent PET/CT scanning primarily for diagnosing shoulder pain. So, the limitation of this study is that it is a retrospective study and analysis was done by examining the reports.

In this study, PET/CT showed negative finding in 3 cases with a surgically repaired rotator cuff tear and PET/CT showed negative finding in 3 out of 4 cases of rotator cuff tear that received conservative management. It was predictable that pain relief was achieved by surgical treatment and there was a decrease in the disease activity and inflammation. Nonsurgical treatment for rotator cuff tear has been variably reported in 33% to 92% of the cases, with effective results in 50% of the cases.

The 3 patients for whom the simple radiographs and PET/CT examination were done at the same period all showed increased uptake. It is predictable that the pain influenced the disease activity. The patients with a chronic progressive disorder like osteoarthritis and rheumatoid arthritis all showed positive findings.

For the cases showing positive findings on PET/CT, rotator cuff tear or adhesive capsulitis was diagnosed in 3 out of 9 cases. These 3 cases (1 case each of calcific tendinitis, impingement syndrome and adhesive capsulitis) did not complain of shoulder pain, but they had increased uptake on the PET/CT findings, and maybe the disease severity was not sufficient to produce pain. The postoperative follow-up PET/CT examination for 4 cases with painful shoulder did not show increased uptake, and so we can consider some other source for their pain because the previous condition for which they underwent surgery was not the cause of their present shoulder pain. Follow-up PET/CT study should be used to evaluate the patients who underwent surgical treatment for their shoulder disorder such as rotator cuff tear, but who are still complaining of

shoulder pain.

PET/CT is an effective imaging modality to assess the functioning of internal organs and their biochemical and physiologic responses. It has also been used to understand tumor behavior and cardiac diseases, and also for evaluating the activity of the disease on follow-up studies.

In this study, the patients who underwent PET/CT examination were retrospectively evaluated for painful shoulder lesion. On the final analysis, PET/CT showed 67% sensitivity, 73% specificity, a positive predictive value of 60%, a negative predictive value of 79%, a false positivity rate of 27% and a false negativity rate of 33% concerning shoulder pain and all 3 cases imaged at same time showed positive findings. Four cases that had had a good result from surgical treatment showed negative findings and 3 cases with chronic non-progressive disorder showed positive finding.

When the PET/CT activity is still increased even after adequate treatment, PET/CT will be an effective modality that can help select the future treatment. Thus, PET/CT can be a useful adjunct to the existing imaging modalities to delineate the symptomatic lesions and direct the treatment for them.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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