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Clinical short communication

Increased ^{18}F-FDG uptake in the trapezius muscle in patients with spinal accessory neuropathy

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ABSTRACT

To investigate ^{18}F-fluorodeoxyglucose (FDG) positron emission tomography (PET) signal changes of denervated muscles in patients with electrophysiologically confirmed neuropathy.
Methods: This is a case series of three cancer patients who were referred to the electromyography laboratory in 2013 due to shoulder discomfort after surgery including neck dissection. Spinal accessory neuropathy was diagnosed based on electrophysiological studies. Patients' medical history, electrophysiological data, and FDG-PET images were reviewed retrospectively. Mean standard uptake values (SUV) of trapezius muscles were measured.
Results: The patients (3 men, aged 61–78 years) showed spinal accessory neuropathy with different degrees of severity. In all patients, preoperative or postoperative FDG-PET showed increased FDG uptake in the ipsilateral trapezius muscle. These results were compatible with previously reported glucose hypermetabolism in denervated skeletal muscles.
Conclusion: This is the first clinical report of increased FDG uptake by denervated muscles in electrophysiologically confirmed neuropathy.

1. Introduction

Electrophysiological studies including needle electromyography (EMG) and nerve conduction studies (NCS) are the gold standard to evaluate peripheral neuromuscular disorders [1]. However, it has disadvantages such as pain by needle insertion and subjectivity in interpretation [1]. A new functional imaging study would be valuable to overcome these limitations. Magnetic resonance (MR) imaging can visualize denervated muscle with high signal intensity of the muscle in fluid-sensitive sequence; [2] however, it has not been used in the clinic to evaluate muscle denervation.

Behera et al. [3] reported incidentally increased ^{18}F-fluorodeoxyglucose (FDG) uptake in denervated calf muscle from a model of ipsilateral spared sciatic nerve injury. Our previous animal study showed significantly increased FDG uptake in the denervated lower leg muscles compared with the contralateral side, 1 week after sciatic nerve transection [4]. Muscle denervation was confirmed by electrophysiological studies. These results are sufficient to confirm glucose hypermetabolism in denervated muscle as an unknown feature of neuromuscular biology. Thus, we suggested FDG positron emission tomography (PET) scan be used as a noninvasive tool for the evaluation of peripheral neuromuscular disorders.

Head and neck cancer patients are occasionally referred to our EMG laboratory because shoulder dysfunction after surgery is common [5]. Most of them have FDG-PET scans for cancer workup. Therefore, we could find three patients who showed FDG-PET signal changes in denervated trapezius muscles by electrophysiologically confirmed spinal accessory neuropathy. The purpose of this study was to present the first clinical case series of glucose hypermetabolism in muscle denervation. We received approval from the Institutional Review Board of Seoul National University Hospital.

2. Cases

2.1. Patient 1

A 78-year-old man underwent left submandibular gland resection with neck dissection (Ib, II, III) due to an adenoid cystic carcinoma in the left submandibular gland (pT2N0 stage) on March 15, 2012. The patient then received postoperative radiation therapy (RT) with a total dose of 66 Gy from April 12, 2012 to June 15, 2012. He was referred to the EMG laboratory on January 9, 2013 (10 months postoperatively) for mild left shoulder discomfort after surgery. Although the symptoms had improved, EMG confirmed chronic left spinal accessory neuropathy

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with evidence of partial axonal injury. The EMG recordings revealed large, polyphasic motor unit action potentials (MUAPs) indicative of reinnervation of denervated muscle, and denervation potential was observed in the left trapezius muscle. Interestingly, postoperative FDG-PET/computed tomography (CT) scans (Fig. 1B) obtained on December 13, 2012 (9 months postoperatively) showed definitely increased FDG uptake in the left trapezius muscle, which was not seen in the preoperative scans (Fig. 1A) on February 6, 2012. Mean standard uptake value (SUV) of the left trapezius muscle using 1-cm radius spherical volume of interest (VOI) was 2.48 ± 0.41 and that of the contralateral trapezius muscle was 0.79 ± 0.10 in the postoperative PET scans.

2.2. Patient 2

A 66-year-old man underwent oral cavity cancer surgery including mass resection and partial maxillectomy with left selective neck dissection on July 1, 2013. Left shoulder weakness developed immediately after surgery. On September 12, 2013 (about 2 months postoperatively), the patient presented at our EMG laboratory. Physical examinations revealed mild atrophy of the trapezius and the sternocleidomastoid muscle, weakness (grade 4) on manual muscle testing during left shoulder abduction, and scapular winging during shoulder abduction. Electrophysiological studies were compatible with left spinal accessory neuropathy with partial axonal involvement. FDG-PET/CT performed on August 23, 2013 (about 1.5 months postoperatively) showed slightly increased FDG uptake in the left trapezius muscle (Fig. 2A; mean SUV, 1.60 ± 0.24; contralateral mean SUV, 0.81 ± 0.10). His weakness was recovered 4 months postoperatively, and follow-up FDG-PET/CT scans taken on August 14, 2014 revealed normal FDG uptake levels and stable muscle volume in the left trapezius muscle (Fig. 2B; mean SUV, 0.79 ± 0.12; contralateral mean SUV, 0.80 ± 0.09).

2.3. Patient 3

A 61-year-old man had received concurrent chemoradiotherapy as an initial treatment for esophageal cancer in 2010. In 2012, the cancer recurred in the upper esophagus and the lymph nodes of the right neck. Extended esophagectomy with three-field lymph node dissection was performed for the local recurrence on September 17, 2012. He was referred to our EMG laboratory for right shoulder and neck pain with severe right trapezius atrophy on February 12, 2013 (5 months postoperatively). EMG recordings showed right spinal accessory neuropathy with nearly complete axonotmesis. We reviewed his FDG-PET/CT studies, and increased FDG uptake in the right trapezius muscle (mean SUV, 2.01 ± 0.37; contralateral mean SUV, 0.97 ± 0.13) was found in preoperative PET scans on September 5, 2012 (Fig. 3A). Additionally, hypermetabolic lymph nodes were observed in the right neck level II area; intraoperative findings revealed severe adhesion around the right accessory nerve. Five months postoperatively, follow-up whole-body FDG-PET/CT scans showed right trapezius atrophy without definite FDG uptake increase (Fig. 3B; mean SUV, 1.00 ± 0.10; contralateral mean SUV, 1.09 ± 0.14).

3. Discussion

This is the first report of increased FDG uptake related to muscle denervation confirmed by electrophysiological evidence in humans. There might be many undiscovered cases of increased FDG uptake in skeletal muscle associated with various types of focal neuropathies.

Patient 1 had two potential causes of spinal accessory neuropathy: intraoperative and RT-induced nerve injury. Operative records revealed no injury to the spinal accessory nerve. Adjuvant RT is a possible source of spinal accessory neuropathy other than direct surgical injury [6]. Even though the etiology is unclear, FDG-PET scans were taken more than 6 months after nerve injury, which is sufficient for motor unit remodeling [1]. Indeed, needle EMG showed evident reinnervation potentials with abundant denervation potential in the left trapezius muscle, indicating that the muscle fibers were in the ongoing process of reinnervation after denervation, which is compatible with the clinical course of the patient. Mean SUV in the left trapezius muscle increased approximately three-fold compared to the contralateral side. This was the most remarkable increase in FDG uptake among the three cases.

In patient 2, spinal accessory neuropathy must have been caused by surgical injury. The FDG uptake in the weakened trapezius muscle was

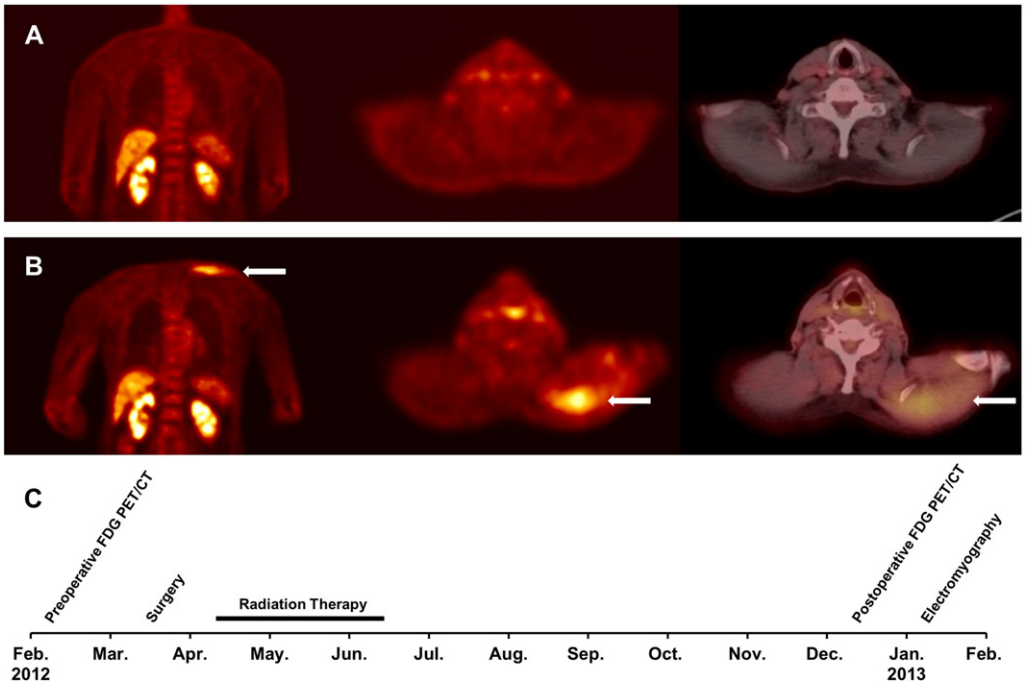

Fig. 1. A 78-year-old man with left submandibular gland cancer. The patient underwent left submandibular gland resection with neck dissection and adjuvant radiation therapy. Postoperative ^{18}F-FDG-PET/CT scans showed definitely increased ^{18}F-FDG uptake in the left trapezius muscle (arrows). (A) Preoperative and (B) postoperative PET/CT images. (C) Clinical course of the patient.