**NOTE** Internal Medicine

**18F-FDG and 11C-MET Positron Emission Tomography Findings of Cutaneous Mast Cell Tumor in a Dog**

Byeong-Teck KANG1,2), Min-Hee KANG3), Chae-Young LIM3), Dae-Young KIM3) and Hee-Myung PARK2)*

1)Cerebral Microcirculation Unit, National Institute of Neurological Disorders and Stroke, National Institutes of Health, Bethesda, MD, 20892 U.S.A., 2)BK21 Program of Basic and Diagnostic Veterinary Specialist Program for Animal Diseases and Department of Veterinary Internal Medicine, College of Veterinary Medicine, Konkuk University, #1 Hwayang-dong, Gwang-jin-gu, Seoul, 143–701 South Korea and 3)Veterinary Medical Diagnostic Laboratory, College of Veterinary Medicine, University of Missouri, Columbia, MO, 65205 U.S.A.

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**ABSTRACT.** A 12-year-old intact male Maltese dog presented with an inguinal mass. Histopathology revealed a grade III mast cell tumor. Computed tomography demonstrated pulmonary and inguinal nodules and masses. Chemotherapy was performed using a vinblastine/prednisone protocol, and the inguinal mass disappeared 5 weeks later. Use of 2-deoxy-2-[18F]fluoro-D-glucose (18F-FDG) and L-[methyl-11C]methionine (11C-MET)-positron emission tomography (PET) demonstrated hypermetabolic areas in the lungs and inguinal region one week after initial chemotherapy. The standardized uptake values of 18F-FDG were not different between lung and inguinal lesions; however, the inguinal lesion had a higher 11C-MET standardized uptake value than the lung lesions. The hypermetabolic area was still visible on the second 18F-FDG-PET scan despite the disappearance of the mass. This is the first report of 11C-MET-PET findings associated with a cutaneous mast cell tumor in a dog.

**KEY WORDS:** canine, 11C-MET, 18F-FDG, mast cell tumor, PET.

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Positron emission tomography (PET) is a nuclear medical technique that is widely used to diagnose, stage and monitor human tumors [16]. The glucose analog 2-deoxy-2-[18F]fluoroo-D-glucose (18F-FDG) is commonly used for these purposes. L-[Methyl-11C]methionine (11C-MET) is currently considered a highly tumor-specific radiotracer due to the high utilization of amino acids in malignant cells and low uptake in inflammatory cells [8]. The newest generation of PET scanners, including the High-Resolution Research Tomograph (HRRT), has been used to supplement limited anatomic information and acquire high quality functional data because of the lower spatial resolution of PET [3, 4].

Canine mast cell tumors (MCTs) are the most common malignant neoplasms of skin associated with diverse appearance and biological behavior, making these tumors challenging to diagnose and treat [21, 22]. Generally, tumor stage-adapted therapy increases the survival time of canine patients with MCT [5, 22]. In addition to histological grade-based staging, PET provides essential data on staging MCT [12]. Therefore, PET should be considered in canine MCT management.

PET is not commonly used in veterinary medicine due to the limitations in scanner availability and radioisotope access. Findings of 18F-FDG-PET for spontaneous MCTs in canines have been described [12], but there have been no reports on 11C-MET-PET features of canine MCTs. The present case report describes HRRT characteristics of a malignant MCT in a dog.

A 12-year-old intact male Maltese dog presented with a ventral abdominal mass near the prepuce. The mass was initially observed 4 months prior to referral, and was surgically excised without histological grading at a local hospital. The mass recurred two months later and continued to enlarge until presentation to the Veterinary Teaching Hospital of Konkuk University.

Physical examination revealed a hard mass (75 × 70 mm) located in the caudoventral abdominal surface near the prepuce (Fig. 3F). Cytologic specimens of the mass obtained by fine needle aspiration revealed prominent malignant round-type cells with poor granulation, irregular nuclei, increased pleomorphism and mitotic figures. The features were suggestive of a malignant MCT. Biopsy was performed for histological grading, which revealed a grade III MCT with a homogeneous population of large round cells with large round nuclei, mild nuclear pleomorphism and moderate granular cytoplasm with distinct cell outlines in a solid cellular sheet (Fig. 1A). Mitoses varied from 0–4 figures per high power field depending on the location. Eosinophils were occasionally scattered. A small number of cytoplasmic granules demonstrated metachromasia upon toluidine blue staining. Immunohistochemistry revealed c-kit-positive tumor cells (Fig. 1B). No abnormalities were seen on complete blood count (CBC), biochemical profile and buffy coat cytology.

Numerous round and relatively well-margined nodules were radiographically observed in the lung fields, including a large nodule (40 × 30 mm) in the right caudal lobe and several small nodules in left cranial and caudal lobes. Large and soft tissue opacity was evident in the caudoventral abdomen. Computed tomography (CT) demonstrated three homogeneous nodules in the left lung and a large mass in the right lung (Fig. 2A). An additional large mass was posi-
Fig. 1. Photomicrographs of a grade III MCT. (A) Appearance of the inguinal mass. Note the neoplastic round cells with large round nuclei, mild nuclear pleomorphism, and moderate granular cytoplasm with distinct cell outlines in a solid cellular sheet. Hematoxylin and eosin stain; × 400 magnification. (B) Image of positive immunoreactivity to c-kit. Hematoxylin counterstain; × 400 magnification.

Fig. 2. Thoracic PET and CT characteristics in a dog with a grade III MCT. Transverse, dorsal and sagittal images are pictured from left to right. (A) CT displaying three homogeneous nodules in the left lung (arrowhead and thin and thick arrows) and a single large mass in the right lung (*). (B) The abnormal lesions were not enhanced in post-contrast imaging. Both 2-deoxy-2-[18F]fluoro-D-glucose (18F-FDG) (C) and [methyl-11C]methionine (11C-MET)-PET (D) demonstrated intense uptake of lesions (asterisks, arrowheads and thin and thick arrows). The mean SUVs of 18F-FDG and 11C-MET were 4.35 and 3.64, respectively.
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tioned in the caudoventral abdomen (Fig. 3A). The abnor-
mal lesions were not enhanced after intravenous
administration of iohexol (Omnipaque; GE Healthcare, UK)
at 525 mg/kg body weight (Figs. 2B and 3B).

A grade III MCT was confirmed based on clinical
progress, imaging and histopathological findings, and pul-
monary metastasis was strongly suspected. Chemotherapy
was performed using a vinblastine/prednisone protocol,
since the dog had a high-grade MCT with metastasis [19,
20]. Intravenous vinblastine (Velbastine; Korea United
Pharm., South Korea) at 2 mg/m² was administered once
weekly for 8 weeks, followed by four treatments every 2
weeks. The dog was also treated with prednisone (Solondo;
Yuhan Medica, South Korea) at 2 mg/kg once per day for 7
days, after which medication was tapered and discontinued
over 3 weeks. CBC was determined one week after each
vinblastine administration. The mass in the abdomen was
significantly reduced in volume (50 × 45 mm) after a single
dose of vinblastine therapy, and 4 weeks later, it had disap-
peared on abdominal palpation and ultrasonography (Fig.
3F). However, pulmonary nodules were continuously
detected on thoracic radiographs. The dog had a good qual-
ity of life for 5 months.

PET scanning of the thorax and abdomen was performed
to evaluate the cellular metabolism of MCT and monitor the
response to chemotherapy. ¹⁸F-FDG-PET coupled with ¹¹C-
MET-PET was performed at 1 week, and a second ¹⁸F-FDG-
PET test was performed 14 weeks after the initial chemo-
therapy. The dog was fasted for 12 hr to ensure stable ¹⁸F-
FDG uptake and was injected with ¹⁸F-FDG or ¹¹C-MET
(0.4 mCi/kg body weight) under general anesthesia main-
tained with isoflurane. ¹⁸F-FDG and ¹¹C-MET were pro-
duced immediately prior to injection using the onsite
cyclotron (Eclipse HP Cyclotron, CTI Molecular Imaging,
Knoxville, TN, U.S.A.). ¹¹C-MET accumulation was
recorded over 30 min beginning 10 min after tracer injec-
tion. After completion of the ¹¹C-MET-PET study, the dog
was injected with ¹⁸F-FDG, placed on a heating pad and
kept at 38 for 1 hr in a quiet area protected from radiation.
The ¹⁸F-FDG-PET scan was continued for 30 min. The total
duration of anesthesia was 130 min. All scans were per-
formed on the HRRT (207 slices, resolution approximately
2.5 mm full width at half maximum resolution in three-
dimensional (3D) acquisition mode, ECAT HRRT; Siemens
Medical Solutions, Malvern, PA, U.S.A.). Data were re-
constructed using the 3D ordinary Poisson ordered-subset

Fig. 3. Abdominal PET and CT characteristics in a dog with a grade III MCT. The PET and CT
images from left to right are transverse and dorsal images. (A) CT demonstrated the presence of a
large mass located in the ventral abdomen (*). (B) This mass was not enhanced in post-contrast
imaging. Both ¹⁸F-FDG- (C) and ¹¹C-MET-PET (D) demonstrated intense uptake of the mass (*).
The mean ¹⁸F-FDG- and ¹¹C-MET-SUVs of the mass were 4.42 and 5.33, respectively. (E) The mass
with high uptake of glucose (SUV: 4.11) was still visible on the second ¹⁸F-FDG-PET scan 14 weeks
after the initial chemotherapy (*). (F) A hard mass (75 × 70 mm) was located in the caudoventral sur-
face of the abdomen near the prepuce (*) (left picture). The mass disappeared 5 weeks after chemo-
therapy (right picture).
increased 18F-FDG-SUV (> 2.5) related to malignancy [7, 9]. Lesions seem to be more reliable, considering the high metabolism in this case; accordingly, it was difficult to define which masses were primary tumors or metastatic lesions in the present case. Hence, PET findings as well as clinical signs might be needed for identifying liver and pancreas metastasis in canine MCTs compared with 11C-MET.

There has been minimal data available describing normal 11C-MET-SUVs of the various canine parenchymal organs. The 11C-MET uptakes of the liver (7.85), intestines (9.28) and bones (5.59) were higher than that of the nodular (3.64) and mass lesions (5.33; Figs. 2D and 3D) in the present case. Based on these findings, disseminated or systemic mastocytosis could be suspected. However, the possibility of influencing systemic organs was ruled out because vomiting, diarrhea, weight loss, anemia and bleeding tendencies were not noted in this dog. For accurate interpretation of 11C-MET-PET images in dogs with suspected or confirmed tumors, normal uptake data should be necessary. Because 11C-MET uptake is usually intense in the liver and pancreas of rats and humans, 11C-MET-PET is limited in diagnosing malignancies in these organs [15, 18]. Even though 11C-MET is specific for cancer cells, 18F-FDG might be more useful for identifying liver and pancreas metastasis in canine MCTs compared with 11C-MET.

The inguinal mass of this case had not been detectable for 5 weeks after the first chemotherapy, but high uptake of glucose in the inguinal region was still visible at the time of the second 18F-FDG-PET scan. If the dog was managed according to the result of PET, aggressive chemotherapy might have been necessary at that time. However, the chemotherapy interval was increased based on the good activity of the dog and disappearance of the mass; clinical signs had worsened at one month after the second PET scan. Previously, 18F-FDG-PET in two dogs with a grade II MCT allowed detection of additional tumor sites not noted on physical examination, which led to alteration of the treatment [12]. Thus, PET findings as well as clinical signs might be needed for the effective treatment of canine MCTs.

PET has been increasingly used in veterinary oncology [1, 2, 6, 11–13]. However, there have been no prior clinical reports describing the 11C-MET-PET features of spontaneously occurring cutaneous MCTs of the dog. This case report described the clinical findings and radiological and HRRT-PET imaging characteristics of a grade III MCT in a dog. The utility of PET imaging for evaluation and management of a canine MCT was demonstrated in the present case. Further investigation is required to accumulate normal uptake data for use of 11C-MET-PET in dogs.
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