DOI: 10.1002/vms3.786

CASE REPORT

WILEY

Evaluation of a dog with inflammatory mammary carcinoma using ^{18}F-2-deoxy-2-fluoro-D-glucose positron emission tomography/computed tomography

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Funding information
National Research Foundation of Korea, Grant/Award Numbers: 2017K1A4A3014959, 2021R1A2C1012058

Inflammatory mammary carcinoma is known to be aggressive, which makes thorough evaluation of the severity of tumour infiltration and metastasis important in determining a recommended treatment course. This case report describes the use of ^{18}F-2-deoxy-2-fluoro-D-glucose positron emission tomography/computed tomography for evaluating the invasiveness and metastasis of inflammatory mammary carcinoma in a dog.

KEYWORDS
animal, carcinoma, dogs, mammary neoplasms, positron-emission tomography

1 | INTRODUCTION

Inflammatory mammary carcinoma (IMC) is the most malignant type of mammary carcinoma; it is very aggressive and highly metastatic in dogs (Kim et al., 2011; Marconato et al., 2009; Raposo et al., 2017). The clinical signs of IMC are redness and oedema of the skin around the mammary glands with acute painful mammary gland enlargement (Kim et al., 2011; Raposo et al., 2017). Surgical resection is a treatment option; however, the surgical margins cannot be accurately defined due to diffuse tumour invasion and extensive inflammation (Raposo et al., 2017). The survival time of dogs with IMC may be increased with chemotherapy; however, in one report survival, time did not significantly increase despite the initiation of chemotherapy (Raposo et al., 2017). Chemotherapeutic options for IMC include carboplatin, doxorubicin, capecitabine, and cisplatin with or without piroxicam (Marconato et al., 2009; Raposo et al., 2017). ^{18}F-2-deoxy-2-fluoro-D-glucose (^{18}F-FDG) positron emission tomography (PET)/computed tomography (CT) has been reported to be useful for evaluating the extent of locoregional disease and the presence of distant metastasis in human patients with inflammatory breast cancer (Raposo et al., 2017). This report describes the clinico-radiological correlation between ^{18}F-FDG PET/CT findings and clinical features in a dog with IMC.

2 | CASE REPORT

A 14-year-old, intact female Maltese dog presented with painful skin lesions including multifocal nodules, crusting, erythema, ulceration, and lichenification in the right axillary region (Figure 1). Two years before presentation, the dog had been diagnosed with an adenoma of the right first and third mammary glands at a local veterinary clinic. Fine-needle aspiration of the mammary glands and right axillary skin lesion revealed clusters of ductular epithelial cells with marked anisocytosis, anisokaryosis, nucleoli, and multinucleated giant cells

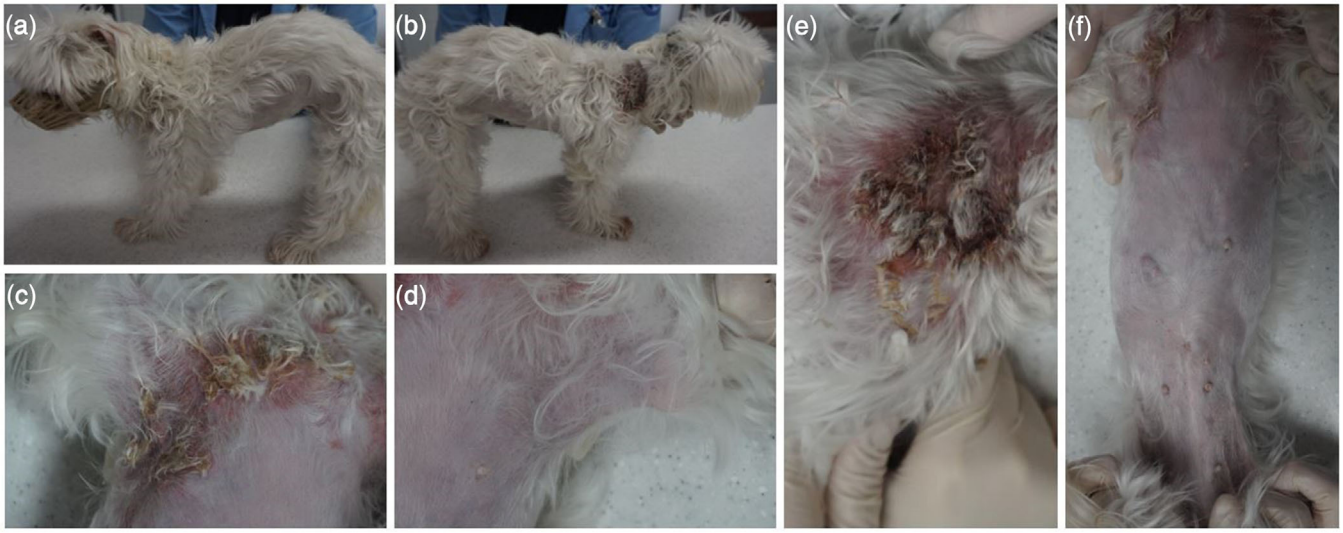

FIGURE 1 Inflammatory mammary carcinoma in a Maltese dog. The left prescapular and thoracic regions (a and f) appear normal. Crusting and ulceration are seen in the right thoracic and prescapular regions (b, e, and f). Erythema, ulceration, crusting, multiple nodules, and lichenification are seen in the right axillary region (c) but not in other regions such as the left axillary region (d)

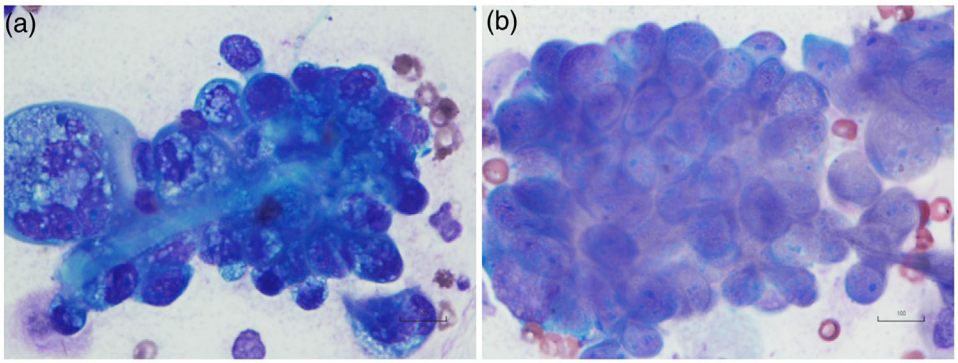

FIGURE 2 Photomicrographs of cells from the mammary gland (a) and right axillary skin lesion (b). Clusters of ductular epithelial cells with marked anisocytosis, anisokaryosis, nucleoli, and multinucleated giant cells are seen, leading to suspicion of malignant adenocarcinoma

(Figure 2). Malignant adenocarcinoma was suspected, and ^{18}F-FDG PET/CT was performed to evaluate for metastasis and to determine the surgical margin.

Under general anaesthesia, sequential contrast-enhanced CT and PET scans were performed 60 min after injection of 0.4 mCi (0.17 mCi/kg) of ^{18}F-FDG. The ^{18}F-FDG PET/CT images revealed bilateral thickening of the thoracic and prescapular skin with increased radiotracer activity in the right mammary glands (Figure 3). Diffuse, multifocal skin lesions that showed a higher ^{18}F-FDG uptake than normal skin were observed in the axilla and thoracic regions bilaterally. We estimated the standardised uptake values (SUVs), which normalise the tissue ^{18}F-FDG concentration relative to the ^{18}F-FDG dose and body weight, of the areas in which metastasis was suspected. Increased ^{18}F-FDG uptake was observed in the skin, mammary glands, and left prescapular lymph node. We also estimated the SUVs of the abdominal skin as reference. The maximum and mean SUVs were as follows: right prescapular skin: 3.46 and 3.05; left prescapular skin: 4.21 and 3.80; left prescapular lymph node 3.17 and 2.73; right first mammary gland: 3.62 and 3.07; third mammary gland: 1.27 and 1.09; left abdominal skin: 0.61 and 0.60; and right abdominal skin: 0.62 and 0.60. The bilateral prescapular skin had a higher ^{18}F-FDG uptake than the abdominal skin and was confirmed to have tumour infiltration or severe inflammation.

Histopathological examination of the lesions at the bilateral prescapular regions revealed multifocal aggregates of neoplastic epithelial cells forming glandular acini surrounded by abundant desmoplastic stroma and moderate to abundant mixed inflammation in the subcutis (Figure 4). Infiltration of tumour cells was observed in the subcutaneous lymphatic vessels, and the cell morphology showed findings that indicated malignancy, such as severe anisokaryosis and multinucleation. The dog was diagnosed with IMC based on the clinical signs and the presence of tumour emboli in the dermal lymphatic vessels.

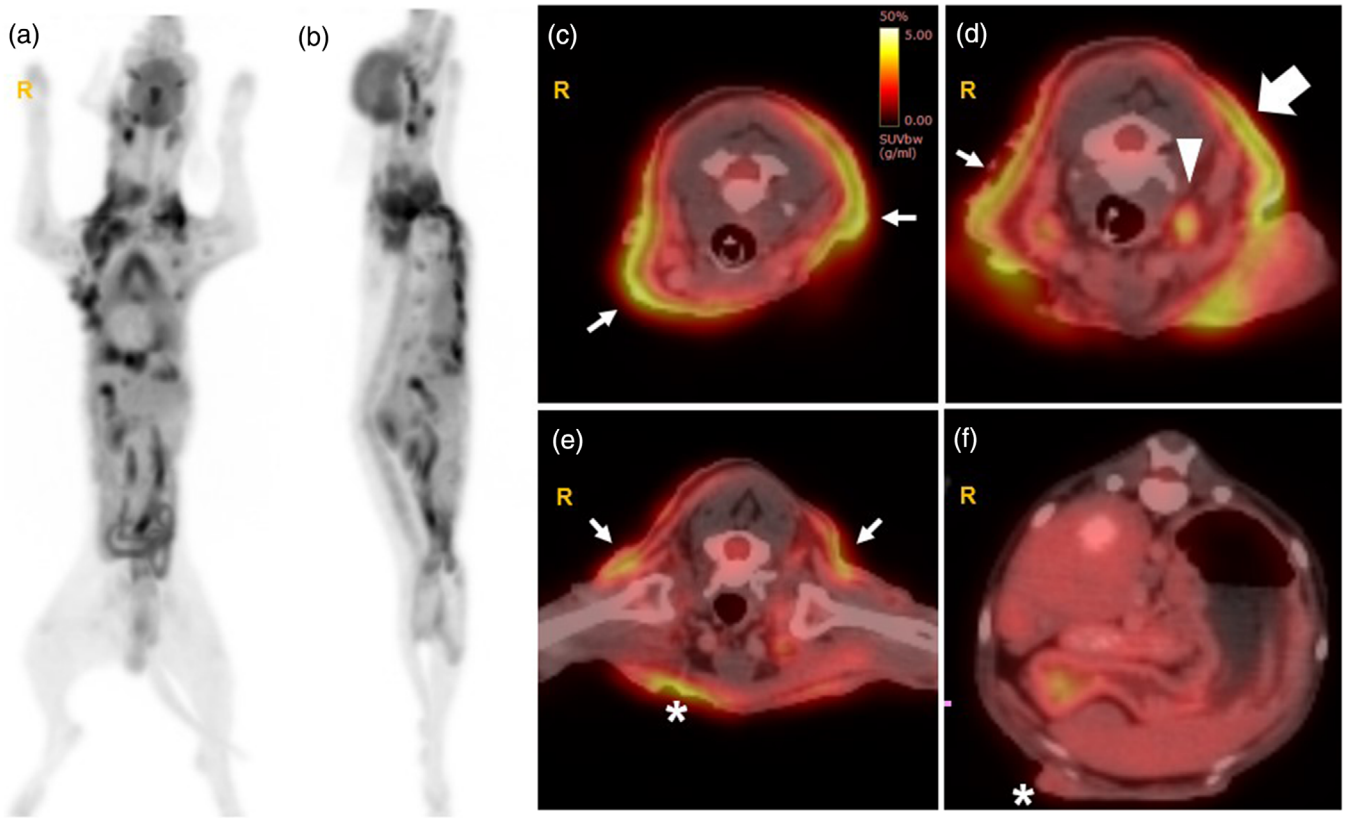

FIGURE 3 Representative ^{18}F-2-deoxy-2-fluoro-D-glucose (^{18}F-FDG) positron emission tomography (PET)/computed tomography (CT) images of a dog with inflammatory mammary carcinoma. Whole-body PET images show cutaneous lesions with increased ^{18}F-FDG uptake in the bilateral axillary and prescapular regions and multifocal cutaneous lesions with increased ^{18}F-FDG uptake throughout the thoracic region (a and b). ^{18}F-FDG PET/CT images show diffuse thoracic cutaneous lesions with increased ^{18}F-FDG uptake bilaterally (arrows; c, d, and e) and increased ^{18}F-FDG uptake in the left prescapular lymph node (arrow head; d), which indicates metastasis or reactive lymphadenopathy. The maximum and mean standardised uptake values (SUVs) of the left prescapular region (thick arrow; d), right prescapular region (thin arrow; d), and left prescapular lymph nodes (arrow head; d) are 4.21 and 3.80, 3.46 and 3.05, and 3.17 and 2.73, respectively. The right first mammary gland has higher maximum (3.62) and mean (3.07) SUVs (asterisk; e) than the right third mammary gland (maximum SUV: 1.27, mean SUV: 1.09) (asterisk; f). R indicates right

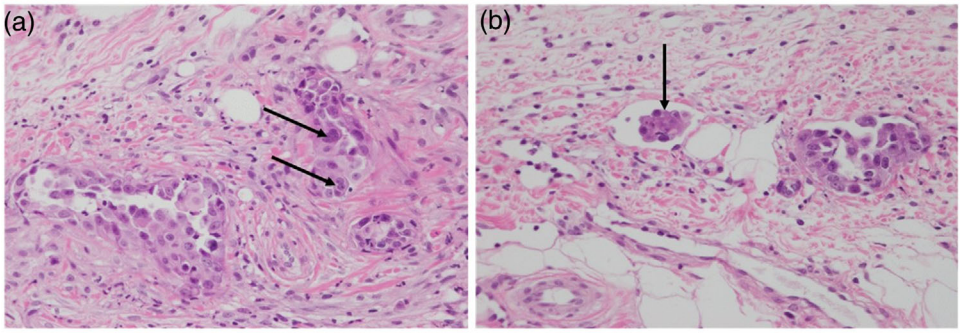

FIGURE 4 Photomicrographs of cells from the right prescapular (a) and left prescapular (b) lesion sites in a dog with inflammatory mammary carcinoma. Anisokaryosis, pleomorphism, and enlargement of neoplastic cells and bizarre cells with multinucleation are seen (arrows; a). Infiltration of tumour cells in the lymphatic vessels is seen (arrow; b). Haematoxylin and eosin, × 400

Surgical resection was not performed due to the presence of multifocal and diffuse cutaneous lesions. The dog died 10 days after the initiation of chemotherapy, and necropsy was not performed because the owner did not consent to it.

3 | DISCUSSION

Canine IMC is a variant of invasive mammary gland carcinoma. It is characterised by aggressive disease progression and is associated with

a high mortality rate (Marconato et al., 2009; Raposo et al., 2017). The treatment for canine IMC is the same as that for human inflammatory breast cancer; it includes surgical resection and chemotherapy (Marconato et al., 2009; Raposo et al., 2017). Surgical resection can only be performed in patients without diffuse invasion or metastasis (Marconato et al., 2009; Raposo et al., 2017). ^{18}F-FDG PET/CT has been used to evaluate metastasis and determine the extent of pathologic involvement in humans with inflammatory breast cancer (Al-Faham et al., 2015; Baslaim et al., 2003; van Uden et al., 2020).

The dog in this case was diagnosed with IMC based on clinical signs and histopathological findings of dermal lymphatic infiltration, which is a hallmark of IMC (Marconato et al., 2009; Raposo et al., 2017). In humans with IMC, an ^{18}F-FDG-PET/CT pattern of multiple scattered highlighted foci, particularly at the site of cutaneous lesions, is observed; this pattern was also observed in this dog (Baslaim et al., 2003). A previous report of ^{18}F-FDG PET/CT in dogs with mammary carcinoma recommended a maximum SUV cut-off for mammary carcinoma of 2 and maximum SUV range for metastatic lymph nodes of 0.56–2.14 (Sánchez et al., 2019). In this dog, the maximum SUV of the right first mammary gland was 3.62, and mammary carcinoma was therefore suspected. Additionally, the maximum SUV of the left prescapular lymph node was 3.17, which was suspected to indicate metastasis. Unlike the skin of the right thoracic region, the skin of left thoracic region appeared normal on visual inspection. However, ^{18}F-FDG PET/CT revealed that the skin of the left thoracic region had a higher ^{18}F-FDG uptake than the abdominal skin, indicating inflammation or metastasis.

Furthermore, histopathological examination of the bilateral prescapular region lesions revealed findings indicative of IMC, which was consistent with the ^{18}F-FDG PET/CT findings. In humans with breast cancer, ^{18}F-FDG uptake has been found to be correlated with poor prognostic factors such as hormone receptor negativity, *p53* mutation, triple negativity, metaplastic histology, and high tumour grade (Groheux et al., 2011). Further studies on the correlation of ^{18}F-FDG uptake with IMC and poor prognostic factors of IMC in dogs are needed.

In conclusion, as with human inflammatory breast cancer, ^{18}F-FDG PET/CT could be a useful diagnostic tool for evaluating metastasis and determining tumour dissemination in dogs with IMC. Furthermore, ^{18}F-FDG PET/CT can detect tumour infiltration even in skin that appears normal on visual inspection.

ACKNOWLEDGEMENTS

The authors thank the dog owner for consenting to the use of the images. This work was supported by the Global Research and Development Center (GRDC) Program through the National Research Foundation (NRF) of Korea funded by the Ministry of Science and ICT (2017K1A4A3014959) and the NRF grant funded by the Korea government (MSIT; No. 2021R1A2C1012058).

CONFLICT OF INTEREST

The authors declare no conflict of interest.

ETHICS STATEMENT

The authors confirm that the ethical policies of the journal, as noted on the author guidelines page, have been adhered to. No ethical approval was required as this was a case report.

AUTHOR CONTRIBUTIONS

Conceptualisation and writing—original draft: Yoonhoi Koo. *Formal analysis and writing – Review and Editing*: Taesik Yun. *Visualisation*: Yeon Chae and Dohee Lee. *Investigation*: Mingyun Son and Dayoung Ku. *Supervision*: Hakhyun Kim and Mhan-Pyo Yang. *Conceptualisation, writing—review and editing, supervision*: Byeong-Teck Kang.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

PEER REVIEW

The peer review history for this article is available at https://publons.com/publon/10.1002/vms3.786.

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REFERENCES

Al-Faham, Z., Al-Katib, S., Jaiyesimi, I., & Bhavnagri, S. (2015). Evaluation of a case of inflammatory breast cancer with 18F-FDG PET/CT. *Journal of Nuclear Medicine Technology*, *43*(4), 289–291. https://doi.org/10.2967/jnmt.114.148494

Baslaim, M. M., Bakheet, S. M., Bakheet, R., Ezzat, A., El-Foudeh, M., & Tulbah, A. (2003). 18-Fluorodeoxyglucose-positron emission tomography in inflammatory breast cancer. *World Journal of Surgery*, *27*(10), 1099–1104. https://doi.org/10.1007/s00268-003-6893-z

Groheux, D., Giacchetti, S., Moretti, J. L., Porcher, R., Espié, M., Lehmann-Che, J., de Roquancourt, A., Hamy, A. S., Cuvier, C., Vercellino, L., & Hindié, E. (2011). Correlation of high 18F-FDG uptake to clinical, pathological and biological prognostic factors in breast cancer. *European Journal of Nuclear Medicine and Molecular Imaging*, *38*(3), 426–435. https://doi.org/10.1007/s00259-010-1640-9

Kim, J. H., Im, K. S., Kim, N. H., Chon, S. K., Doster, A. R., & Sur, J. H. (2011). Inflammatory mammary carcinoma with metastasis to the brain and distant organs in a spayed Shih Tzu dog. *Journal of Veterinary Diagnostic Investigation: Official Publication of the American Association of Veterinary Laboratory Diagnosticians, Inc.*, *23*(5), 1079–1082. https://doi.org/10.1177/1040638711416622

Marconato, L., Romanelli, G., Stefanello, D., Giacoboni, C., Bonfanti, U., Bettini, G., Finotello, R., Verganti, S., Valenti, P., Ciaramella, L., & Zini, E. (2009). Prognostic factors for dogs with mammary inflammatory carcinoma: 43 cases (2003-2008). *Journal of the American Veterinary Medical Association*, *235*(8), 967–972. https://doi.org/10.2460/javma.235.8.967

Raposo, T. P., Arias-Pulido, H., Chaher, N., Fiering, S. N., Argyle, D. J., Prada, J., Pires, I., & Queiroga, F. L. (2017). Comparative aspects of canine and human inflammatory breast cancer. *Seminars in Oncology*, *44*(4), 288–300. https://doi.org/10.1053/j.seminoncol.2017.10.012

Sánchez, D., Romero, L., López, S., Campuzano, M., Ortega, R., Morales, A., Guadarrama, M., Cesarman-Maus, G., García-Pérez, O., & Lizano,

M. (2019). 18F-FDG-PET/CT in canine mammary gland tumors. *Frontiers in Veterinary Science*, *27*, 280. https://doi.org/10.3389/fvets.2019.00280

van Uden, D. J. P., Prins, M. W., Siesling, S., de Wilt, J. H. W., Blanken-Peeters, C. F. J. M., & Aarntzen, E. H. J. G. (2020). [18F]FDG PET/CT in the staging of inflammatory breast cancer: A systematic review. *Critical Reviews in Oncology/Hematology*, *151*, 102943. https://doi.org/10.1016/j.critrevonc.2020.102943

How to cite this article: Koo, Y., Yun, T., Chae, Y., Lee, D., Son, M., Ku, D., Kim, H., Yang, M.-P., & Kang, B.-T. (2022). Evaluation of a dog with inflammatory mammary carcinoma using ^{18}F-2-deoxy-2-fluoro-D-glucose positron emission tomography/computed tomography. *Veterinary Medicine and Science*, *8*, 1361–1365. https://doi.org/10.1002/vms3.786