Original Article

Ga-68 DOTATATE PET/CT in the Evaluation of Paragangliomas and Other Indeterminate Lesions in the Head and Neck

Russ Kuker, Jiaqiong Wang[1], Natalya Nagornaya[1], Rita G. Bhatia[1], Robert Quencer[1], Aldo Serafini

Division of Nuclear Medicine, Department of Radiology, University of Miami Miller School of Medicine/Jackson Memorial Hospital, [1]Division of Neuroradiology, Department of Radiology, University of Miami Miller School of Medicine/ Jackson Memorial Hospital, Miami, FL, USA

Abstract

Background and Purpose: Paragangliomas (PGLs) are rare neuroendocrine tumors with imaging features that can overlap with other entities. This study hypothesizes that given overexpression of somatostatin receptor (SSTR) 2, PGLs can be differentiated on Ga-68 DOTATATE positron emission tomography/computed tomography (PET/CT) from other benign or malignant lesions. **Materials and Methods:** Ninety-six patients with known tumors of the head and neck who underwent Ga-68 DOTATATE PET/CT from May 2017 to December 2021 were retrospectively reviewed from a single institution. Of these, 43 patients had histopathological confirmation and 66 positive lesions were discovered on PET/CT. For each lesion, the SUV max, the SUV lesion to liver ratio, and the SUV lesion to spleen ratio were analyzed. **Results:** PGLs (n = 37) showed the most intense uptake, and the mean of SUVmax was 69.3 (range 3.7–225.9). Metastatic PGL and metastasis from other neuroendocrine tumors (n = 13) demonstrated intermediate uptake, the mean of SUVmax was 15.16 (range 2.3–40.3). Meningiomas (n = 3) had intermediate uptake, and the mean of SUVmax was 12.37 (range 2.5–19.4). One patient with esthesioneuroblastoma had 5 lesions in the head and neck, and the mean of SUVmax was 18.9 (range 6.9–49.4). Schwannomas (n = 4) had very low uptake, and the mean of SUVmax was 1.75 (range 1.1–2.2). Other rare cases with low uptake included 1 each of osteosarcoma, acinic cell carcinoma, ectopic thyroid tissue, and plasmacytoma, and the mean of SUVmax was 4.75 (range 2.3–6.1). **Conclusions:** Ga-68 DOTATATE PET/CT can be a useful adjunct in differentiating tumors in the head and neck. PGLs demonstrate the highest uptake. Meningioma, esthesioneuroblastoma, and neuroendocrine tumor metastasis have intermediate uptake. Schwannomas and other rare tumors exhibit low uptake.

Keywords: *DOTATATE, head and neck, neuroendocrine, paraganglioma*

Introduction

Paragangliomas (PGLs) are rare neuroendocrine tumors originating from neural crest or paraganglion cells. In the head and neck, PGLs can occur at the carotid bifurcation, at the jugular foramen, along the course of the vagus nerve, and in the middle ear cavity.[1,2] Patients with hereditary PGLs of the head and neck, especially those with mutations of the succinate dehydrogenase (SDH) complex, are at a higher risk for developing metastatic disease or multiple PGLs.[3]

Because PGLs tend to be asymptomatic at the early stage and biochemically silent, the accurate diagnosis of these tumors is often challenging.[2] Although there are characteristic features of PGLs on computed tomography (CT) and magnetic resonance imaging (MRI), sometimes their imaging findings overlap with other tumors in the head and neck making the diagnosis more elusive.

Previous studies have demonstrated the overexpression of somatostatin receptors (SSTR) in PGLs,[4] especially SSTR2.[5,6] Ga-68 DOTATATE demonstrates the highest affinity for SSTR2, not only different from Ga-68 DOTANOC which preferentially binds to SSTR3 and SSTR5 but also distinct from Ga-68 DOTATOC which has specific affinity to SSTR5.[7] Ga-68 DOTATATE positron emission tomography (PET)/CT is more sensitive and accurate than In-111 octreoscan for the detection of neuroendocrine tumors[8] due to its improved contrast and spatial resolution over planar and single-photon emission computerized tomography (SPECT) imaging. Ga-68 DOTATATE PET/CT has been shown to detect 44% more lesions than Tc-99m

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Address for correspondence:
Dr. Russ Kuker,
Division of Nuclear Medicine, Department of Radiology, University of Miami Miller School of Medicine/Jackson Memorial Hospital, Miami, FL 33136, USA.
E-mail: rkuker2@med.miami.edu

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octreotide SPECT/CT scan and detect 36% more lesions than CT/MRI.[9]

We hypothesize that Ga-68 DOTATATE PET/CT is effective in differentiating PGLs from other lesions that arise in similar locations in the head and neck.

Materials and Methods

Study design

In this retrospective study, the electronic medical record and picture archive communication system were searched to identify patients with known tumors of the head and neck who underwent evaluation with Ga-68 DOTATATE PET/CT from May 2017 to December 2020 from a single institution. The keywords included in the search criteria consisted of paraganglioma, glomus, carotid body, meningioma, schwannoma, and neck mass. Before performing the Ga-68 DOTATATE PET/CT, all patients had CT or MRI imaging which demonstrated a lesion suspicious for PGL or an indeterminate neck mass. Ninety-six patients met these search criteria (33 men, 63 women), and of these, 43 patients had histopathological confirmation either from biopsy or from surgical resection. The 53 patients without histopathological confirmation were excluded from further analysis. The study protocol was approved by the institutional review board of the university. Due to the retrospective nature of this study, the patient consent was waived.

Imaging technique

All 96 patients underwent PET/CT scans from skull to thighs obtained 60 min after the intravenous injection of 190 ± 10 MBq of ^{68}Ga-DOTATATE. All PET/CT scans were obtained on a Phillips Gemini TF 16 slice (Manufacturer: Philips Healthcare, Best, The Netherlands), Phillips Gemini TF 64 slice (Manufacturer: Philips Healthcare, Best, The Netherlands), or Siemens m-CT 64 slice Flow PET/CT scanner (Manufacturer: Siemens Medical System, Erlangen, Germany). PET imaging was obtained in three-dimensional mode. PET images were reconstructed on a 144 × 144 matrix (Phillips) or a 200 × 200 matrix (Siemens) using an iterative algorithm provided by the manufacturer, which also uses time of flight. Low-dose CT studies for attenuation correction and anatomic coregistration were performed without contrast.

Data analysis

The Ga-68 DOTATATE PET/CT studies were each interpreted independently by two nuclear medicine physicians. The SUV max was determined, and the focal areas of abnormal uptake showing a higher SUV max than surrounding tissues were considered lesions. To assess the lesion to background ratio and characterize the degree of SSTR expression, the SUV max of each lesion was compared to the liver background (SUV lesion to liver ratio) and to the spleen background (SUV lesion to spleen ratio). In essence, these ratios provide an estimate of the Krenning score which is a qualitative metric originally described in In-111 pentetreotide scintigraphy to determine the eligibility for SSTR radionuclide therapy. All PET/CT studies were evaluated on dedicated workstations using Thinking Systems viewer (Thinking Systems Corporation). Correlating CT and MRI studies were evaluated on workstations using Philips iSite PACS (Manufacturer: Philips Healthcare, Best, The Netherlands).

Results

Description of cohort

Of the 96 patients who met the search criteria, 43 patients with histopathological confirmation were included in this study and 66 positive lesions were discovered on the Ga-68 DOTATATE PET/CT scans. The lesions observed in this patient cohort demonstrating increased DOTATATE uptake included PGL (37 lesions in 24 patients), neuroendocrine cancer metastasis (13 lesions in 7 patients), meningioma (3 lesions in 3 patients), schwannoma (4 lesions in 4 patients), esthesioneuroblastoma (5 lesions in 1 patient), and 1 lesion per patient each of osteosarcoma,

Table 1: Standardized uptake values for different lesions in the head and neck on Gallium-68 DOTATATE positron emission tomography/computed tomography

Type of tumor	Number of patients	Number of lesions	Mean (range)	Mean (range)	
			SUVmax	SUV lesion/SUV liver*	SUV lesion/SUV spleen**
Paraganglioma	24	37	69.3 (3.7-225.9)	8.2 (0.7-26.0)	2.7 (0.2-7.1)
Neuroendocrine cancer metastasis	7	13	15.16 (2.3-40.3)	1.9 (0.4-5.5)	0.7 (0.1-1.5)
Meningioma	3	3	12.37 (2.5-19.4)	1.4 (0.3-2.1)	0.5 (0.1-0.8)
Schwannoma	4	4	1.75 (1.1-2.2)	0.2 (0.1-0.3)	0.1 (0.1-0.1)
Esthesioneuroblastoma	1	5	18.9 (6.9-49.4)	1.42 (0.5-3.7)	0.7 (0.3-1.8)
Osteosarcoma	1	1	4.9	0.7	0.2
Acinic cell carcinoma	1	1	2.3	0.2	0.1
Ectopic thyroid tissue	1	1	5.7	0.5	0.2
Plasmacytoma	1	1	6.1	0.6	0.2

*SUV lesion/SUV liver ratio>1 indicates the lesion is more intense than the liver background, **SUV lesion/SUV spleen ratio>1 indicates the lesion is more intense than the spleen background. SUV: Standardized uptake value

acinic cell carcinoma (ACC), ectopic thyroid tissue, and plasmacytoma [Table 1].

Paraganglioma

Twenty-four patients with pathologically confirmed PGLs showed intense Ga-68 DOTATATE uptake in 37 lesions identified in the head and neck. The mean of SUVmax was 69.3 (range of 3.7–225.9). 36/37 lesions (97.2%) demonstrated uptake higher than the liver background, and 27/37 lesions (73.0%) demonstrated uptake higher than the spleen background [Figure 1]. One lesion with uptake less than the liver background was seen in a small glomus jugulare at the skull base, which could be susceptible to attenuation from the dense surrounding bone.

Among these 24 patients with PGLs, 5 cases (20.8%) had multifocal Ga-68 DOTATATE avid disease and 16 patients (66.7%) demonstrated mutations in the SDH genes. Two of the patients with multifocal disease elicited a family history of PGLs.

Neuroendocrine cancer metastasis

In the current study cohort, 13 metastatic lesions were identified in the head and neck from PGLs or other neuroendocrine tumors, and these lesions demonstrated variable intermediate-level Ga-68 DOTATATE uptake. The mean of SUVmax was 15.16 (range of 2.3–40.3). In 10/13 lesions (77%), the uptake was higher than the liver background, and in 2/13 lesions (15%), the uptake was higher than the spleen background. The two metastatic lesions with uptake greater than the spleen background were from an ileal carcinoid primary tumor. The metastatic lesions with uptake greater than the liver background included primary tumors arising from the small bowel and a mesenteric carcinoid. One metastatic cervical lymph node from a PGL demonstrated uptake less than the liver background, and two metastatic calvarial lesions from an adrenal primary were also less than the liver background.

Meningioma

The three cases of meningioma had intermediate-level Ga-68 DOTATATE uptake. The mean of SUVmax was 12.37 (range of 2.5–19.4). In 2/3 lesions (66.7%), the uptake was higher than the liver background, and all were less than the spleen background [Figure 2]. In one lesion, the uptake was much lower than the liver background; however, this lesion was easily characterized on MRI.

Esthesioneuroblastoma

One patient with esthesioneuroblastoma had five Ga-68 DOTATATE avid lesions in the head and neck region, including primary tumor and four metastatic lymph nodes. The mean of SUVmax was 18.9 (range of 6.9–49.4). In 2/5 lesions (40%), the uptake was higher than the liver background. The primary mass involved the right pterygopalatine fossa, right sphenoid sinus, and right orbital apex and demonstrated intense uptake higher than the spleen. The other four Ga-68 DOTATATE avid lesions were all cervical lymph nodes and displayed uptake with intensity less than the spleen background.

Schwannoma

The four cases of schwannoma had very low-intensity DOTATATE uptake. The mean of SUVmax was 1.75 (range of 1.1–2.2), and all were less than the liver and spleen [Figure 3]. The schwannomas identified in our study were located in the carotid space, cerebellopontine angle, and level 2 of the neck.

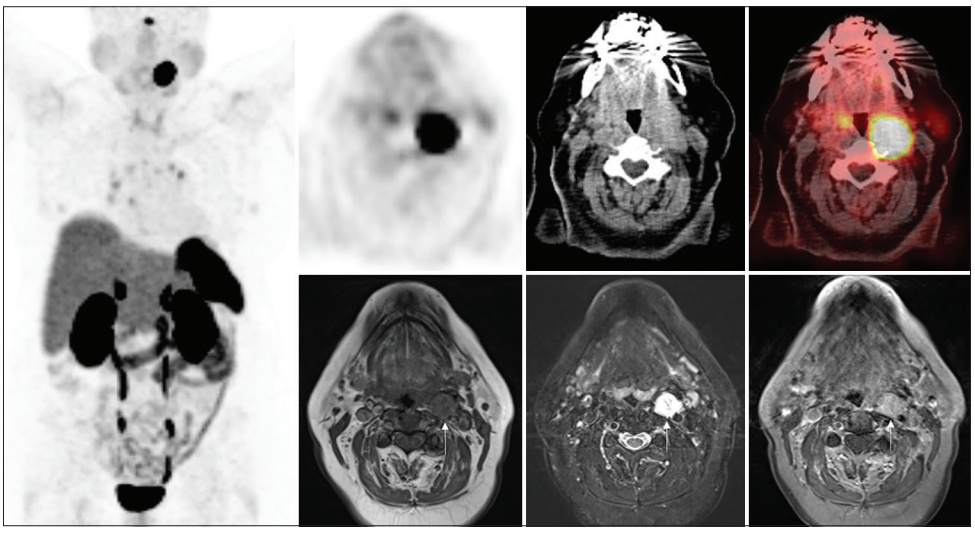

Figure 1: A typical case of paraganglioma in a 73-year-old female found to have a left carotid body tumor. The Ga-68 DOTATATE PET/CT scan showed intense Ga-68 DOTATATE uptake by the mass at the left carotid space, SUV 168, the ratio of lesion to liver background was 26.3. The follow-up MRI on the same patient showed a T1 isointense, T2 hyperintense, avidly enhancing lesion that splayed the left internal and external carotid arteries, with prominent vascular flow voids (white arrows). The patient underwent excision of this lesion and the final pathology confirmed paraganglioma. Immunohistochemistry for succinate dehydrogenase B was positive. PET/CT: Positron emission tomography/computed tomography, MRI: Magnetic resonance imaging

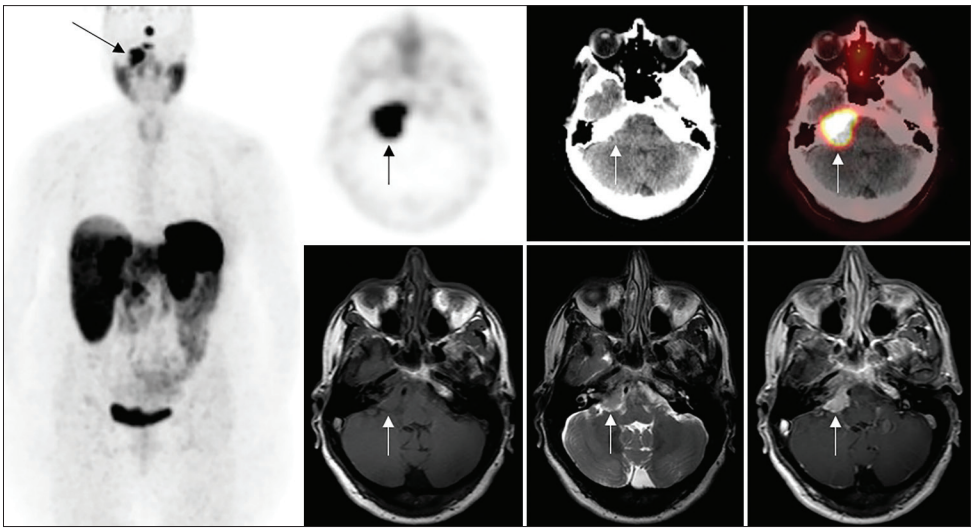

Figure 2: Ga-68 DOTATATE PET/CT showed increased Ga-68 DOTATATE uptake within a mass centered at the right cerebellopontine angle, SUV 15.2, the ratio of lesion to liver background was 1.8. The final pathology confirmed meningioma. MRI on the same patient demonstrates a broad dural-based, T1 isointense, T2 isointense, avidly enhancing extra-axial mass centered at the right cerebellopontine angle, involving the right petrous bone. The lesion extends posteriorly over the porous acousticus without extension into the internal auditory canal. PET/CT: Positron emission tomography/computed tomography, MRI: Magnetic resonance imaging

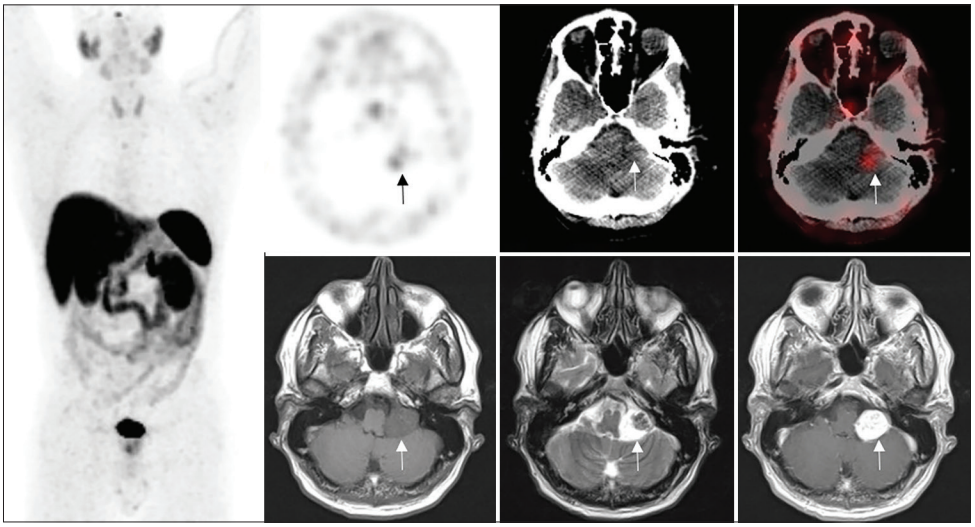

Figure 3: Ga-68 DOTATATE PET/CT revealed a mass at the left cerebellopontine angle with minimal Ga-68 DOTATATE uptake, SUV 2.0. The ratio of lesion to liver background was 0.1. The MRI for the same patient showed a T1 hypointense, T2 heterogeneous hyperintense, avidly enhancing lesion at the left cerebellopontine angle. The patient underwent left postauricular infratemporal fossa approach resection and the final pathology confirmed schwannoma. PET/CT: Positron emission tomography/computed tomography, MRI: Magnetic resonance imaging

Rare cases

Other rare cases with low-intensity DOTATATE uptake included one each of osteosarcoma, ACC, ectopic thyroid tissue, and plasmacytoma. These lesions exhibited a mean of SUVmax of 4.75 (range of 2.3–6.1), and all were less than the liver and spleen background.

A case of right temporal bone osteosarcoma showed minimal peripheral uptake, SUV 4.9, less than the liver background.

A patient with a past history of left parotid acinic cell carcinoma (ACC) underwent resection and postoperative radiation therapy. The patient's follow-up scan showed a large lytic lesion centered at the left jugular foramen, with minimal Ga-68 DOTATATE uptake, SUV 2.3, much lower than the liver background. The biopsy confirmed ACC.

A case of ectopic thyroid tissue from a right neck mass, which splayed the right internal and external carotid artery, demonstrated low-level Ga-68 DOTATATE uptake, SUV 5.7, less than the liver background.

Finally, low-level Ga-68 DOTATATE uptake was found in a case of solitary plasmacytoma in the right skull base centered at the occipital bone and occipital condyle and involving the jugular foramen and hypoglossal canal. The intensity of uptake was much lower than the liver background, SUV 6.1.

Discussion

As evidenced in this retrospective study, many lesions found in the head and neck demonstrate increased uptake on Ga-68 DOTATATE PET/CT related to SSTR expression. The degree of DOTATATE avidity in each lesion was assessed by the SUV max and the lesion to background ratio, in which the uptake in each lesion was compared to the physiologic background activity in the liver and spleen. In addition to providing a relative uptake score, this lesion to background ratio has been used to assess candidacy for peptide receptor radionuclide therapy (PRRT) which is typically reserved for patients with DOTATATE-positive disease where the tumor uptake is greater than or equal to the liver background.

Paraganglioma

PGLs observed in our study showed intense Ga-68 DOTATATE uptake related to the overexpression of SSTRs in PGLs. As early as 1992, Reubi *et al*. found SSTR overexpression in pheochromocytomas (PCCs) and PGLs.[4] Leijon *et al*. later found that SSTR2 and SSTR3 were abundantly expressed in PGLs and PCCs. SSTR2 were also strongly positive in metastatic PGLs.[5] SSTR2A was the most prominent SSTR expressed in PGLs.[6]

Mutations in the SDH genes were identified in 16 out of 24 PGL patients (66.7%) in the current study. Previous reports have shown that 40% of PGLs are linked to genetic syndromes and most frequently due to mutations of the SDH complex.[10,11] SDHB mutation carriers have a predisposition to malignant disease and possibly extraparaganglial neoplasms, and SDHD mutation carriers are more likely to have multifocal PGLs.[3] SDH-deficient tumors were more likely to express SSTR2A and SSTR3 when compared with SDH-sufficient PCCs and PGLs.[12]

The overexpression of SSTRs in PGLs provides the basis for the accurate localization of PGLs via Ga-68 DOTATATE PET/CT. Ga-68 DOTATATE demonstrates the highest affinity to SSTR2.[7] Ga-68 DOTATATE PET/CT is more sensitive and accurate than In-111 octreoscan due to its better contrast and spatial resolution over planar and SPECT imaging.[8] More importantly, Ga-68 DOTATATE PET/CT provides significant insight for PRRT with radioisotope-labeled somatostatin analogs such as Lu-177-DOTATATE.

Paraganglioma versus Meningioma

The three cases of meningiomas identified in our study demonstrated intermediate-level Ga-68 DOTATATE uptake, which sometimes overlapped with PGLs particularly smaller lesions that are more susceptible to attenuation. Meningiomas express all five subtypes of SSTRs, with a predominance of SSTR2.[13-15] Currently, the most reliable immunohistochemical markers for meningiomas are epithelial membrane antigen (EMA) and progesterone receptor. Menke *et al*. demonstrated that SSTR2A is a more sensitive diagnostic marker of meningioma than EMA.[16] Boulagnon-Rombi *et al.* found that SSTR2A was the most sensitive (95.2%) and specific (92%) marker of meningioma to distinguish from other mimics such as schwannoma and neurofibroma.[17] SSTR5 was more frequently expressed in benign meningiomas than in malignant meningiomas.[13]

Due to the expression of all five subtypes of SSTRs in meningiomas, Ga-68 DOTATATE PET/CT is not always helpful to differentiate meningiomas and PGLs. The radiological differential diagnosis of meningiomas and PGLs is aided by their characteristic features on CT and MRI, with special attention to the bone margins and the presence or absence of flow voids. On MRI, meningiomas demonstrate a dural tail, intermediate T2 signal, and the absence of vascular flow voids. In contrast, PGLs are hypervascular tumors that often demonstrate prominent vascular flow voids, hyperintense T2 signal, and the absence of a dural tail. On CT, bone hyperostosis is characteristic in all types of meningiomas,[18-20] while PGLs typically demonstrate extensive permeative bone destruction. Meningiomas involving the jugular foramen infiltrate the surrounding skull base in all directions, referred to as the "centrifugal" growth pattern. In contrast, jugular foramen PGLs typically extend superolaterally from the jugular foramen to involve the middle ear cavity and posterior cranial fossa.[21] Jugular foramen PGLs less likely infiltrate medially to involve the jugular tubercle, hypoglossal canal, or the clivus.[22]

Ga-68 DOTATATE PET/CT may help in the detection of residual or recurrent meningioma after surgery. For the unresectable meningioma or progressive meningioma, Ga-68 DOTATATE PET/CT may serve as a predictive biomarker for outcome to facilitate individualized treatment optimization in patients with uni- and multifocal meningiomas.[23] The use of PRRT with Lu-177 DOTATATE or Y-90 DOTATOC may potentially benefit these patients.[23,24]

Paraganglioma versus Schwannoma

In addition to meningioma, the differential diagnosis between schwannoma and PGL is sometimes difficult on CT and MRI. Schwannomas account for approximately 25%–45% of tumors of the head and neck.[25] Schwannomas originate from the Schwann cell sheath along the distribution of peripheral cranial nerves, the most common the vagus nerve, the trigeminal nerve, the vestibular nerve, and the facial nerve.[26-28] Schwannomas can also involve the jugular foramen and follow the course of lower cranial nerves.

The distinction between schwannoma and PGL is sometimes challenging on anatomical imaging. Ga-68 DOTATATE PET/CT can be very useful in differentiating PGLs from schwannomas, providing complementary information to CT/MRI. In the current study, the four schwannoma

cases demonstrated minimal Ga-68 DOTATATE uptake, in contrast to PGLs which demonstrated intense uptake.

The minimal Ga-68 DOTATATE uptake by schwannomas is probably related to the low expression level of SSTR in schwannoma cells. Reubi *et al.* did not detect SSTRs in 11 schwannomas.[29] Anis *et al.* reported that schwannomas had negative immunohistochemical staining for SSTR2A.[30] Other researchers had conflicting results. Mawrin *et al.* reported the presence of the mRNA transcripts of all five types of SSTR1–SSTR5 in schwannomas but negative in nonneoplastic Schwann cells.[31] Stafford *et al.* found that SSTR2 was the most prevalent subtype expressed in acoustic neuromas.[32]

Esthesioneuroblastoma

In the current study, esthesioneuroblastoma demonstrated intermediate-level Ga-68 DOTATATE uptake. Esthesioneuroblastoma is derived from olfactory neuroepithelium and may secrete adrenocorticotropic hormone (ACTH) and can cause ACTH-dependent Cushing syndrome.[33,34] Esthesioneuroblastoma overexpresses SSTRs.[35] It has been reported positive on In-111 octreotide scan[33] and Ga-68 DOTATOC PET/CT scan.[34,36] Liu *et al.* detected two esthesioneuroblastoma cases on Ga-68 DOTATATE PET/CT, which were missed on F-18 FDG PET/CT, and identified a patient for treatment with Lu-177 DOTATATE.[37]

Imaging with Ga-68 DOTATATE PET/CT may facilitate the potential application of PRRT for the treatment of esthesioneuroblastoma, specifically for unresectable lesions or metastatic disease. Hasan *et al.* evaluated seven esthesioneuroblastoma patients who received Lu-177 DOTATATE treatment for recurrent unresectable or progressive metastatic disease and found 4 cases with partial response, 2 cases with disease stabilization, and 1 case with early progression.[38] After four cycles of Lu-177 octreotate treatment of a highly resistant esthesioneuroblastoma, Schneider *et al.* reported radiation necrosis with a partial response of all lesions and symptomatic improvement.[35]

Osteosarcoma

The current study reported minimal peripheral Ga-68 DOTATATE uptake in a case of right temporal bone osteosarcoma. Osteosarcoma is the most common type of primary malignant bone tumor. SSTRs have been detected in osteosarcomas;[29,39] however, not every case of osteosarcoma expresses SSTRs. Ioannou *et al.* evaluated the expression of SSTRs in 29 osteosarcoma patients and found its presence in 4 cases but its absence in 25 cases.[40] They found that the four osteosarcoma patients with positive SSTR expression had a very low disease-free and overall survival rate compared to the 25 osteosarcoma patients with negative SSTRs.[40]

Previously, osteosarcoma has been detected with In-111 octreotide scintigraphy[41] and In-111 pentetreotide scintigraphy.[42] It is rare to see reports of osteosarcoma on Ga-68 DOTATATE PET/CT. The low level of Ga-68 DOTATATE uptake may help differentiate osteosarcoma from other lesions in the head and neck.

Acinic cell carcinoma

The current study presented a case of ACC at the left jugular foramen with minimal Ga-68 DOTATATE uptake. The most common benign tumor of the parotid gland and submandibular gland is pleomorphic adenoma, and the most common malignant tumor of the salivary glands is adenoid cystic carcinoma.[43] ACC is rare in the parotid gland. Modi *et al.* reported two cases of papillary cystic variant of ACC of the parotid gland.[44] Makis *et al.* reported an incidental ACC of the parotid gland which was positive on In-111 octreotide scintigraphy but negative on I-123 meta-iodobenzylguanidine (MIBG) scintigraphy.[45] Castro Oliveira *et al.* also reported positive radiotracer uptake in a right parotid gland ACC and liver metastasis on SSTR scintigraphy octreoscan.[46]

Ectopic thyroid tissue

The current study reported a case of ectopic thyroid tissue with low-level Ga-68 DOTATATE uptake, less than the liver background. This case illustrates the fact that normal thyroid tissue also expresses SSTRs. Atkinson *et al.* found that SSTR1, 3, 4. and 5 were highly expressed in the normal thyroid tissue, while SSTR2A and SSTR2B were not expressed in the normal thyroid tissue.[47] They also showed that SSTR2B was the most common receptor expressed in benign thyroid disease, while SSTR2B and SSTR5 were the most common SSTRs expressed in differentiated thyroid cancer.[47] Herac *et al.* identified the protein expression of SSTR2A and SSTR5 in medullary thyroid carcinoma (MTC).[48] The SSTR2A protein expression was significantly associated with lymph node metastases, and the SSTR5 protein expression was significantly associated with advanced stages of MTC.[48] The truncated variant of SSTR5 was overexpressed in poorly differentiated thyroid cancer.[49] The expression of SSTRs in thyroid tissue mandates the attention to Ga-68 DOTATATE uptake in the thyroid gland for the potential of benign and malignant thyroid disease.

Plasmacytoma

The current study presented a case of low-level Ga-68 DOTATATE uptake in a solitary plasmacytoma in the right skull base.[50] The low-level Ga-68 DOTATATE activity could be due to the expression of SSTRs on plasmacytoma cells. SSTRs have been detected on the plasmacytoma MOPC-315 cell line.[51] The subtypes SSTR2, SSTR3, and predominantly SSTR5 were expressed in multiple myeloma cell lines.[52]

Multiple myeloma and plasmacytoma have been detected on In-111 pentetreotide whole-body SSTR scintigraphy.[53]

Plasmacytoma has been shown to have positive uptake on In-111 octreotide scintigraphy[54] and can mimic PGL of the skull base.[55] Previously, it was reported that a solitary plasmacytoma in the body of the third lumbar vertebra had mild Ga-68 DOTATATE uptake.[56] These findings emphasize that other osseous lesions can express SSTRs and should not be mistaken for tumor metastasis when evaluating positive foci of osseous uptake.

Similar to Ga-68 DOTATATE uptake by plasmacytoma, a case with multiple myeloma demonstrated increased Ga-68 DOTANOC uptake in two lytic lesions.[57] Ga-68 DOTANOC PET/CT has also been proven to be useful for the baseline evaluation of patients with head and neck PGLs due to their significantly higher SUV values compared to paragangliomas at other sites.[58]

Limitations

As a retrospective review, there are many limitations inherent to this study. There is a selection bias in that all subjects included in the study had known lesions in the head and neck observed on CT or MRI that were either suspicious for PGL or had indeterminate imaging findings. Therefore, the utility of Ga-68 DOTATATE PET/CT for the routine workup of all neck masses is unproven. Many patients were not able to undergo biopsy or surgery and were observed clinically over time; these patients were excluded from the study due to lack of histopathological confirmation. Given a longer period of follow-up, some of these patients might progress necessitating surgical intervention, which could contribute to our results. Further prospective studies are needed to assess the impact of Ga-68 DOTATATE PET/CT on patient management and to determine its cost-effectiveness.

Conclusion

Ga-68 DOTATATE PET/CT is a useful tool for evaluating SSTR expression *in vivo* and should be considered when encountering a lesion in the head and neck that has indeterminate findings on CT or MRI. PGLs demonstrate the highest uptake on Ga-68 DOTATATE PET/CT. Potential mimickers such as meningioma, esthesioneuroblastoma, and neuroendocrine tumor metastasis have intermediate uptake. Schwannomas and other rare tumors exhibit low uptake. Ga-68 DOTATATE PET/CT is an excellent imaging modality for staging and treatment planning of PGLs to assess for multifocal disease or incidental lesions outside of the head and neck. Furthermore, Ga-68 DOTATATE PET/CT can provide important insight for PRRT with radioisotope-labeled somatostatin analogs such as Lu-177 DOTATATE.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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