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Case report

FDG PET imaging of paragangliomas of the neck: comparison with MIBG SPET

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Abstract. Two patients with cervical paragangliomas underwent positron emission tomography (PET) with 2-[^{18}F]-fluoro-2-deoxy-D-glucose (FDG). There was marked tumor uptake and retention of FDG. Adjacent salivary gland accumulation of FDG was minimal, though quite prominent with *meta*-iodobenzylguanidine. FDG PET offers another potentially useful approach to functional imaging of these uncommon tumors, independent of the presence of specific amine uptake mechanisms or cell surface receptors required by other scintigraphic techniques.

Key words: Positron emission tomography – Paragangliomas – 2-[^{18}F]-Fluoro-2-deoxy-D-glucose – *Meta*-iodobenzylguanidine – Single-photon emission tomography

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Introduction

Cervical paragangliomas are uncommon neoplasms derived from neural crest cells, and are also referred to as chemodectomas, carotid body tumors, glomus vagale tumors, or glomus tympanicum tumors, depending upon their structure of origin. Bilaterality and association with paragangliomas elsewhere are more common in the setting of familial and endocrine neoplasia syndromes [1]. Distant metastases (12% of carotid body tumors) and catecholamine synthesis (1% of paragangliomas) are rare [1, 2]. The usual history of these tumors is of relentless local growth, eventually producing symptoms by mass effect and progressive compromise of local neurovascular structures [3]. Anatomic imaging techniques rely upon characteristic spatial relations and high vascularity of the tumors, while modern scintigraphy exploits their neuroendocrine heritage with meta-iodobenzylguanidine (MIBG) and somatostatin receptor agonists. We describe the metabolic imaging of these tumors with positron emission tomography (PET) and 2-[^{18}F]-fluoro-2-deoxy-D-glucose (FDG), and explore the potential usefulness of this technique in comparison with MIBG single-photon emission tomography (SPET).

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Materials and methods

PET images (12 min transmission, 15 min emission) of the neck were obtained beginning ~50 min following intravenous injection of 370 MBq (10 mCi) FDG using a Siemens Exact whole-body PET scanner. The data were reconstructed into cross-sectional images with a Hann filter and a cutoff frequency of 0.3. Whole-body images from the top of the skull to the proximal lower extremities were acquired by the method of Dahlbom [4]. SPET images of the neck were obtained 48 h after intravenous injection of 18.5 MBq (0.5 mCi) of iodine-131 MIBG for 30 min (patient 1) or 24 h after intravenous injection of 370 MBq (10 mCi) iodine-123 MIBG for 15 min (patient 2) using a Picker Prism triple-headed gamma camera rotated through 120 stops. Data were reconstructed into cross-sectional images by filtered back projection, a Butterworth filter and a cutoff of 0.2–0.5. Planar spot images were acquired from the top of the skull to the proximal lower extremities for 20 min each at 48 h (patient 1, ^{131}I-MIBG) and 10 min each at 24 h (patient 2, ^{123}I-MIBG) using a dual-head gamma camera with high-energy and low-energy collimators respectively.

Results

Patient 1

A 61-year-old woman with a history of mild asthma and gastroesophageal reflux presented with a firm left neck mass of ~2 cm diameter which had not resolved despite multiple courses of antibiotics. Panendoscopy of the upper aerodigestive tract was unremarkable. Exploration of

the left neck revealed a number of small lymph nodes located over the internal jugular vein, biopsies of which yielded only normal lymphoid tissue. However, a 3 cm by 3 cm, fleshy, violaceous mass was visible immediately deep to the nodes, splaying the internal and external carotid arteries at their origin. A provisional diagnosis of a carotid body tumor was made and the incision closed. Subsequent urinary catecholamine and metabolite levels were normal.

FDG PET, ^{131}I-MIBG planar and SPET, MRI, and carotid angiography studies were performed (Fig. 1). PET images showed intense accumulation of FDG within the tumor (Fig. 1A, D, G). The standardized uptake value (SUV) was 7.7[5]. Salivary gland activity was minimal.

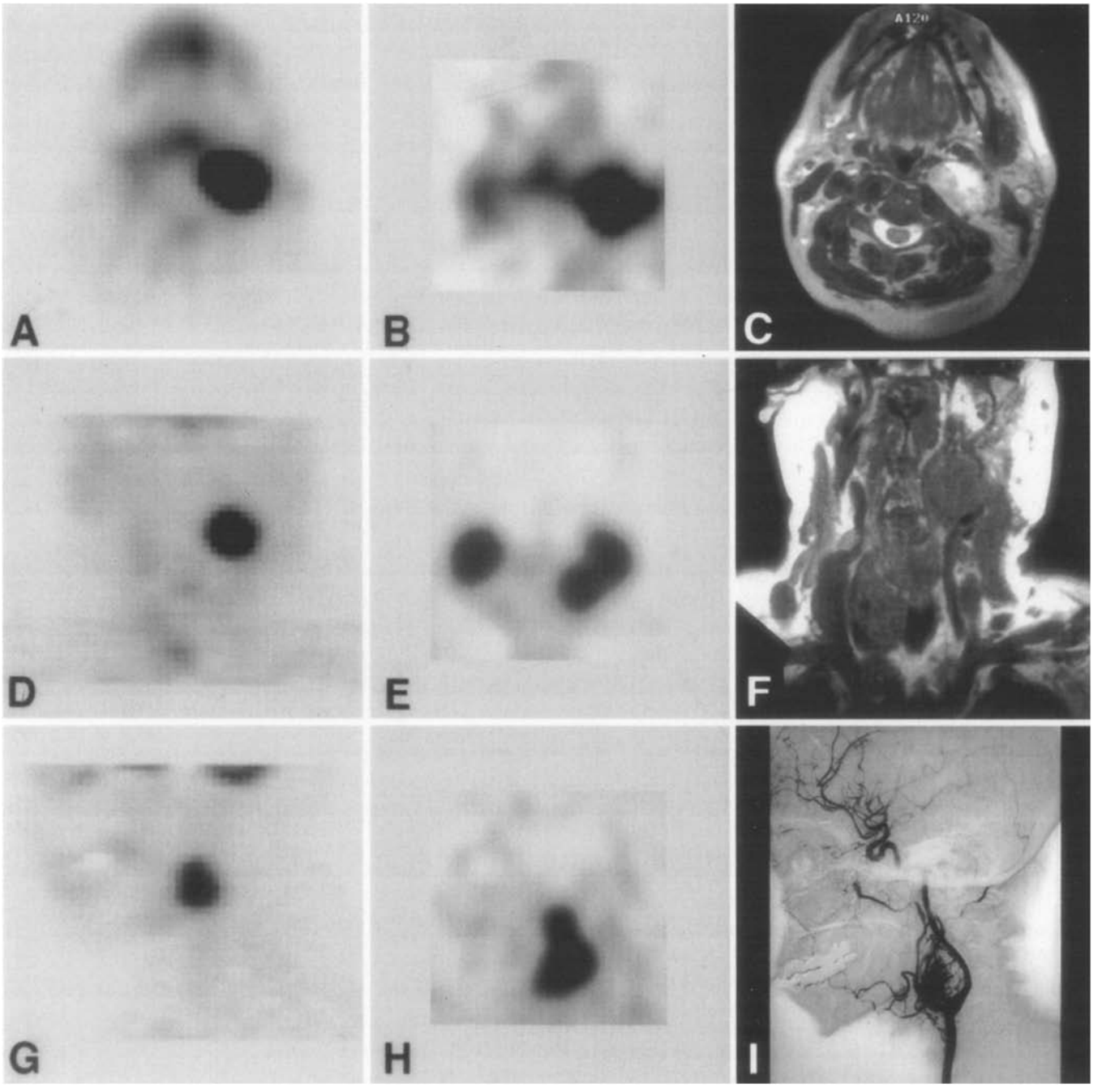

Fig. 1 A–I. Representative images from patient 1. Transverse (*top row*), coronal (*center row*), and sagittal sections (*bottom row*) from FDG-PET (**A , D, G**), ^{131}I-MIBG SPET (**B, E, H**), MRI (**C, F**), and carotid angiography studies (**I**). There is intense uptake of FDG and MIBG within the left neck mass. Normal left parotid salivary gland activity seen on ^{131}I-MIBG images is masked by tumor uptake in transverse section **B**, but evident superior to tumor uptake in coronal section **E** and sagittal section **H**. T1-weighted MR images after (**C**, axial) and before (**F**, coronal) administration of gadolinium demonstrate the left-sided soft tissue mass with inhomogeneous enhancement following gadolinium injection. Angiography (**I**) shows a mass with a vascular blush splaying the carotid bifurcation, characteristic of a carotid body tumor

MIBG SPET images demonstrated intense tracer uptake in the tumor adjacent to the normal left parotid activity (Fig. 1B , E , H). For comparison, the MRI and angiographic studies are also shown in Fig. 1. There was a single lesion within the carotid bifurcation isointense to adjacent soft tissue on precontrast T1-weighted images, with intense heterogeneous "salt and pepper" appearance following gadolinium contrast enhancement (Fig. 1C, F, I)[6]. Whole-body images from both the FDG and MIBG studies were otherwise unremarkable, and showed no evidence of tumors elsewhere.

The resection was uneventful and histologic examination was consistent with a carotid body tumor.

Patient 2

A 41-year-old otherwise healthy woman presented to her local otolaryngologist describing persistent rhinorrhea, nasal congestion and more recent development of painless right neck swelling. Findings on physical examination were mild right anterior cervical adenopathy, a 3×4 cm mass posterior to the angle of the right mandible, sluggish movements of the right vocal cord and marked medial displacement of the right palate. Profuse hemorrhage complicated biopsy of the right neck prominence, which was reported as consistent with a "glomus tumor".

The patient was referred to this institution for further investigation. Carotid angiography revealed a vascular lesion at the carotid bifurcation splaying the proximal internal and external carotid arteries, with a characteristic intense vascular blush. An oxygen-15 water quantitative cerebral perfusion study revealed no adverse reduction in perfusion, electroencephalographic changes, or neurologic dysfunction upon occlusion of the right internal carotid artery. FDG PET images showed intense uptake of tracer by the lesion (Fig. 2A , C). The SUV was 5.6. MIBG SPET images showed distinct accumulation within the tumor, medial to the right parotid activity (Fig. 2 B), while planar view showed only subtle asymmetry adjacent to the parotid glands (Fig. 2 D). There was no abnormal uptake elsewhere in the body on either the FDG or MIBG studies to suggest additional neuroendocrine tumors. Plasma and urine catecholamines and metabolites were normal.

The feeding vessels were embolized and the tumor subsequently resected. This required a mandibulotomy, together with partial resection of the right external carotid artery, internal jugular vein, the vagus, hypoglossal, spinal accessory and lingual nerves, and the right cervical sympathetic chain. Histology showed a glomus tumor. After additional revision procedures and renervation of the right vocal cord the patient has satisfactory laryngeal function and cosmetic result.

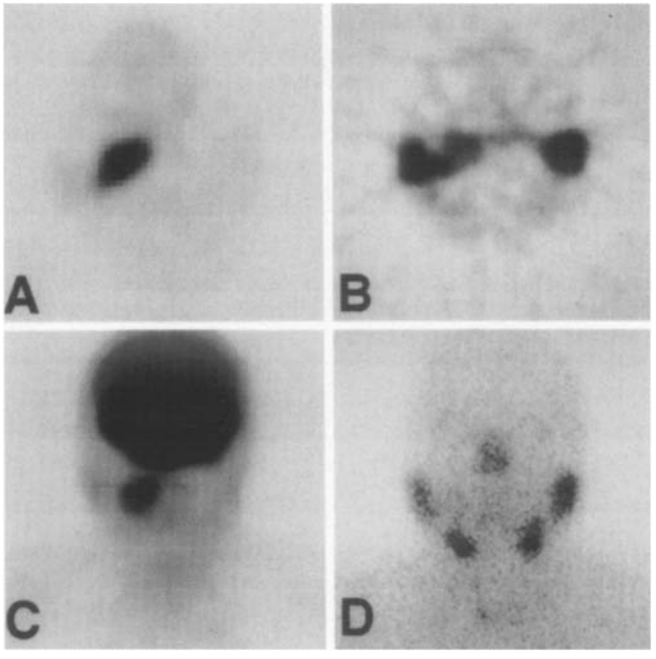

Fig. 2 A–D. Images from patient 2. Transverse (**A**) and anterior projection (**C**) images from FDG PET demonstrate an abnormal focus of FDG accumulation in the right neck. The corresponding ^{123}I-MIBG transverse section is presented in **B**. Note that the tumor, readily visible on SPET, is not apparent on a standard anterior planar view (**D**)

Discussion

The typical location and hypervascularity of carotid body tumors has been described by dynamic computed tomography and contrast angiography studies [7]. Magnetic resonance imaging shows focal low signal regions within the tumor on T1-weighted pre-contrast images, a heterogeneous "salt and pepper" appearance on T2-weighted images, and intense enhancement following administration of gadolinium [6].

Scintigraphy of these tumors initially comprised simple radionuclide angiography, used in one series to screen kindred members in familial paraganglionoma [1, 8]. The neural crest origin of the tumors, and the presence of biogenic amine uptake-1 and intracellular storage, was later exploited using MIBG. The low incidence of carotid body tumors has been a factor in the limited reported experience with this agent in carotid body tumors. Van Gils et al. demonstrated tumor uptake of ^{123}I-MIBG in 8 of 15 patients with known chemodectomas [2]. The sensitivity with ^{131}I-MIBG appears slightly lower, with uptake described in known lesions in four of ten patients [9]. The normal marked salivary gland uptake of MIBG may mask the presence of an adjacent tumor and, thus, SPET should be performed whenever possible [10].

Neuroendocrine tissues frequently express somatostatin receptors. As part of a study of paragangliomas with indium-111 pentetreotide, Kwekkeboom et al. reported successful detection of tumor in 13 of 14 patients with known carotid body tumors [11]. Among 25 patients with paragangliomas, unsuspected additional tumor sites

were identified in nine. The ability to study the whole body in a single examination is an advantage in a condition where multiple lesions may be present. Our patients were studied prior to commercial availability of this agent.

The substantial elevation of glucose uptake and retention by tumors relative to most non-neoplastic tissue is fundamental to FDG PET imaging in oncology [12]. This approach has been successful in visualizing neuroendocrine tumors even when the specific cellular mechanisms necessary for imaging with MIBG are absent [13]. PET with FDG clearly demonstrated the known tumors in these two patients. These tumors, though benign, were quite metabolically active. Salivary gland uptake of FDG was very low compared to that of MIBG, an advantage given the characteristic location of these tumors. This preliminary report suggests that FDG PET may be a useful adjunct in the detection and staging of cervical paragangliomas.

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