Incidental Diagnosis of an Arachnoid Granulation on Ga-68 DOTATATE PET/MRI

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Arachnoid granulations (AGs), also known as Pacchionian granulations, are growths of the arachnoid membrane, allowing cerebrospinal fluid (CSF) to resorb from the sub-arachnoid space into the venous system. The growth of these AGs occasionally forms pits or remodeling of the skull base and calvarium. The prevalence of AGs on CT or MRI has been shown to vary dependent on the study populations and imaging techniques (e.g., MRI with or without MR angiography) as well as slice thickness of the imaging exams, given their occasionally small size. In one study, AGs were observed in 24% of patients undergoing contrast-enhanced CT and in 13% of contrast-enhanced MRI [1]. AGs and AG-associated pits tend to increase in size and number with age and exhibit similar imaging features to CSF on both CT and MRI. Characteristic MRI findings include isointense or even slightly hyperintense signal intensity relative to CSF on T1-weighted imaging following Gd-based contrast agent administration (**c**, arrow), and bright signal intensity similar to CSF on T2 weighted sequences (**d**, arrow) [1, 2]. On CT, AG pits typically are observed as a well-circumscribed lesion with similar density to CSF that remodel the skull base or calvarium and may be perceived as an osteolytic lesion (**f**, arrow). AGs are also found within the dural venous sinuses causing a

filling defect, commonly at insertion points of draining cortical veins. AGs have been shown to exhibit increased somatostatin receptor (SSTR), with all 12 tissue samples dissected from the superior sagittal sinus revealing equally strong SSTR subtypes 1 and 2 expressions [3].

The role of Ga-68 DOTATATE, a radioactive SSTR agonist, is well established for neuroendocrine tumors [4]. Moreover, it has added value for the diagnosis and clinical management of meningioma because of the high expression of SSTR subtype 2 in most cases [5, 6], and has been shown to have greater sensitivity compared with contrast-enhanced MRI [7–9]. Unlike AGs, meningiomas are typically dural-based mass lesions, isointense to gray matter on both T1- and T2-weighted MRI and demonstrate brisk enhancement after Gd-based contrast agent administration. Meningiomas can occasionally be intra-osseous or even extra-cranial. It is postulated that meningiomas arise from arachnoid cap cells and commonly occur where these cells are most numerous, such as in areas of AGs [10–12]. The observed mild DOTATATE uptake (SUV 3.0) seen in our case may be characteristics for AGs, as opposed to the intense uptake commonly seen in meningiomas with SUV 14.8 (interquartile range 11–26) [9]. Specifically, meningiomas in the area of the sphenoid wing have been shown to be more likely to be transosseous in 42 of 45 lesions (93%) than extraosseous in 3 of 45 lesions (7%) [9]. In the case presented, the characteristic MRI and CT findings, coupled with the low DOTATATE avidity, support the diagnosis of arachnoid granulation and excludes the presence of a meningioma or metastatic neuroendocrine tumor. Hybrid DOTATATE PET/MRI affords spatially registered functional and anatomic datasets allowing for enhanced detection and evaluation of small extra-axial brain lesions. It is important to be able to differentiate between AGs and other neoplastic processes, as imaging findings of a meningioma may require serial observation or even resection for diagnosis and clinical

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Fig. 1 **a** Maximum-intensity-projection (MIP) image. **b** DOTATATE PET. **c** Gd-enhanced T1-weighted image (DIXON FS, TE 14 ms, TR 1270 ms). **d** T2-weighted image (TE 95 ms, TR 1600 ms). **e** Fused PET/T2-weighted image and **f** unenhanced CT. PET imaging shows mild focal DOTATATE uptake in the left sphenoid wing with a maximum standard uptake value (SUV) of 3.0 (**a**, **b**, arrow), which is less avid than the physiologic pituitary uptake (**a**, arrowhead, SUV 6.3). The reference

aorta shows SUV 1.7. An extra-axial lesion with mild, focal DOTATATE uptake and characteristic MRI findings was incidentally noted on a restaging PET/MRI (**c**, **d**, **e**, arrow) as well as previous staging CT, which is most compatible with an arachnoid granulation (AG) with associated remodeling the skull base (**f**, arrow). There was no evidence of a meningoencephalocele.

management. On the other hand, further imaging of or biopsy of AGs is not warranted, as these normal structures do not typically require intervention or treatment [13].

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Compliance with Ethical Standards

Conflict of Interest Nghi C. Nguyen, Chan-Hong Moon, and Joseph M. Mettenberg declare that they have no conflict of interest.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed Consent The institutional review board of our institution approved this retrospective study, and the requirement to obtain informed consent was waived.

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