

**Supplemental content for
Sporadic Primary Pheochromocytoma: A Prospective Intraindividual
Comparison of Six Imaging Tests (CT, MRI, and PET/CT Using ⁶⁸Ga-DOTATATE,
FDG, ¹⁸F-FDOPA, and ¹⁸F-FDA)**

Abhishek Jha, MD, Mayank Patel, MD, Jorge A. Carrasquillo, MD, Alexander Ling, MD, Corina Millo, MD, Babak Saboury, MD, MPH, Clara C. Chen, MD, Paul Wakim, PhD, Melissa K. Gonzales, BS, Leah Meuter, BS, Marianne Knue, CRNP, Sara Talvacchio, RN, Peter Herscovitch, MD, Jaydira Del Rivero, MD, Alice P. Chen, MD, Naris Nilubol, MD, David Taïeb, MD, PhD, Frank I. Lin, MD, Ali Cahid Civelek, MD, Karel Pacak, MD, PhD, DSc

doi.org/10.2214/AJR.21.26071

Published online: August 25, 2021

The authors have supplied these materials to give readers additional information about the work.

Table S1-Clinical characteristics of patients with histologically-confirmed sporadic adrenal pheochromocytoma and study results for CT^a and MRI

Patient	Age (y)	Hypersecretion ^b	Laterality of Lesion	Lesion size ^c (cm)	Conspicuity Score on CT		Positivity for PHEO ^e (CT)	Conspicuity Score on MRI		Positivity for PHEO ^e (MRI)
					R1 ^d	R2		R1 ^d	R2	
1	29	EPI, NE, NMN, DA, CgA	Left	6.4	5	4	+	5	5	+
2	58	EPI, MN, NE, NMN, CgA	Right	3.2	NA	NA	NA	5	5	+
3	67	MN, NMN, DA	Left	6.1	5	4	+	NA	NA	NA
4	44	NE, NMN, DA	Right	2.0	3	3	-	4	5	+
5	20	NE, NMN, DA, CgA	Right	3.7	5	4	+	5	5	+
6	74	EPI, MN, NMN, CgA	Left	3.4	5	4	+	5	5	+
7	54	MN, NMN, DA, CgA	Right	3.0	5	5	+	5	5	+
8	70	EPI, MN, NE, NMN, DA, CgA	Right	3.1	3	3	-	NA	NA	NA
9	49	MN, NMN, DA, CgA	Right	2.6	3	3	-	5	5	+
10	55	EPI, MN, NE, NMN, DA, CgA	Left	9.5	3	3	-	4	5	+
11	44	NE, NMN, CgA	Right	9.0	4	4	+	4	4	+
12	75	EPI, MN, NMN, DA, CgA	Left	5.5	5	4	+	5	5	+
13	51	NE, NMN, DA, CgA	Left	7.5	NA	NA	NA	4	4	+
14	35	EPI, MN, NE, NMN, CgA	Right	8.0	5	5	+	5	5	+

^aPerformed using a single portal-venous phase as part of a whole-body staging CT examination

^bBased on plasma biochemical evaluation

^cBased on histopathologic analysis of surgically resected lesion

^dConspicuity scores from R1 were used for subsequent analysis.

^eLesion deemed negative for PHEO for conspicuity score of 1-3 and positive for PHEO for conspicuity score of 4-5

CgA = chromogranin A; DA = dopamine; EPI = epinephrine; MN = metanephrine; NA = not available (patient did not undergo given imaging examination); PHEO = pheochromocytoma; R1 = reader 1; R2 = reader 2

Table S2-Patient-level SUV_{max} measurements, conspicuity scores, and lesion positivity results for ⁶⁸Ga-DOTATATE PET/CT

Patient	SUV _{max} Measurements ^a					Conspicuity Score ^b		Lesion Positivity for PHEO
	Lesion ^a	Contralateral ^b Adrenal Gland	Ratio of Lesion to Contralateral Adrenal Gland	Normal ^b Liver	Ratio of Lesion to Liver	R1	R2	
1	34.7	21.1	1.7	7.6	4.6	5	5	+
2	71.5	28.1	2.6	8.8	8.1	5	5	+
3	52.7	46.8	1.1	13.5	3.9	5	5	+
4	36.0	35.8	1.0	12.2	3.0	5	4	+
5	28.9	20.9	1.4	14.1	2.1	5	5	+
6	21.7	31.4	0.7	10.7	2.0	3	2	-
7	99.4	42.2	2.4	9.0	11.0	5	5	+
8	36.9	10.0	3.7	7.5	4.9	5	5	+
9	34.6	31.9	1.1	13.4	2.6	3	2	-
10	15.0	11.7	1.3	10.3	1.5	5	4	+
11	16.7	25.6	0.7	10.4	1.6	4	4	+
12	37.5	34.6	1.1	9.6	3.9	2	1	-
13	94.8	49.8	1.9	14.9	6.4	5	5	+
14	30.5	20.9	1.5	11.5	2.7	5	5	+

^aSUV_{max} measurements of adrenal lesions were obtained by R1 and of contralateral adrenal gland and liver by R2.

^bConspicuity scores of R1 were used for subsequent analyses when the readers' dichotomized scores were concordant for whether lesion was negative (conspicuity score of 1-3) or positive (conspicuity score of 4-5).

PHEO = pheochromocytoma; R1 = reader 1; R2 = reader 2

Table S3-Patient-level SUV_{max} measurements, conspicuity scores, and lesion positivity results for FDG PET/CT

Patient	SUV _{max} Measurements ^a					Conspicuity Score ^b		Lesion Positivity for PHEO
	Lesion	Contralateral Adrenal Gland	Ratio of Lesion to Contralateral Adrenal Gland	Normal Liver	Ratio of Lesion to Liver	R1	R2	
1	9.9	9.2	1.1	3.2	3.1	5	5	+
2	5.7	3.1	1.8	3.7	1.5	5	4	+
3	11.0	6.7	1.6	6.8	1.6	3	4	+
4	5.6	4.6	1.2	4.3	1.3	1	2	-
5	20.9	3.2	6.5	4.3	4.9	5	5	+
6	6.8	4.5	1.5	3.3	2.1	5	5	+
7	3.6	3.1	1.2	3.6	1.0	1	1	-
8	12.2	12.0	1.0	1.9	6.3	5	4	+
9	11.5	4.1	2.8	4.0	2.9	3	5	+
10	19.0	4.2	4.5	2.9	6.6	5	5	+
11	19.0	6.6	2.9	3.5	5.4	5	5	+
12	10.4	4.4	2.4	3.4	3.1	5	5	+
13	5.2	4.6	1.2	4.1	1.3	4	4	+
14	6.5	2.9	2.3	4.4	1.5	2	1	-

^aSUV_{max} measurements of lesions were obtained by R1 and of contralateral adrenal gland and liver by R2

^bConspicuity scores of R1 were used for subsequent analyses when the readers' dichotomized scores were concordant for whether lesion was negative (conspicuity score of 1-3) or positive (conspicuity score of 4-5). If readers were discrepant for whether lesion was negative or positive for PHEO, then a joint review was performed, and consensus score (indicated in bold) was used for subsequent analyses.

NA = not available; PHEO = pheochromocytoma; R1 = reader 1; R2 = reader 2

Table S4-Patient-level SUV_{max} measurements, conspicuity scores, and lesion positivity results for ¹⁸F-FDOPA PET/CT

Patient	SUV _{max} Measurements ^a					Conspicuity Score ^b		Lesion Positivity for PHEO
	Lesion	Contralateral Adrenal Gland	Ratio of Lesion to Contralateral Adrenal Gland	Normal Liver	Ratio of Lesion to Liver	R1	R2	
1	45.8	5.5	8.3	3.0	15.3	5	5	+
2	NA	NA	NA	NA	NA	NA	NA	NA
3	25.4	11.7	2.2	5.5	4.6	5	5	+
4	31.2	6.3	4.9	3.7	8.3	5	5	+
5	33.1	4.6	7.1	3.2	10.3	5	5	+
6	NA	NA	NA	NA	NA	NA	NA	NA
7	23.0	6.7	3.4	3.2	7.1	5	5	+
8	NA	NA	NA	NA	NA	NA	NA	NA
9	14.5	7.4	2.0	4.0	3.6	5	5	+
10	78.4	4.4	17.7	2.9	27.0	5	5	+
11	64.9	8.2	8.0	3.5	18.6	5	5	+
12	11.6	8.9	1.3	2.6	4.5	5	5	+
13	40.7	7.6	5.4	3.4	11.9	5	5	+
14	11.7	5.3	2.2	2.8	4.1	5	5	+

^aSUV_{max} measurements of adrenal lesions were obtained by R1 and of contralateral adrenal gland and liver by R2.

^bConspicuity scores of R1 were used for subsequent analyses when the readers' dichotomized scores were concordant for whether lesion was negative (conspicuity score of 1-3) or positive (conspicuity score of 4-5).

NA = not available; PHEO = pheochromocytoma; R1 = reader 1; R2 = reader 2

Table S5-Patient-level SUV_{max} measurements, conspicuity scores, and lesion positivity results for ¹⁸F-FDA PET/CT

Patient	SUV _{max} Measurements ^a					Conspicuity Score ^b		Lesion Positivity for PHEO
	Lesion	Contralateral Adrenal Gland	Ratio of Lesion to Contralateral Adrenal Gland	Normal Liver	Ratio of Lesion to Liver	R1	R2	
1	38.6	7.9	4.9	9.5	4.1	5	5	+
2	50.0	17.9	2.8	10.8	4.6	5	5	+
3	73.8	40.9	1.8	15.7	4.7	5	5	+
4	20.8	18.9	1.1	9.1	2.3	3	4	-
5	28.1	8.3	3.4	11.7	2.4	5	5	+
6	NA	NA	NA	NA	NA	NA	NA	NA
7	32.4	16.1	2.0	9.8	3.3	5	5	+
8	NA	NA	NA	NA	NA	NA	NA	NA
9	NA	NA	NA	NA	NA	NA	NA	NA
10	NA	NA	NA	NA	NA	NA	NA	NA
11	NA	NA	NA	NA	NA	NA	NA	NA
12	NA	NA	NA	NA	NA	NA	NA	NA
13	31.4	17.2	1.8	9.7	3.3	4	5	+
14	NA	NA	NA	NA	NA	NA	NA	NA

^aSUV_{max} measurements of lesions were obtained by R1 and of contralateral adrenal gland and liver by R2

^bConspicuity scores of R1 were used for subsequent analyses when the readers' dichotomized scores were concordant for whether lesion was negative (conspicuity score of 1-3) or positive (conspicuity score of 4-5). If readers were discrepant for whether lesion was negative or positive for PHEO, then a joint review was performed, and consensus score (indicated in bold) was used for subsequent analyses.

NA = not available; PHEO = pheochromocytoma; R1 = reader 1; R2 = reader 2

Figure S1. Multimodality imaging of 44-year-old man (patient 4) with clinical suspicion for pheochromocytoma (PHEO) based on symptoms of anxiety, hot flashes, exertional palpitations, and sweating. Patient also had elevated plasma norepinephrine, dopamine, and normetanephrines, and right adrenal mass on prior CT. Maximum intensity projection PET images (A-D) and fused axial PET/CT images (E-H) using ^{18}F -FDOPA (A, E), ^{68}Ga -DOTATATE (B, F), ^{18}F -FDA (C, G), and FDG (D, H), as well as axial T2-weighted MR image (I), and axial portal venous-phase contrast-enhanced CT image (J), show a right adrenal mass. Mass was deemed positive for PHEO on ^{68}Ga -DOTATATE PET/CT, ^{18}F -FDOPA PET/CT, and MRI (arrows), and negative for PHEO on ^{18}F -FDA PET/CT, FDG PET/CT, and CT (arrowheads). Focal uptake in the right upper quadrant in the region of the liver and right ribs on ^{18}F -FDA PET/CT (black arrow, C) corresponds to uptake in the dome of the gallbladder. Conspicuity score (CS) and SUV_{max} by reader 1 were as follows: ^{18}F -FDOPA—CS: 5, SUV_{max} : 31.2; ^{68}Ga -DOTATATE—CS: 5, SUV_{max} : 36.0; ^{18}F -FDA—CS: 3, SUV_{max} : 20.8; FDG—CS: 1, SUV_{max} : 5.6; MRI—CS: 4; CT—CS: 3. Subsequent surgical resection confirmed PHEO.

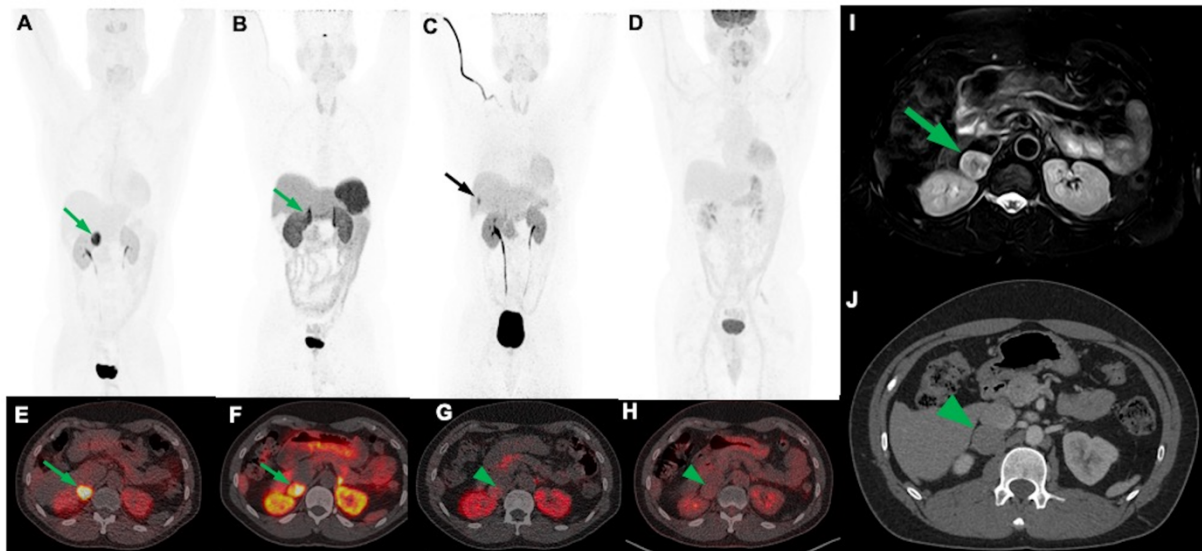


Figure S2. Multimodality imaging of 76-year-old woman (patient 12) with sporadic pheochromocytoma (PHEO), diagnosed by refractory hypertension on multiple antihypertensives, elevated urine normetanephrine and metanephrine, and left adrenal mass on prior ultrasound and CT. Maximum intensity projection PET images (A-C) and fused axial PET/CT images (D-F) using ^{18}F -FDOPA (A, D), ^{18}F -FDG (B, E), and ^{68}Ga -DOTATATE (C, F), as well as axial contrast-enhanced T1-weighted MR image (G), and axial portal venous-phase contrast-enhanced CT image (H) show a left adrenal mass. Mass was deemed positive for PHEO on all tests (arrows) other than on ^{68}Ga -DOTATATE PET/CT, on which it was deemed negative for PHEO (arrowhead). Conspicuity score (CS) and SUV_{max} by reader 1 were as follows: ^{18}F -FDOPA—CS: 5, SUV_{max} : 11.6; FDG—CS: 5, SUV_{max} : 10.4; ^{68}Ga -DOTATATE—CS: 2, SUV_{max} : 37.5; MRI—CS: 5; CT—CS: 5. Patient did not undergo ^{18}F -FDG PET/CT. Subsequent surgical resection confirmed PHEO. False-negative interpretation on ^{68}Ga -DOTATATE PET/CT was attributed to predominant photopenia within mass, with only a linear area of peripheral increased uptake anteriorly.

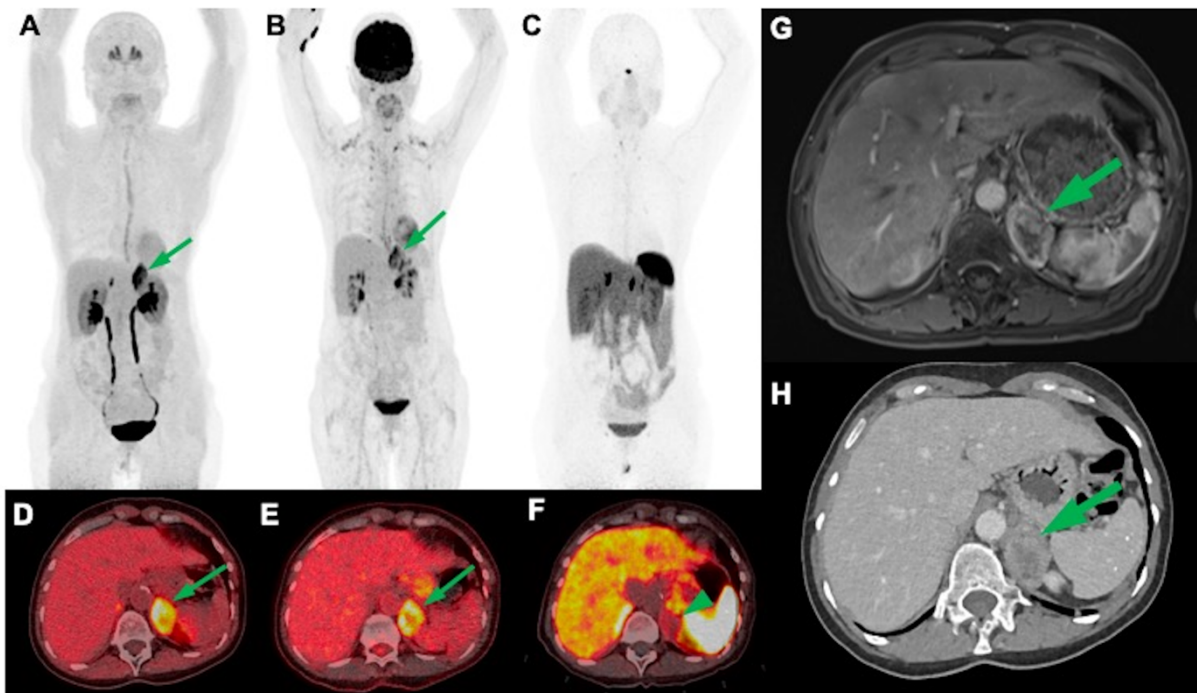


Figure S3. Multimodality imaging of 50-year-old woman (patient 9) referred with diagnosis for pheochromocytoma (PHEO). Patient had experienced symptoms of palpitations, anxiety, dizziness, sweating, hot flashes, headaches, blurry vision, exertional chest pain, shortness of breath, and fluctuating hypertensive episodes. Patient also had right adrenal mass on prior CT, which revealed PHEO on biopsy. Maximum intensity projection PET images (A-C) and fused axial PET/CT images (D-F) using ^{18}F -FDOPA (A, D), ^{68}Ga -DOTATATE (B, E), and FDG (C, F), as well as axial contrast-enhanced T1-weighted MR image (G), and axial portal venous-phase contrast-enhanced CT image (H) show a right adrenal mass. Mass was deemed positive for PHEO on ^{18}F -DOPA PET/CT, ^{18}F -FDG PET/CT, and MRI (arrows) and false-negative for PHEO on ^{68}Ga -DOTATATE PET/CT and CT (arrowheads). Conspicuity score (CS) and SUV_{max} by reader 1 were as follows: ^{18}F -FDOPA—CS: 5, SUV_{max} : 14.5; ^{68}Ga -DOTATATE—CS: 3, SUV_{max} : 34.6; MRI—CS: 5; CT—CS: 3. For FDG PET/CT, a consensus CS of 5 was reached after joint review between the two readers, as their initial reads were discrepant (reader 1, CS: 3; reader 2, CS: 5) for whether lesion was negative (conspicuity score of 1-2) or positive (conspicuity score of 3-5) for PHEO. Reader 1 measured an SUV_{max} of this lesion of 11.5. Patient did not undergo ^{18}F -FDA PET/CT. Subsequent surgical resection confirmed PHEO. False-negative interpretation on ^{68}Ga -DOTATATE PET/CT was attributed to predominant photopenia within mass, with only a linear area of peripheral increased uptake anteriorly.

