

# PET/CT在功能性内分泌 肿瘤中的应用

中山大学附属第一医院核医学科

张祥松

**u 功能性内分泌肿瘤**是指一系列不仅有肿瘤特点而且有内分泌功能的双重特性的肿瘤

**u 细胞来源多样性：**内分泌腺体，外分泌腺中的散在内分泌细胞（如消化道和呼吸道）、不具有内分泌功能的组织和器官

**u 可分泌多种激素**

**u 可多腺体、多器官组织受累**

**u 临床表现多样、迥异**

## U 影像特点:

u 体积小

u 可局限或散在分布

u 可多部位受累

u 位置隐匿

u .....

# u 影像诊断方法:

u CT

u MRI

u 超声、超声内镜

u **PET/CT、PET/MR**

# uPET示踪剂

u  $^{68}\text{Ga}$ -DOTA-NOC, 反映生长抑素受体表达

u  $^{18}\text{F}$ -DOPA, 反映儿茶酚胺代谢

u  $^{18}\text{F}$ -FDG, 反映葡萄糖代谢, 与肿瘤增殖  
活性和恶性程度相关

u  $^{11}\text{C}$ -Methionine, 反映氨基酸代谢

u  $^{18}\text{F}$ -AV133, 反映VMAT2受体表达

# 生长抑素受体靶向显像剂

生长抑素受体靶向显像剂的药效结构多为由生长抑素（Somatostatin）衍生的多肽，如Pentetreotide和Octreotide，放射性核素（ $^{111}\text{In}$ 、 $^{68}\text{Ga}$ 、 $^{99\text{m}}\text{Tc}$ 、 $^{64}\text{Cu}$ 等）通过连接基团与药效结构连接，其中 $^{68}\text{Ga}$ 标记的显像剂是研究的热点：

较常用

$^{68}\text{Ga}$ -DOTA-Tyr3-octreotide ( $^{68}\text{Ga}$ -DOTA-TOC)

$^{68}\text{Ga}$ -DOPA-Nal3-octreotide ( $^{68}\text{Ga}$ -DOTA-NOC)

$^{68}\text{Ga}$ -DOTA-Tyr3-octreotate ( $^{68}\text{Ga}$ -DOTA-TATE)

$^{111}\text{In}$ -DTPA-octreotide ( $^{111}\text{In}$ -Pentetreotide)

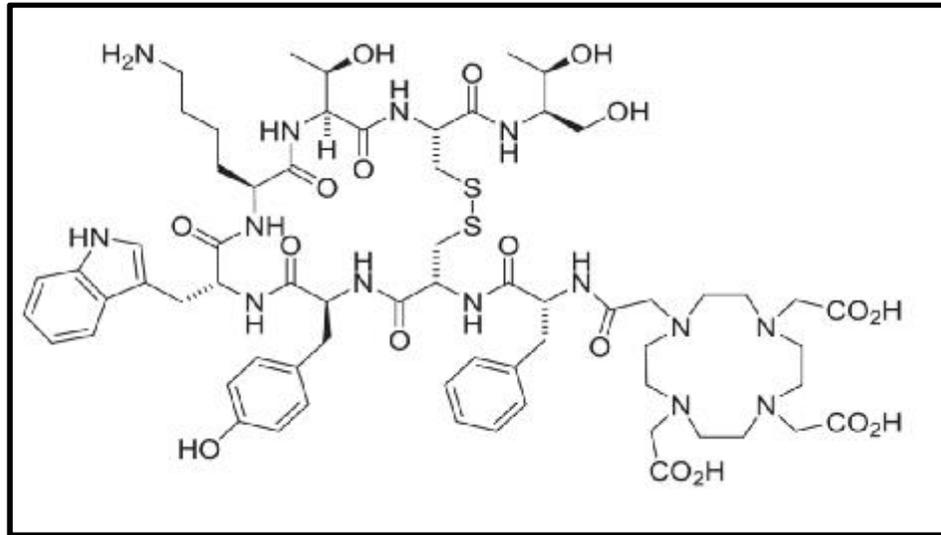
$^{111}\text{In}$ -DOTA-Tyr3-octreotide ( $^{111}\text{In}$ -DOTA-TOC)

$^{111}\text{In}$ -DOTA-Nal3-octreotide ( $^{111}\text{In}$ -DOTA-NOC)

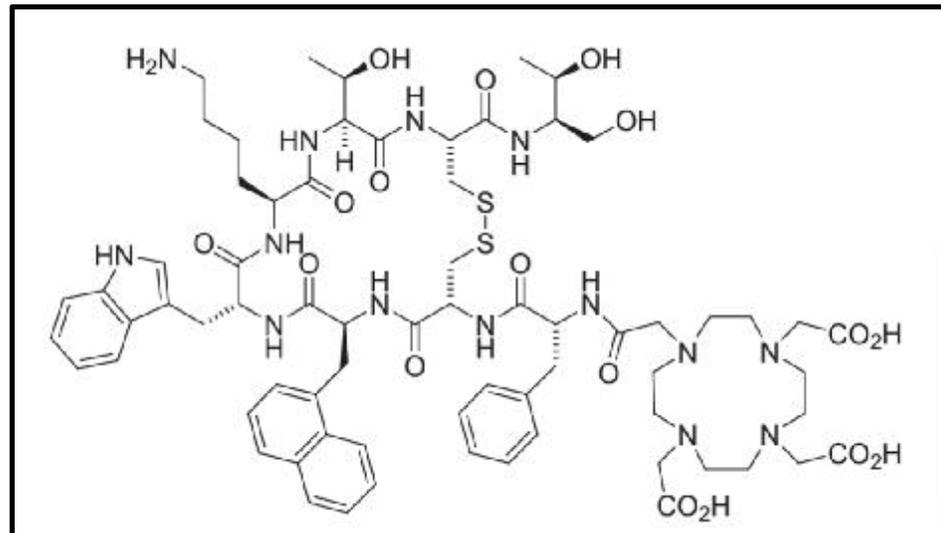
$^{111}\text{In}$ -DOTA-Tyr3-octreotate ( $^{111}\text{In}$ -DOTA-TATE)

$^{99\text{m}}\text{Tc}$ -HYNIC-Tyr3-Octreotide ( $^{99\text{m}}\text{Tc}$ -HYNIC-TOC)

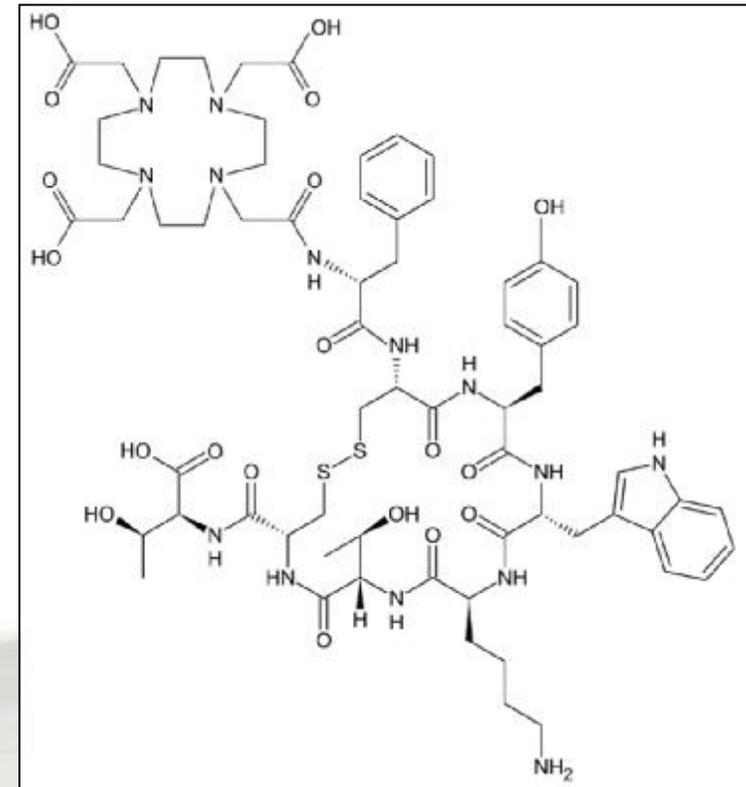
$^{99\text{m}}\text{Tc}$ -HYNIC-Tyr3-Octreotate ( $^{99\text{m}}\text{Tc}$ -HYNIC-TATE)



DOTA-TOC



DOTA-NOC

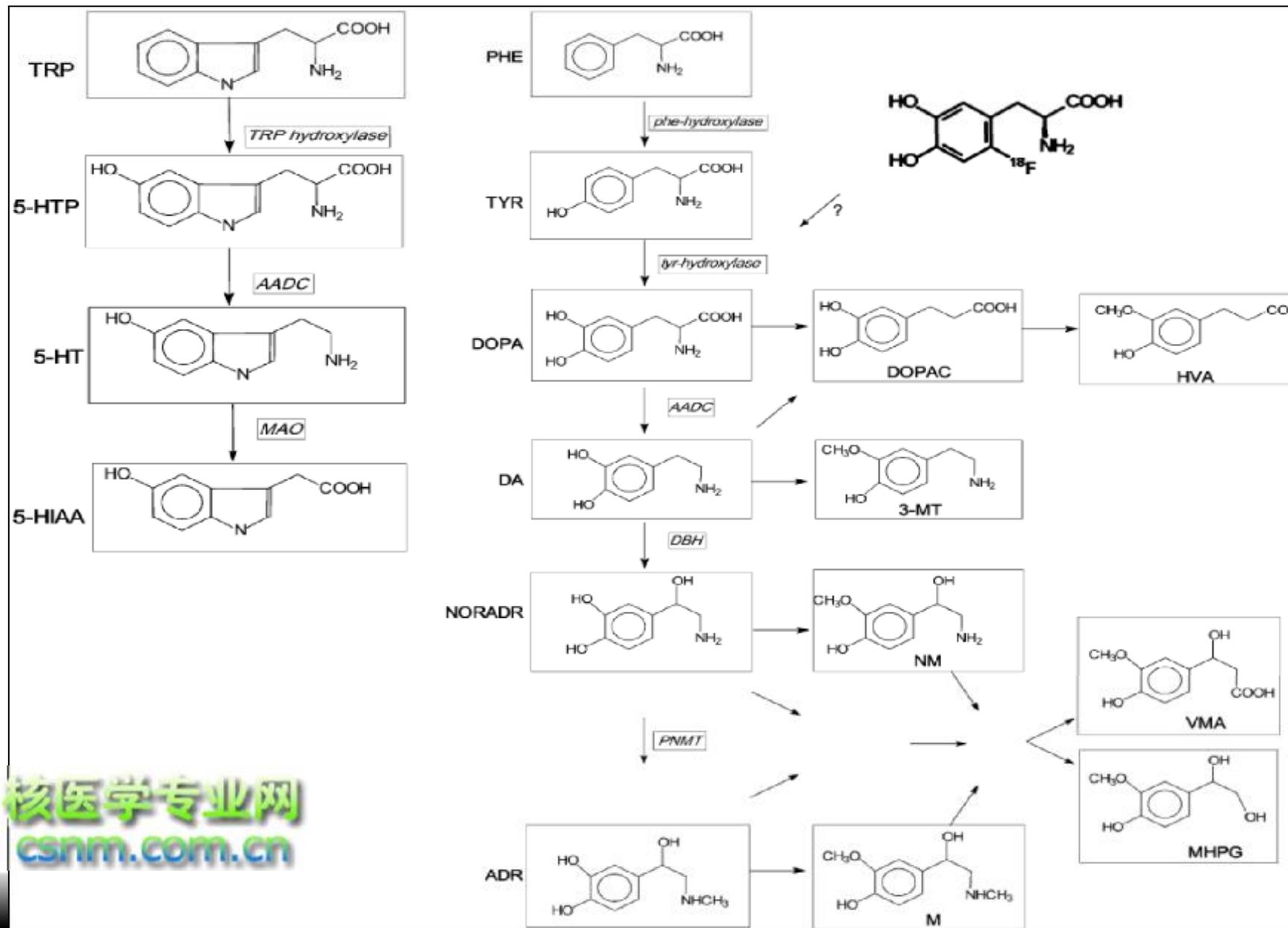


DOTA-TATE

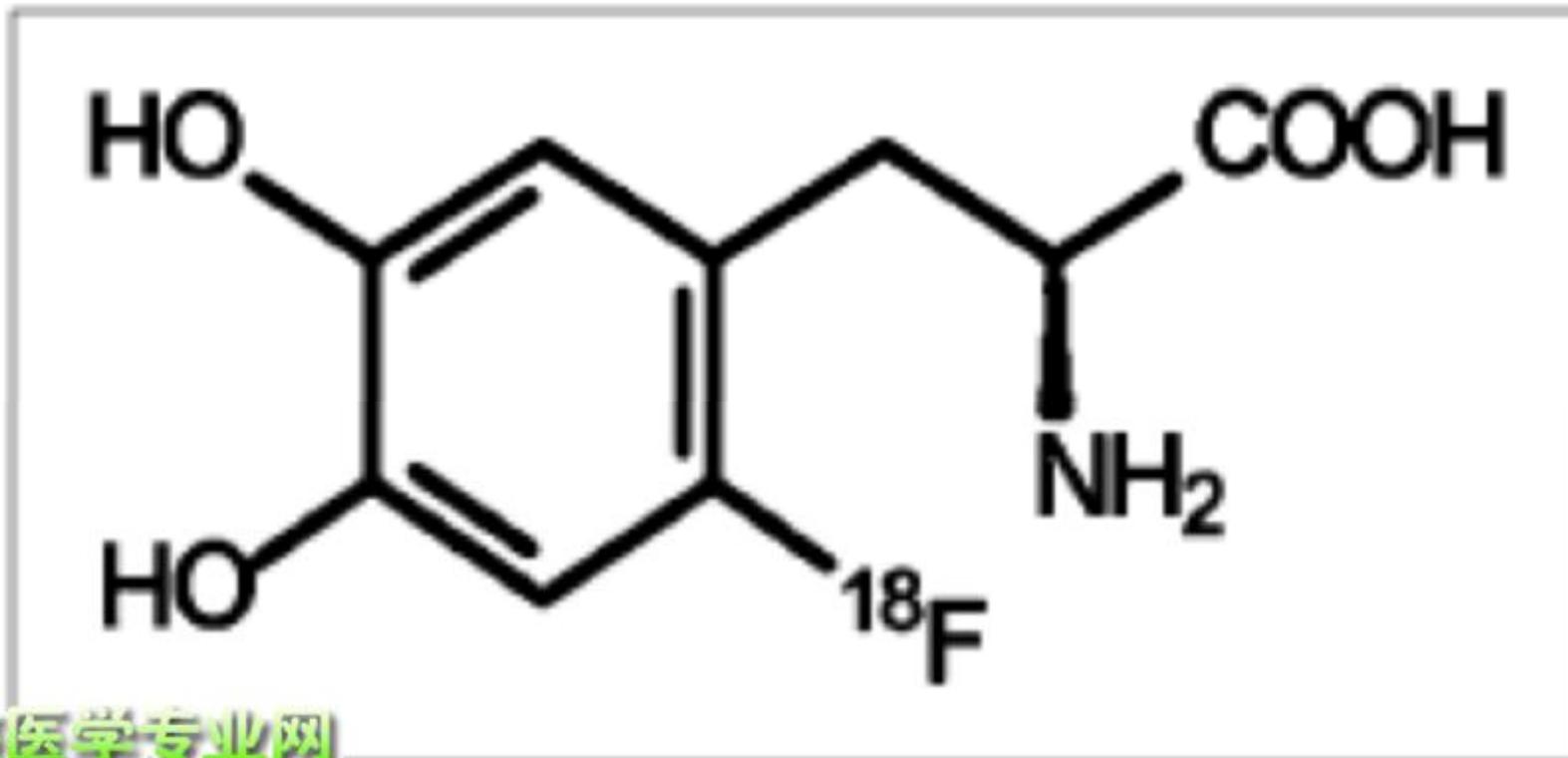
## Sstr binding affinity of <sup>68</sup>Ga-sstr-ligands

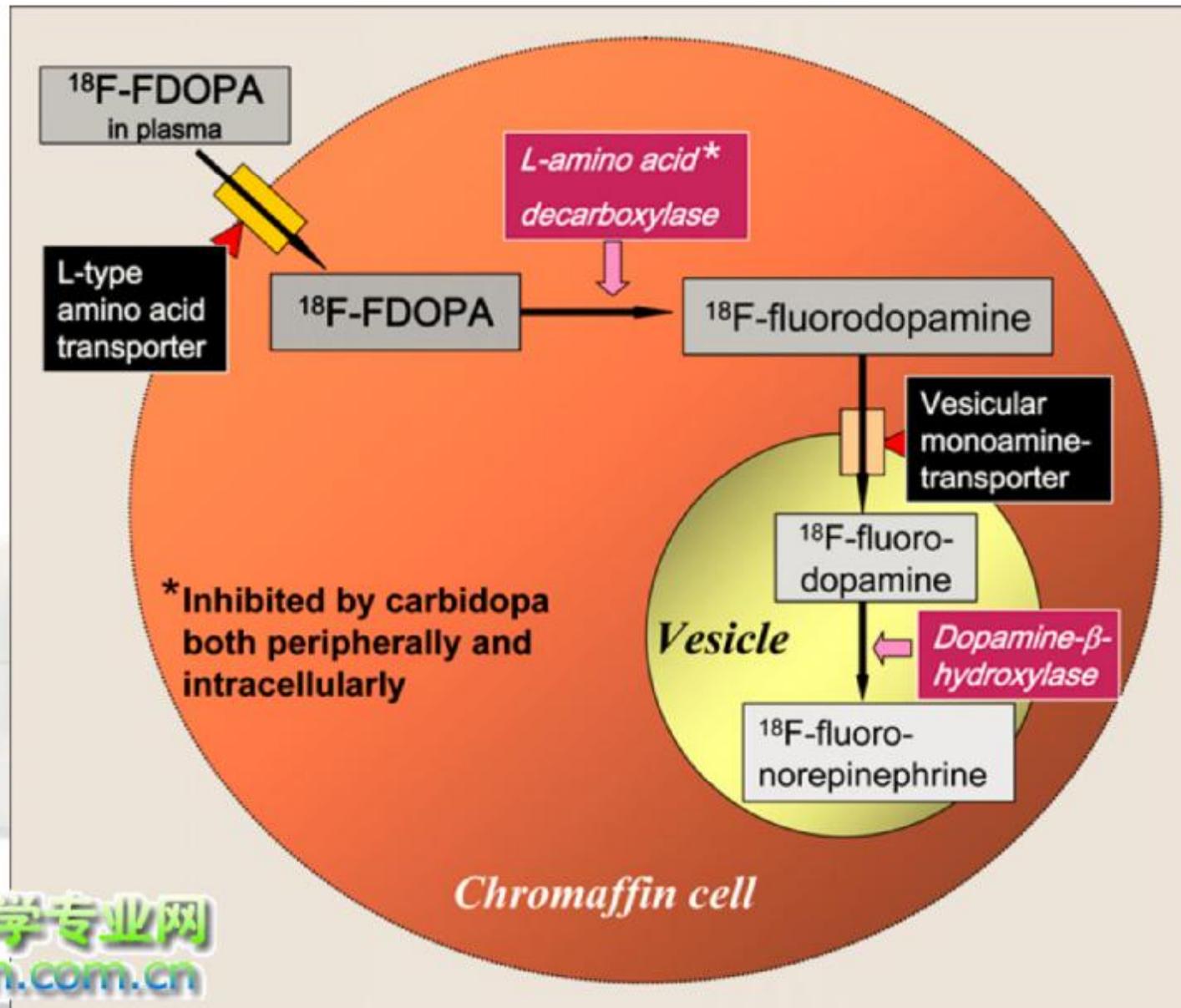
Peptide	sstr1	sstr2	sstr3	sstr4	sstr5
DOTATOC	>10,000	14 ± 2.6	880 ± 324	>1,000	393 ± 84
DOTATATE	>10,000	1.5 ± 0.4	>1,000	453 ± 176	547 ± 160
DOTALAN	>10,000	26 ± 3.4	771 ± 229	>10,000	73 ± 12
Ga-DOTATOC	>10,000	2.5 ± 0.5	613 ± 140	>1,000	73 ± 21
Ga-DOTATATE	>10,000	0.2 ± 0.04	>1,000	300 ± 140	377 ± 18
Ga-DOTANOC	>10,000	1.9 ± 0.4	40.0 ± 5.8	260 ± 74	7.2 ± 1.6
Y-DOTATOC	>10,000	11 ± 1.7	389 ± 135	>10,000	114 ± 29
Y-DOTATATE	>10,000	1.6 ± 0.4	>1,000	523 ± 239	187 ± 50
Y-DOTANOC	>1,000	3.3 ± 0.2	26 ± 1.9	>1,000	10.4 ± 1.6
Y-DOTALAN	>10,000	22.8 ± 4.9	290 ± 105	>10,000	16.3 ± 3.4

# Catecholamine/Serotonin synthesis pathways

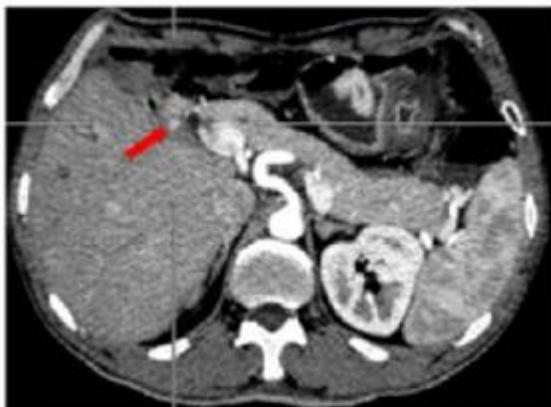
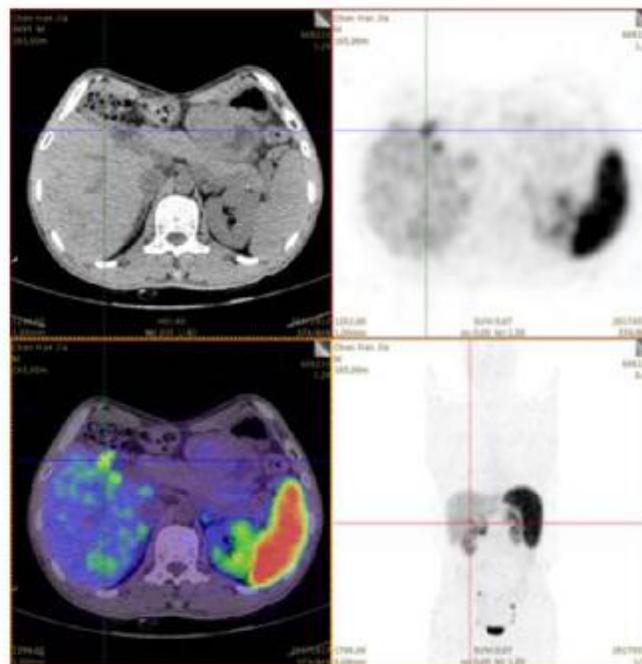
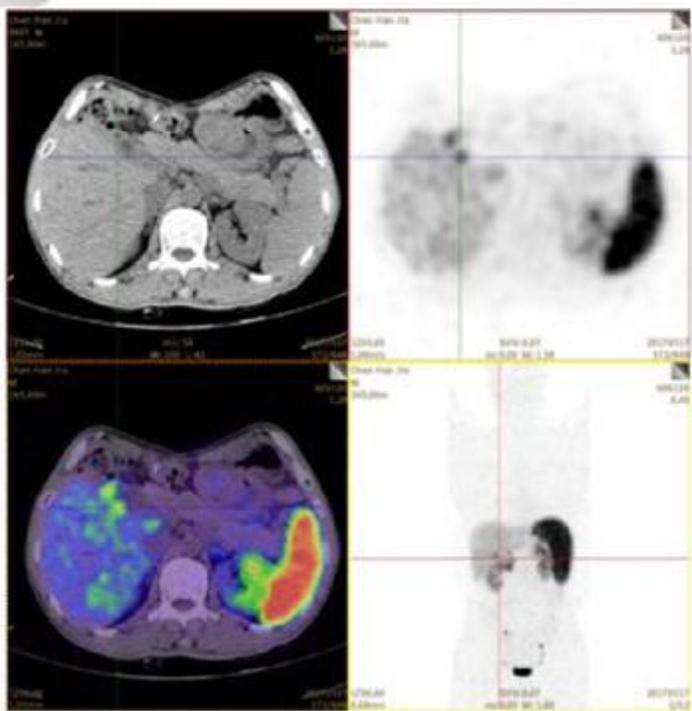


# 6-L-<sup>18</sup>F-fluorodihydroxyphenylalanine (<sup>18</sup>F-DOPA)



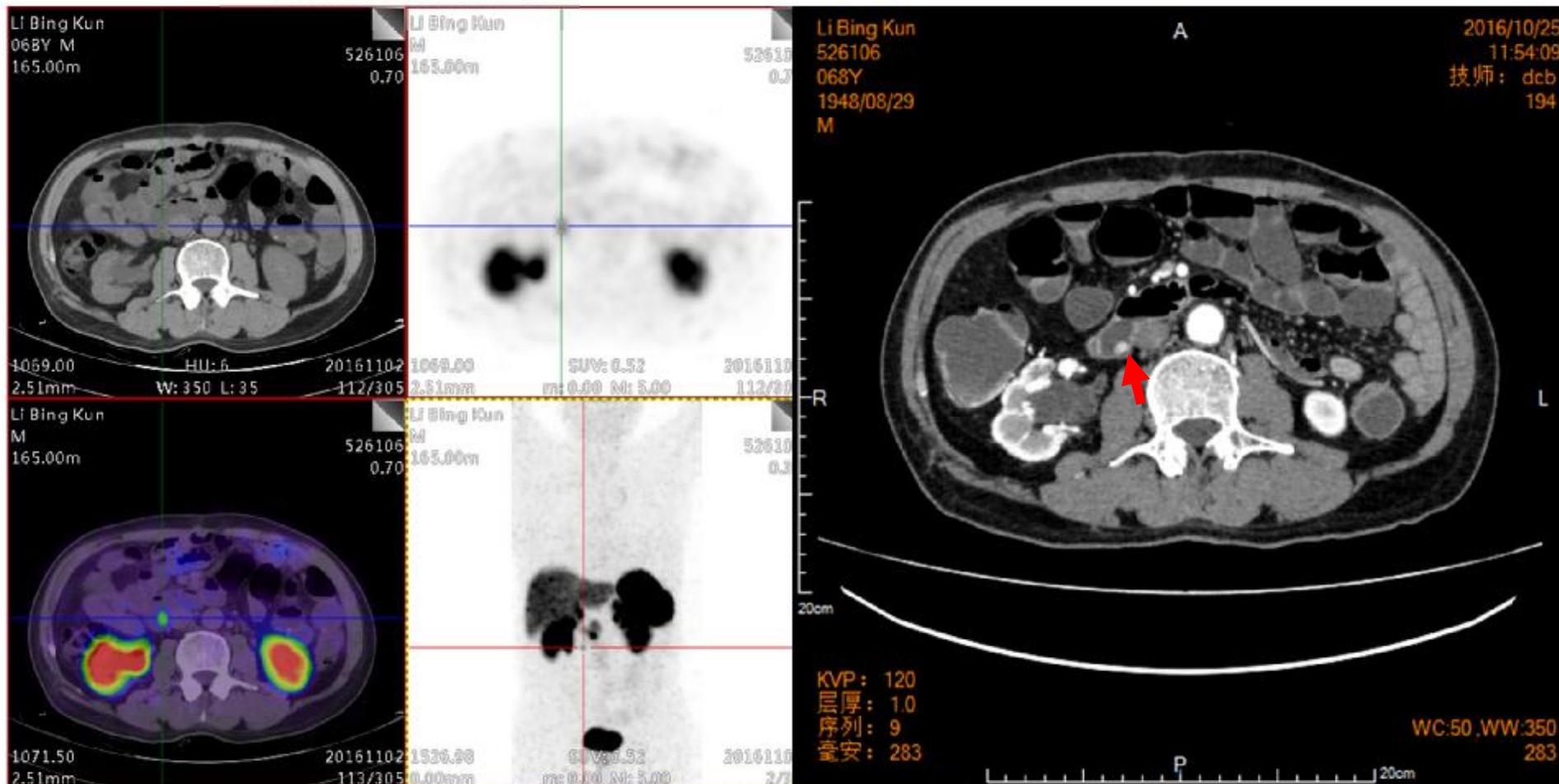


# 胃泌素瘤： $^{68}\text{Ga}$ -生长抑素受体 PET/CT显像



# 胃泌素瘤

## <sup>68</sup>Ga-DOTA-NOC



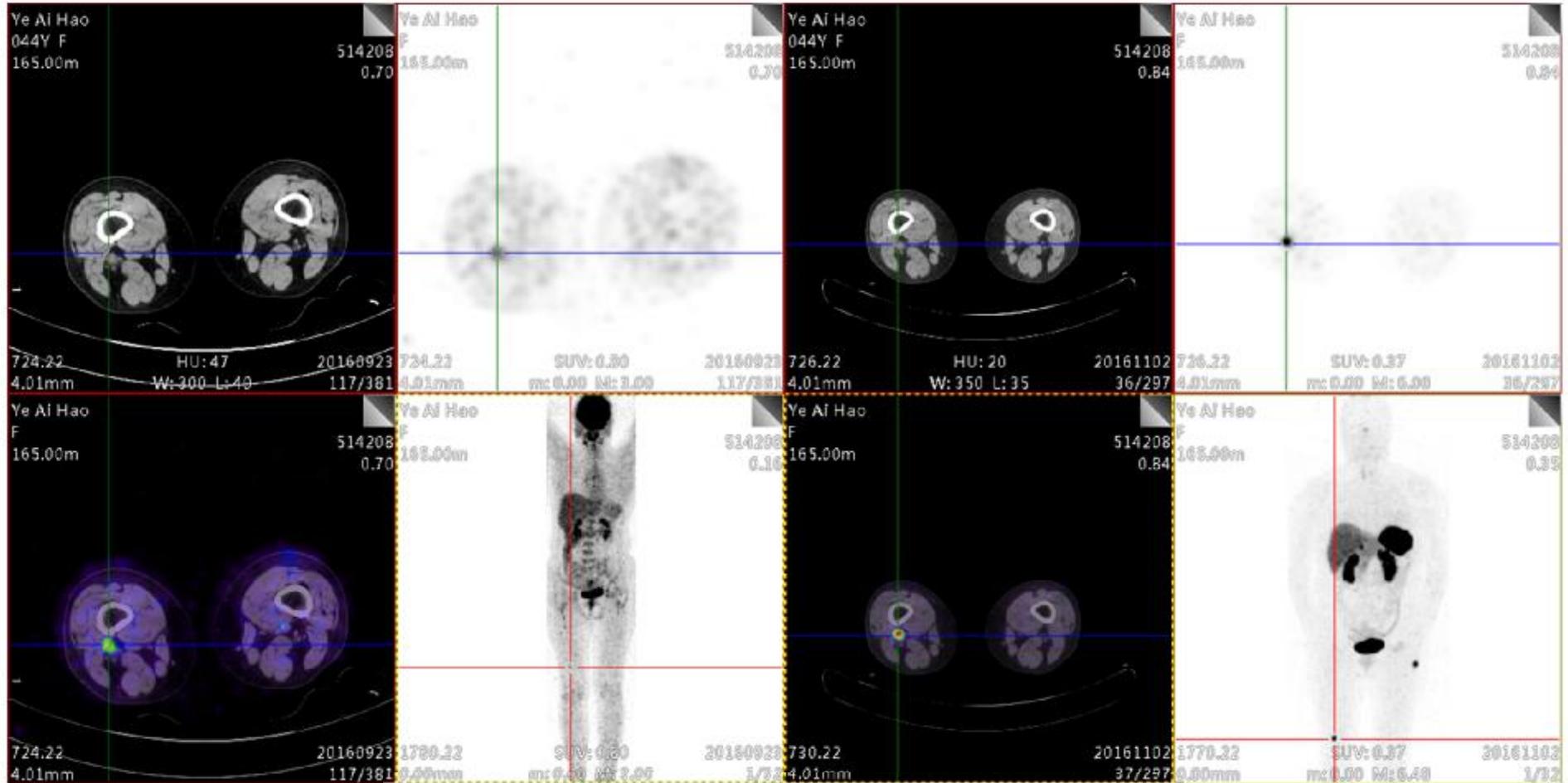
### 石蜡切片报告:

(十二指肠)送检灰红组织一块,直径约0.9cm,全埋制片。  
镜下:肿物位于粘膜下层,由巢团状分布的轻-中度异型的中等大小瘤细胞构成。  
免疫组化:瘤细胞CK (+), Syn (+), CgA (+), CD56 (+), GASTIN部分弱 (+) ?  
, MGMT (+), SSTR2 (+), VEGFR2弱 (+), Ki-67<1% (+)。  
结合HE形态及免疫组化结果,病变符合(十二指肠壁)神经内分泌瘤, G1。

# 肿瘤相关性低磷骨软化症

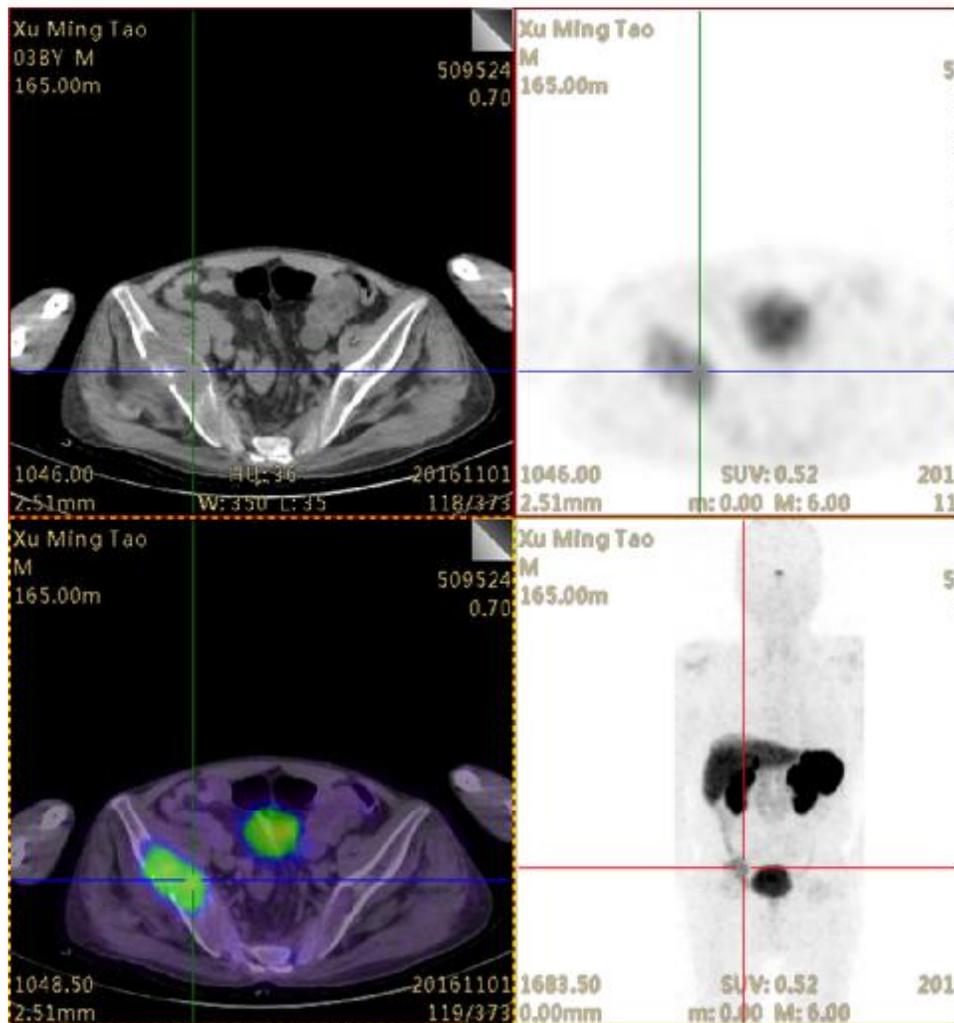
$^{18}\text{F}$ -FDG

$^{68}\text{Ga}$ -DOTA-NOC



磷酸盐尿性间叶性肿瘤

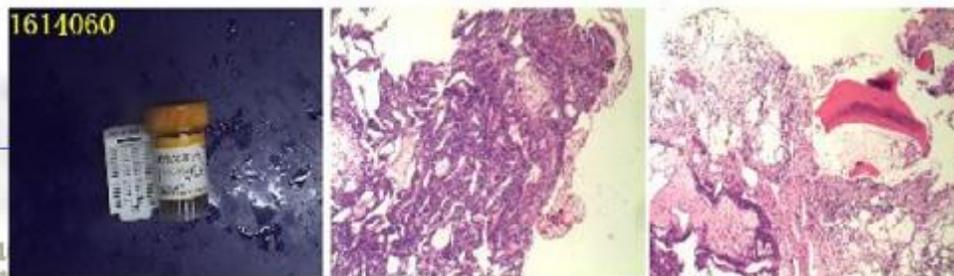
# 磷酸盐尿性间叶性肿瘤



## 病理活体组织诊断报告书

病理号: 1614060

姓名: 许名滔      性别: 男      年 38岁      住院号:  
 送检医院: 中山一院      科别: 外科      病区: 门诊  
 临床诊断: 右侧髌骨翼软组织肿瘤      送检医师: 王      送检日期: 2016-11-18



### 病理诊断:

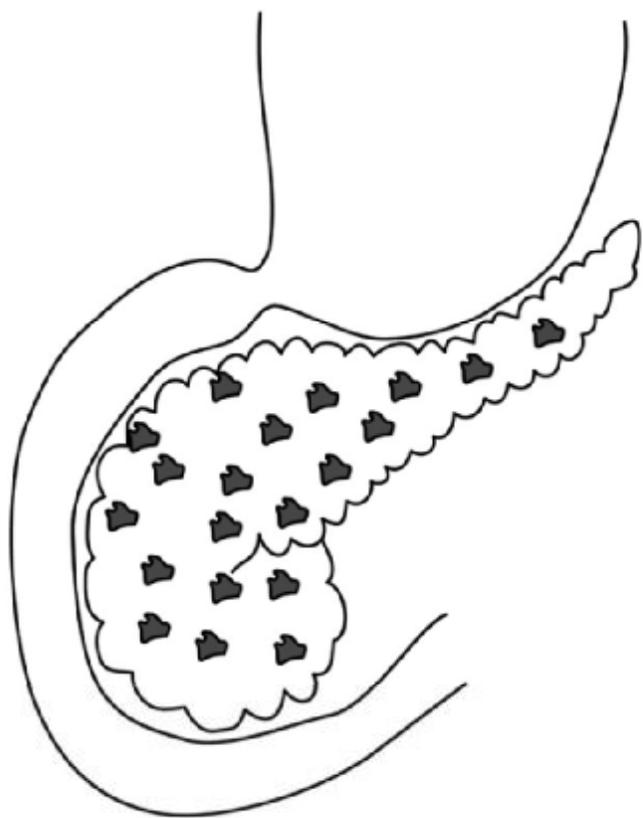
(右侧髌骨) 送检直径1.3cm灰红碎组织一堆, 全埋制片。  
 镜下: 送检碎骨组织内可见肿瘤细胞呈圆形或卵圆形, 其间见较多扩张的血管腔, 瘤细胞似围绕血管生长, 具轻度不典型性, 核分裂像不易见, 建议来我科做免疫组化(共16项)以协助进一步分析。

2016年12月2日,  
 免疫组化: 肿瘤细胞Vimentin (+), CD56 (+), H-caldesmon (+), Syn灶性弱 (+); CK、Actin、Desmin、CgA、S-100、CD34、CD31、Calponin、P63、Somatostatin、calcitonin均(-), Ki-67约2% (+)。  
 结合形态、免疫组化结果及临床表现, 病变倾向(右侧髌骨)磷酸盐尿性间叶性肿瘤, 请结合临床及影像学综合判断。

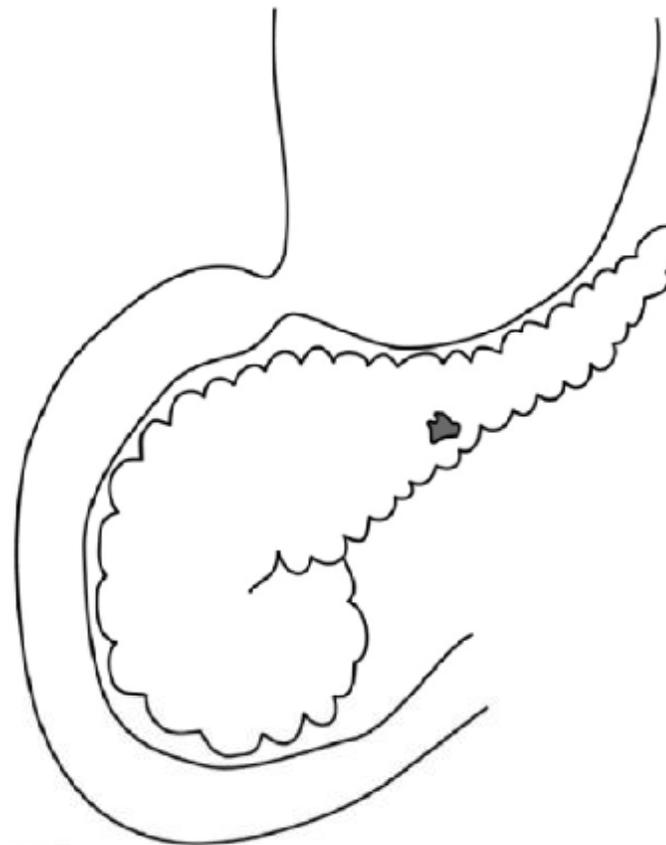


# 先天性高胰岛素血症

- 弥漫性病变：胰腺需要切掉**95%**以上，但孩子长大后，会患上糖尿病
- 局灶性病变：切除病变，能完全治愈

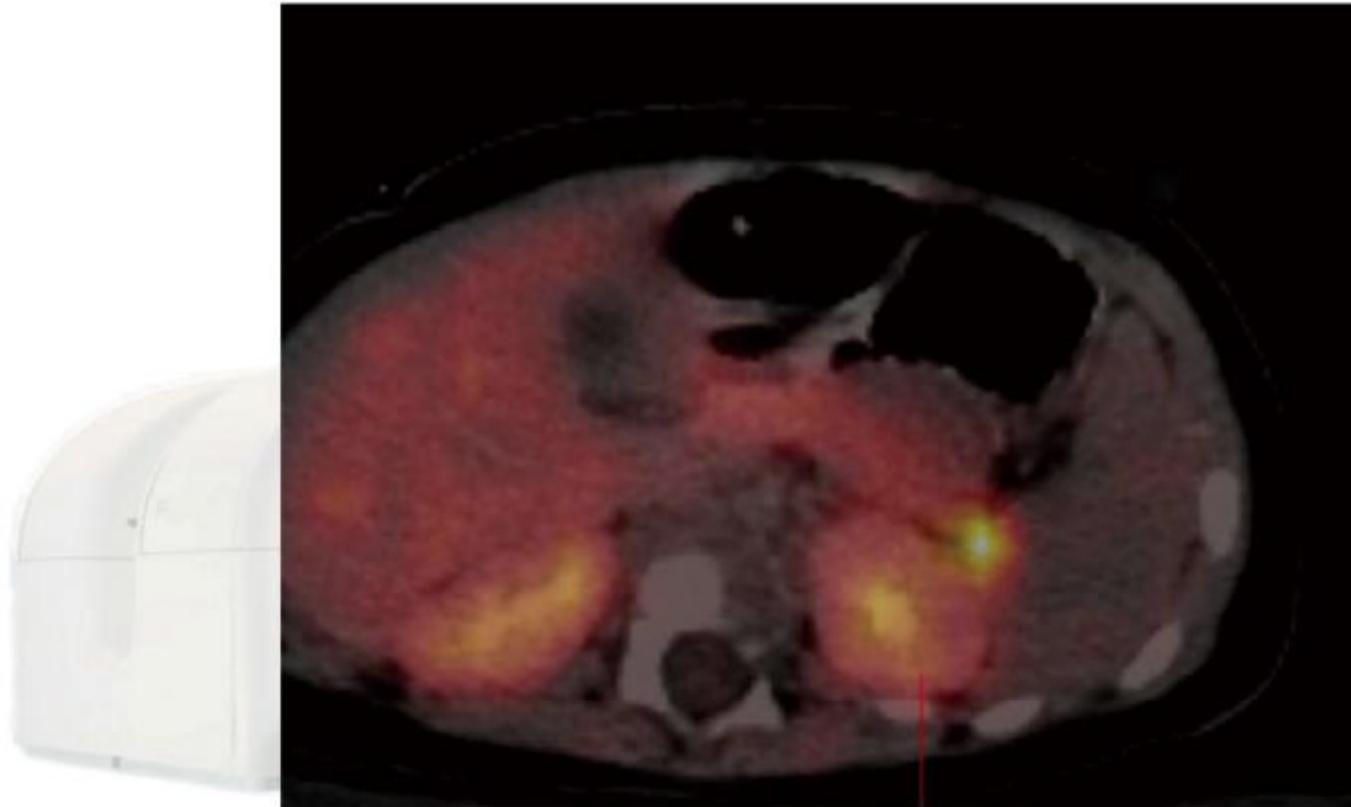


**Diffuse**



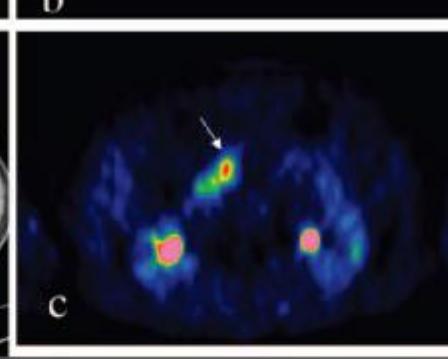
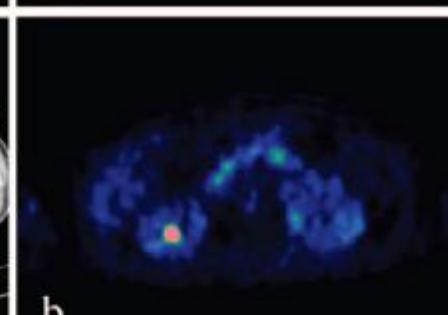
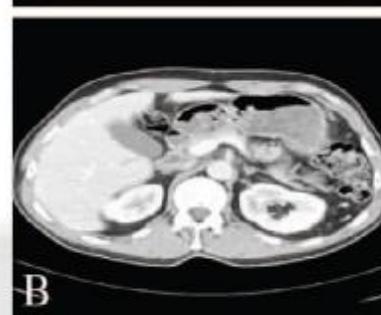
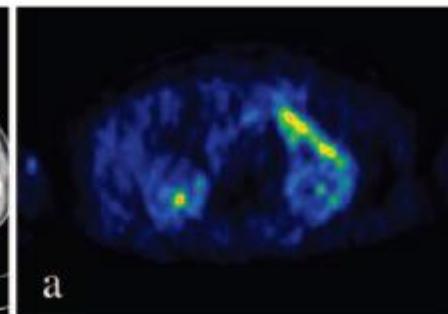
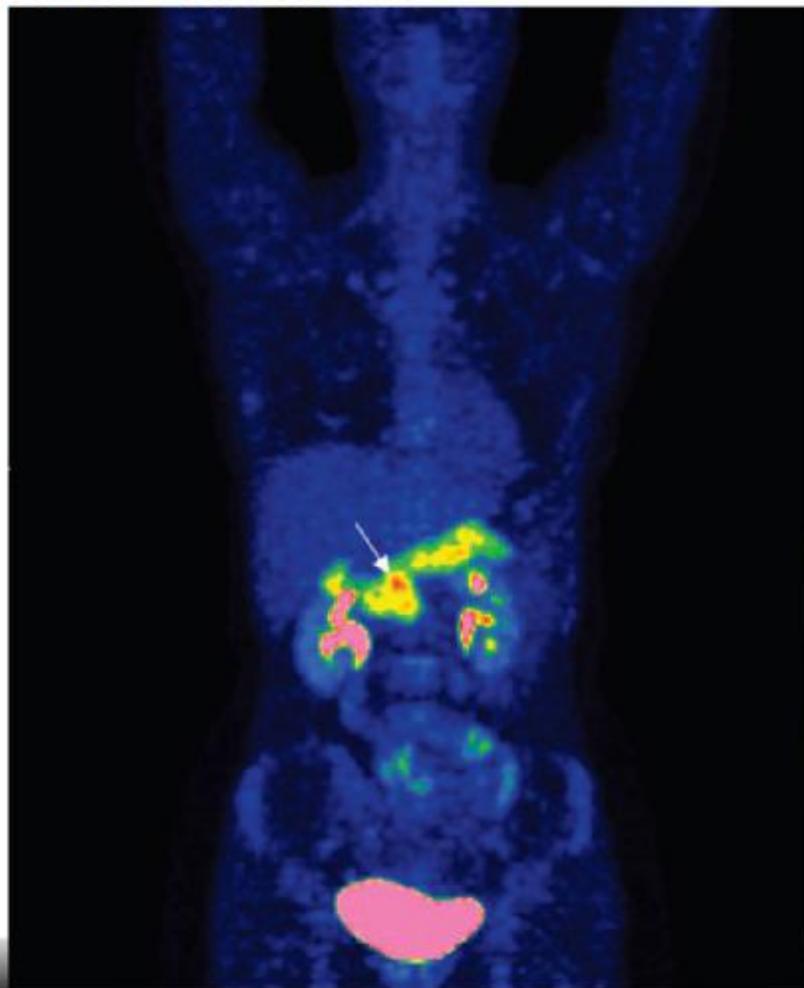
**Focal**

## **Congenital hyperinsulinism: Role of fluorine-18L-3, 4 hydroxyphenylalanine positron emission tomography scanning**

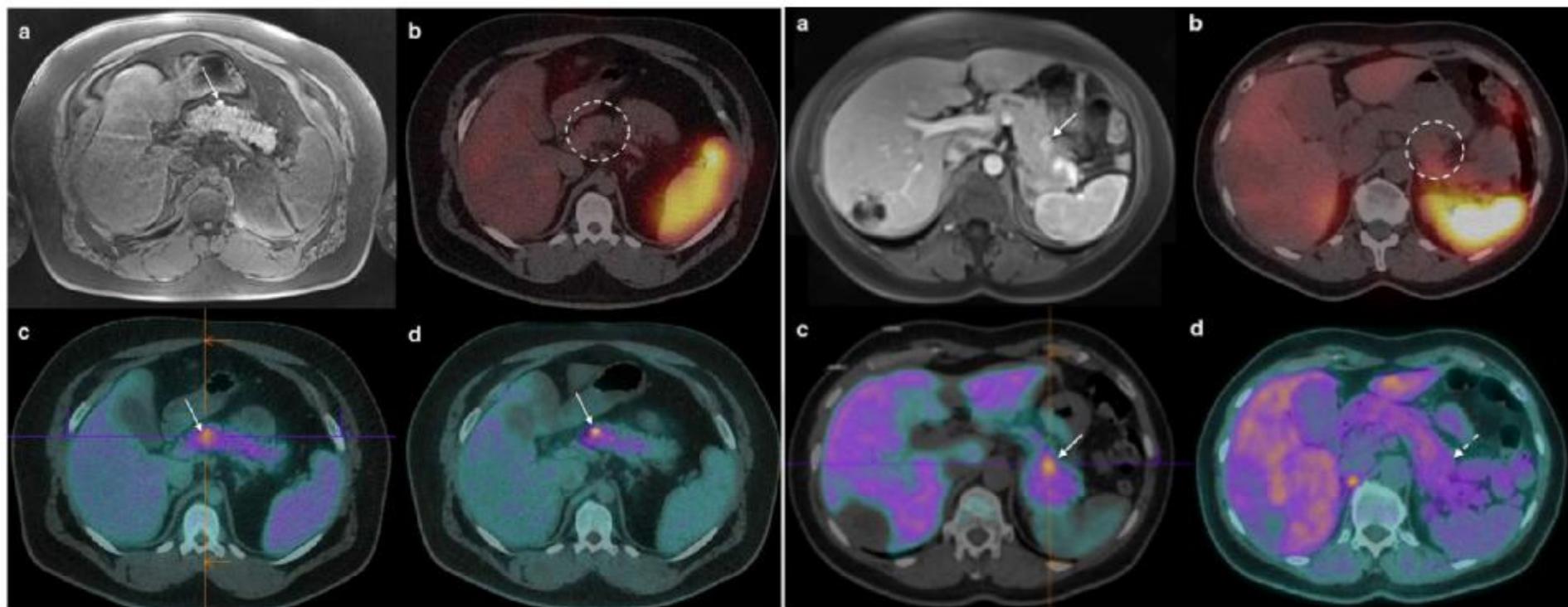


- **Distinguish between the focal and diffuse forms of CHI;**
- **Enable accurate localization of the focal lesion**

## Fluorine-18-L-Dihydroxyphenylalanine ( $^{18}\text{F}$ -DOPA) Positron Emission Tomography as a Tool to Localize an Insulinoma or $\beta$ -Cell Hyperplasia in Adult Patients

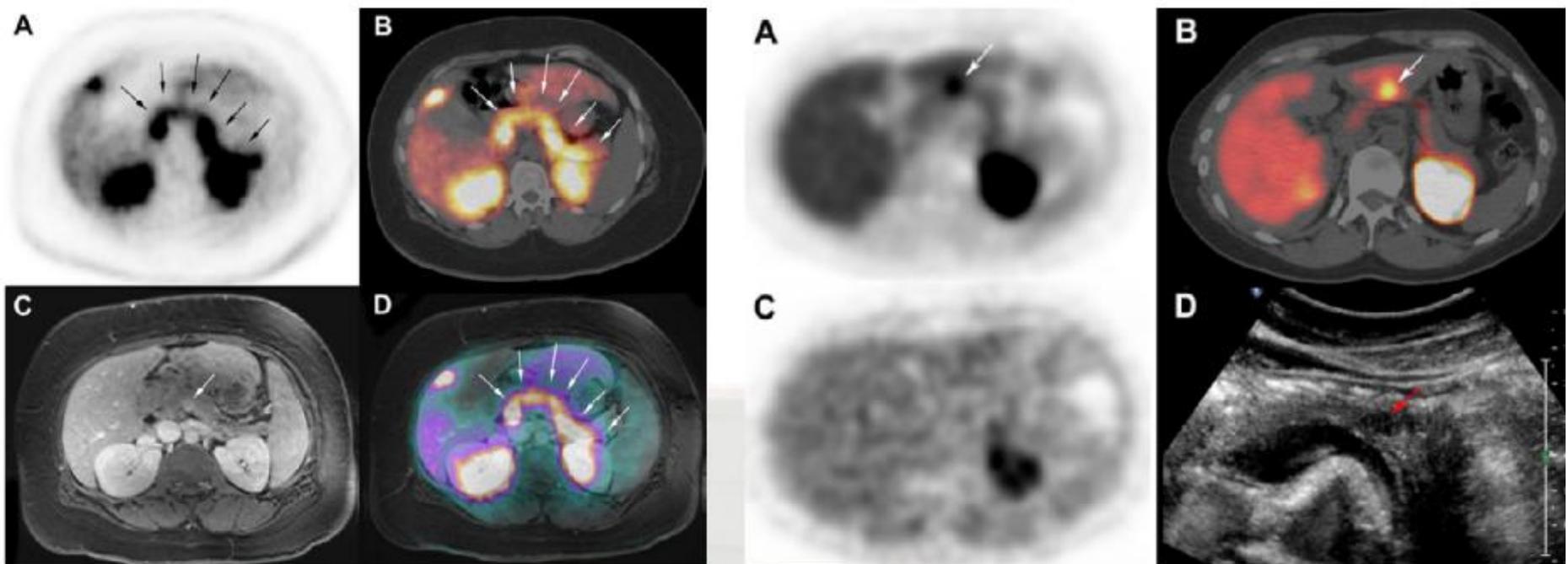


## Carbidopa-assisted $^{18}\text{F}$ -fluorodihydroxyphenylalanine PET/CT for the localization and staging of non-functioning neuroendocrine pancreatic tumors



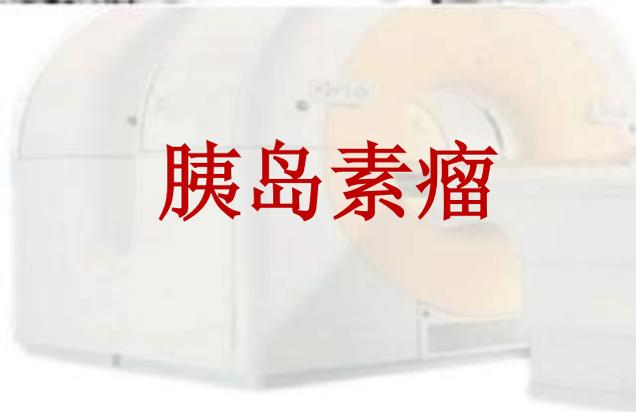
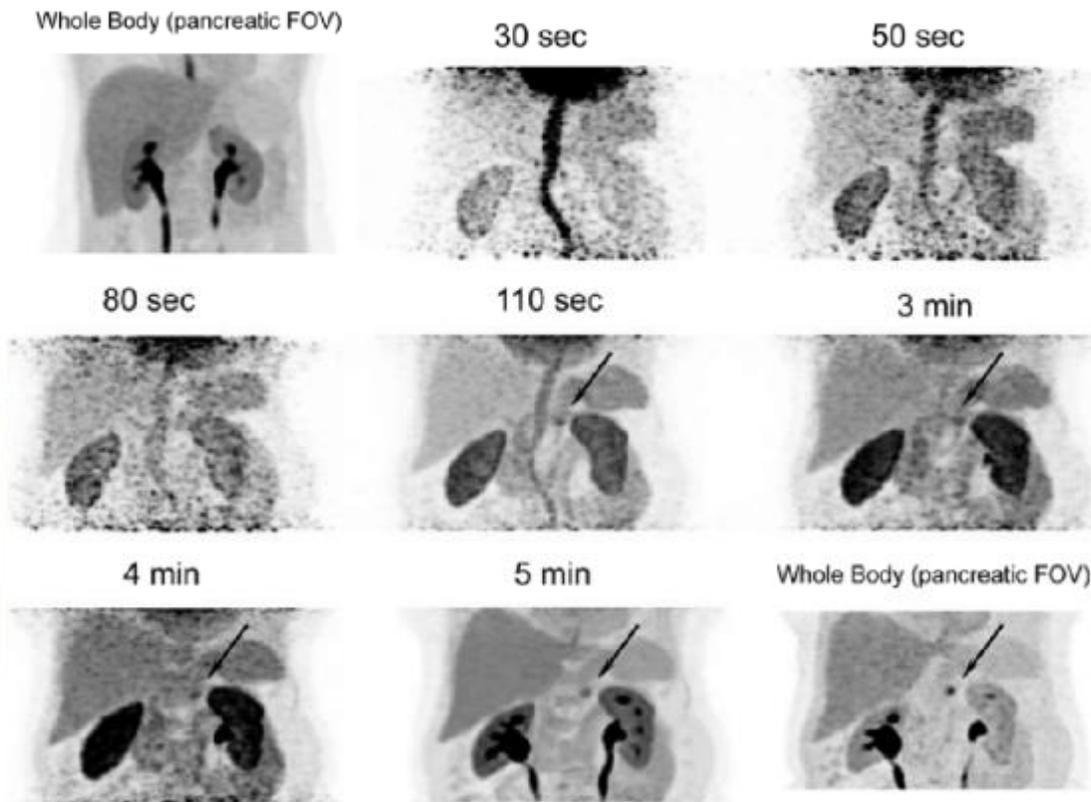
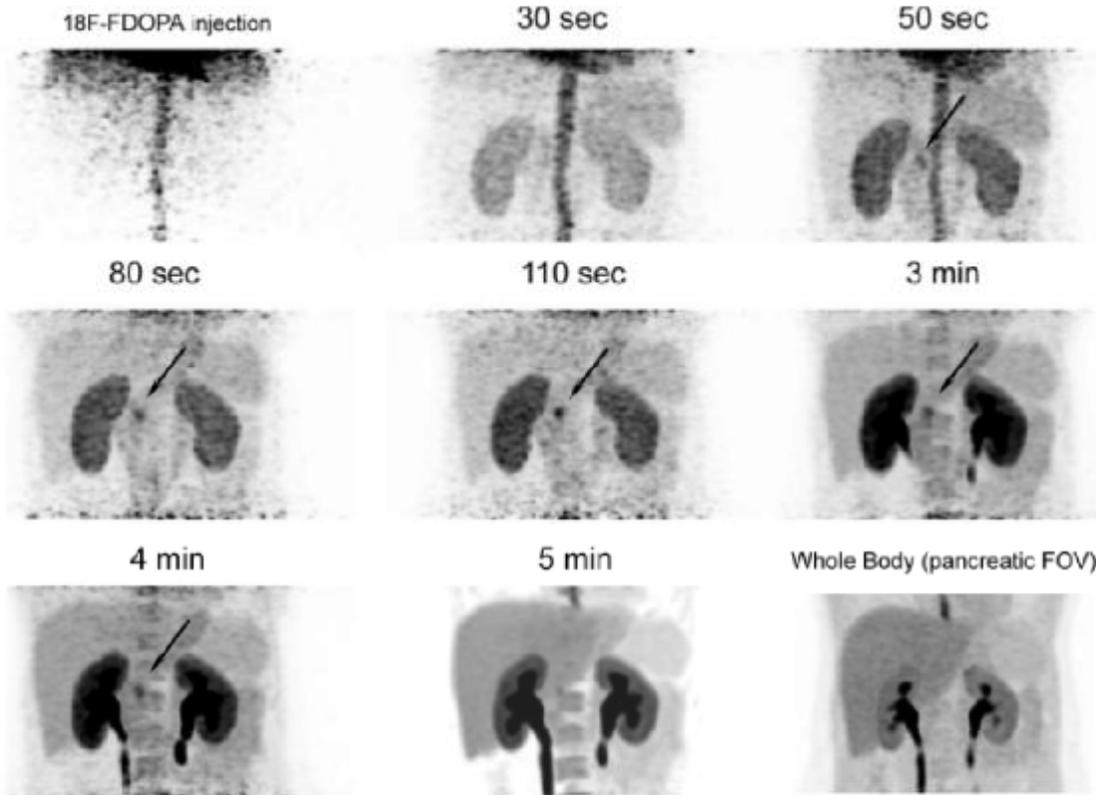
灵敏度：90%（卡比多巴辅助 $^{18}\text{F}$ -DOPA），68%（生长抑素受体显像）

## $^{18}\text{F}$ -FDOPA PET/CT imaging of insulinoma revisited



恩他卡朋片（珂丹）：特异性外周儿茶酚胺-O-甲基转移酶抑制剂

# 胰岛素瘤

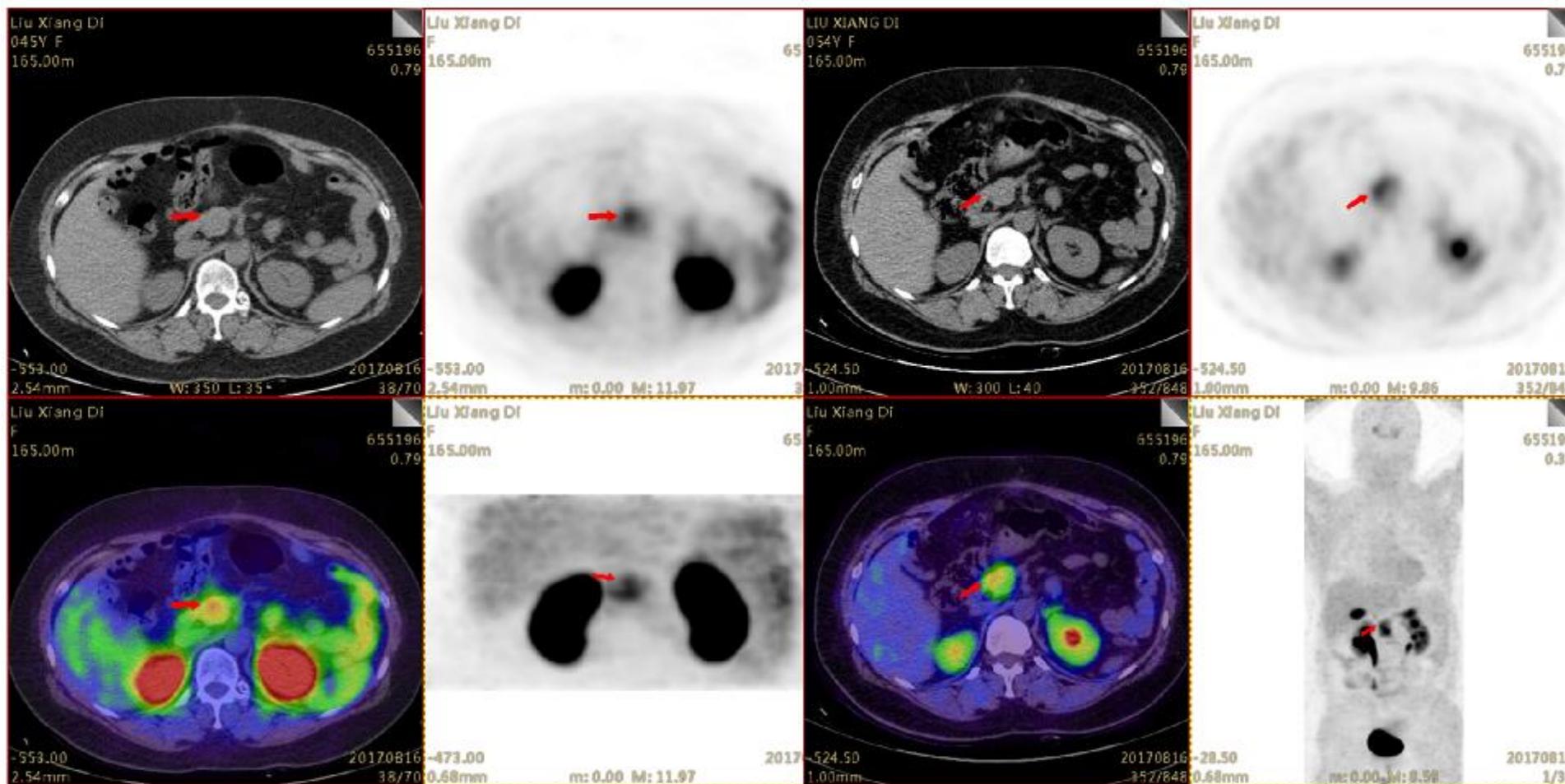


## PET动态扫描技术

# 胰岛素瘤术后复发，服用珂丹后 1h注射<sup>18</sup>F-DOPA

0~3分钟早期相

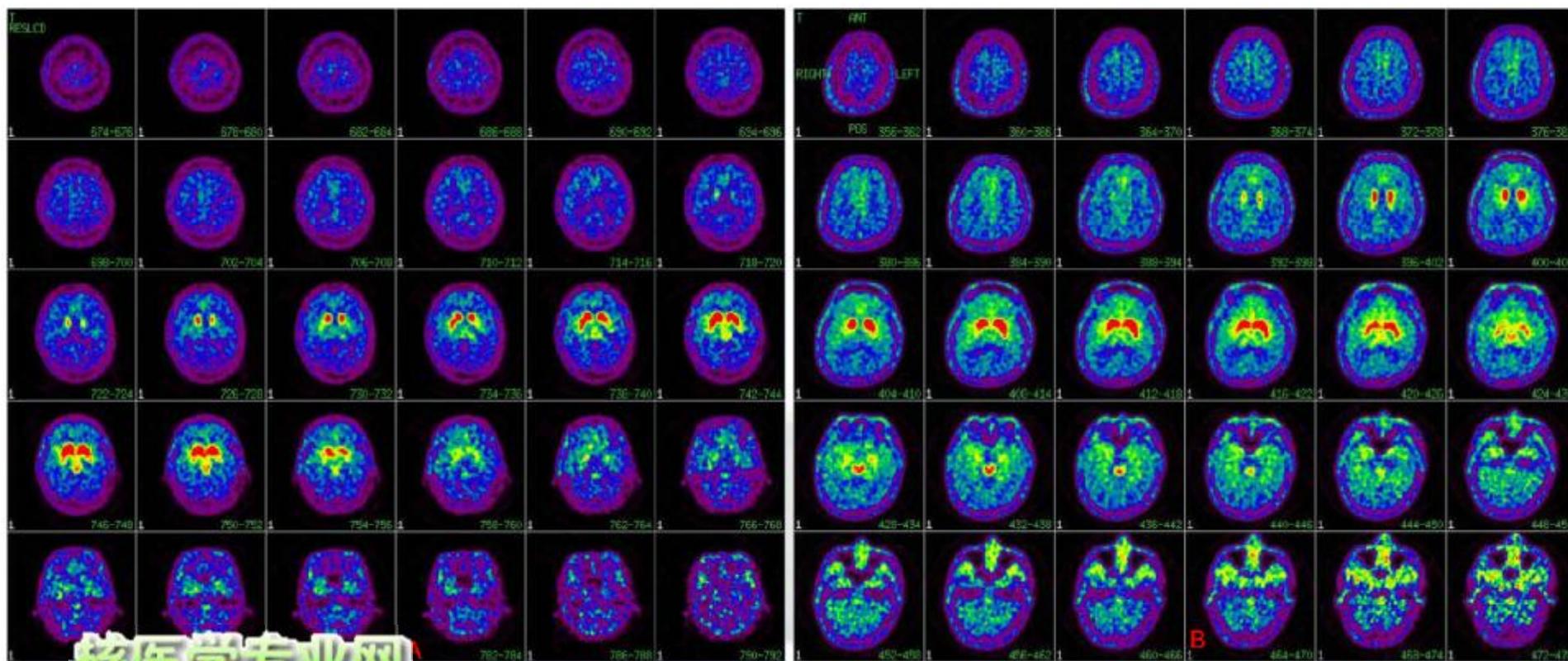
45分钟后延迟相



# PD患者<sup>18</sup>F-DOPA显像服用珂丹效果对比

显像前1h服用珂丹

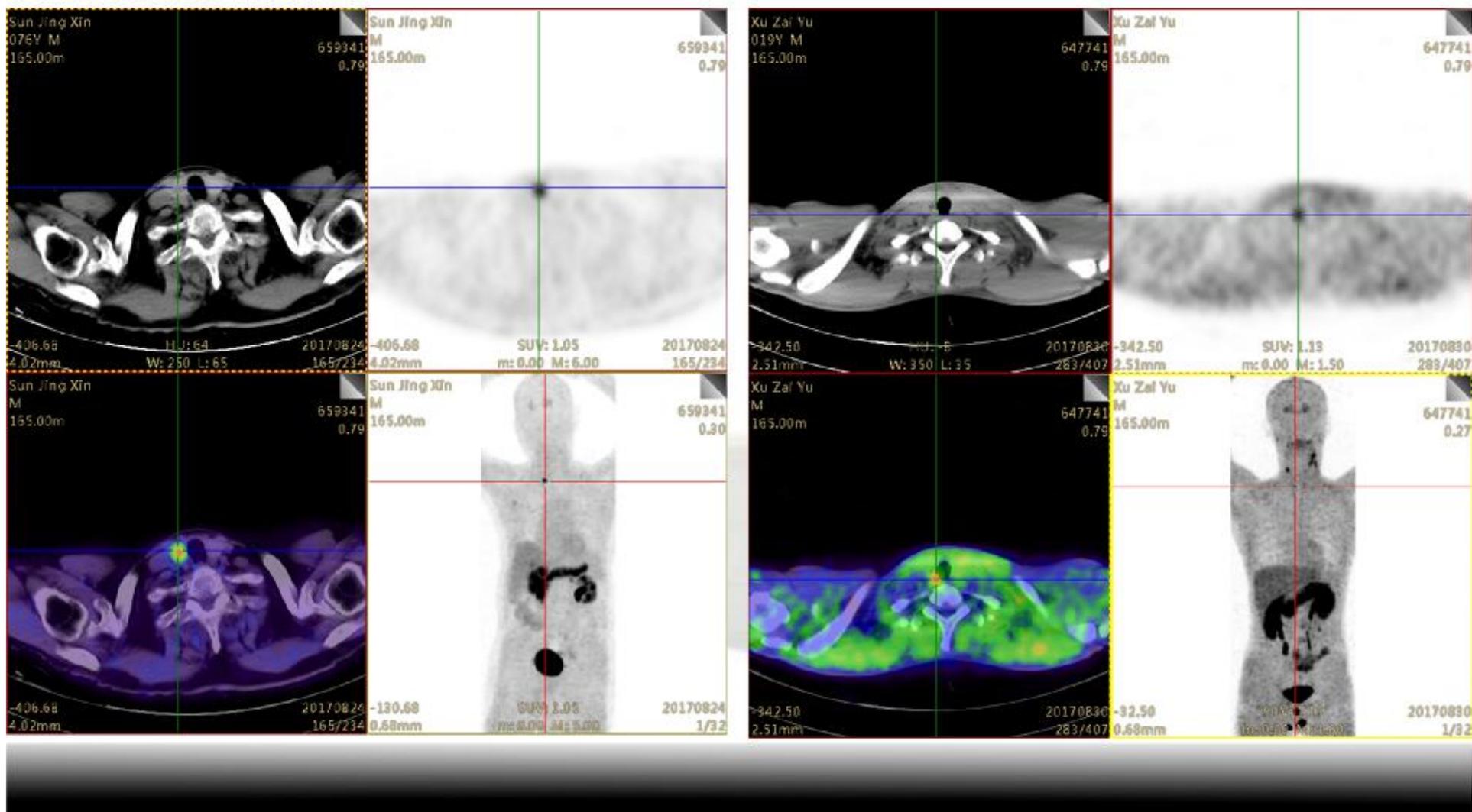
显像前未服用珂丹



# 甲状腺髓样癌18F-DOPA显像

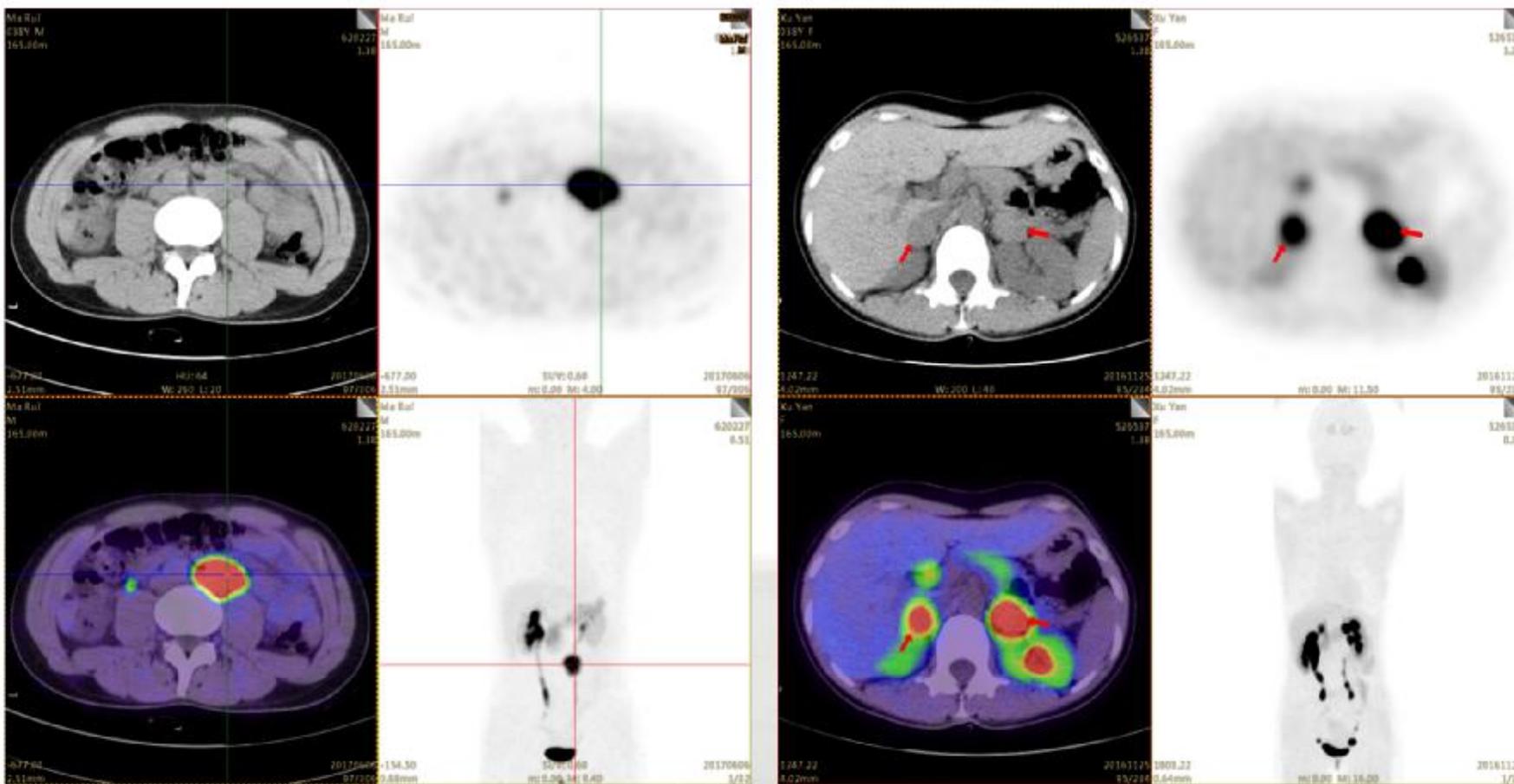
## 术前分期

## 术后残留



# 嗜铬细胞瘤

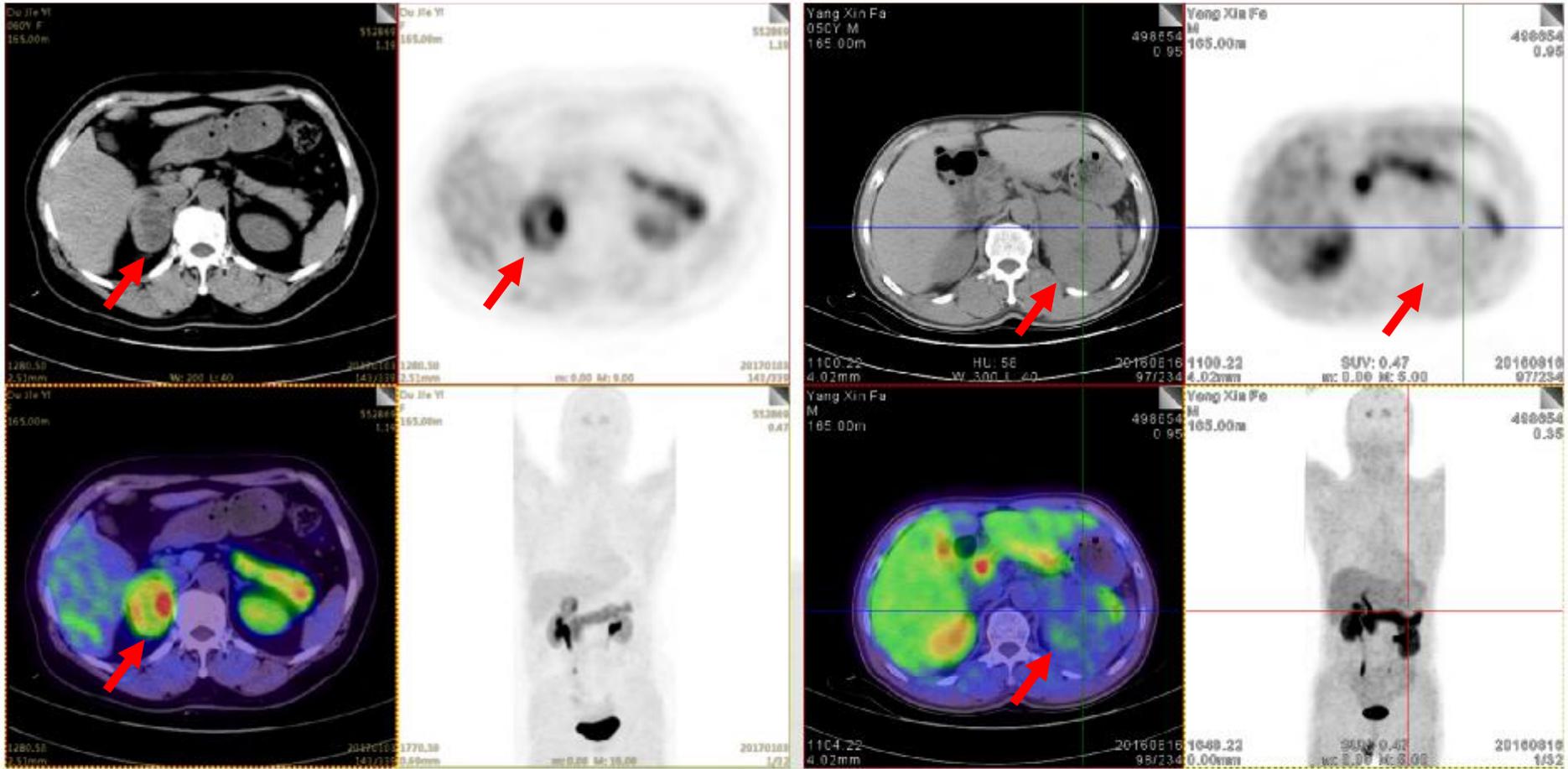
## $^{18}\text{F}$ -DOPA



肾上腺外

双侧肾上腺

# $^{18}\text{F}$ -DOPA



嗜铬细胞瘤

肾上腺皮质癌

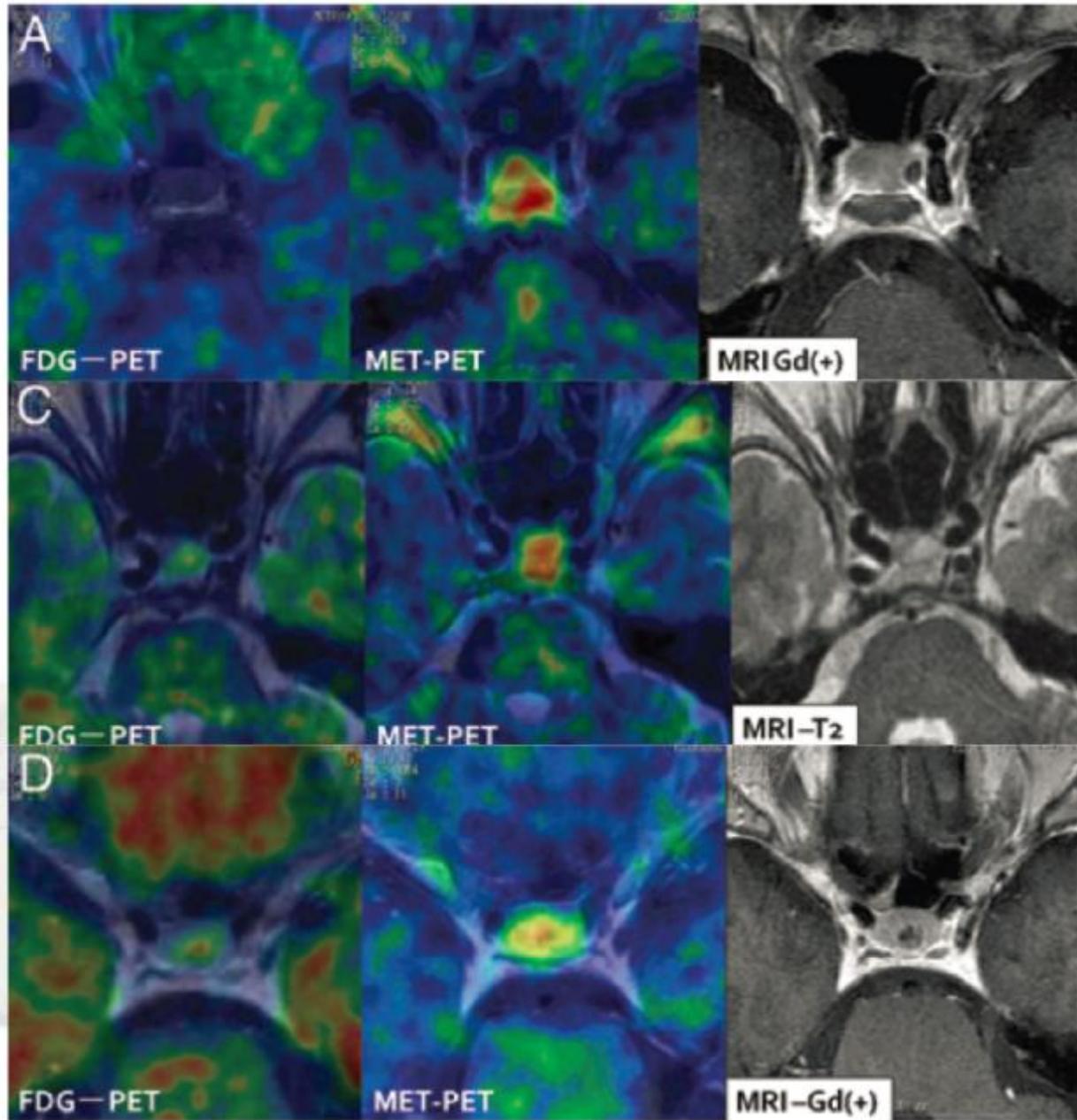
Usefulness of composite methionine–positron emission tomography/3.0-tesla magnetic resonance imaging to detect the localization and extent of early-stage Cushing adenoma

TABLE 1: Diagnostic accuracy of 1.5- and 3.0-T MR imaging\*

Stage of Disease	No. of Patients (%)	
	1.5 T	3.0 T
preclinical CD	2/5 (40)	1/7 (14)
overt CD	6/9 (67)	3/9 (33)
total accuracy	8/14 (57)	4/16 (25)

\* CD = Cushing disease.

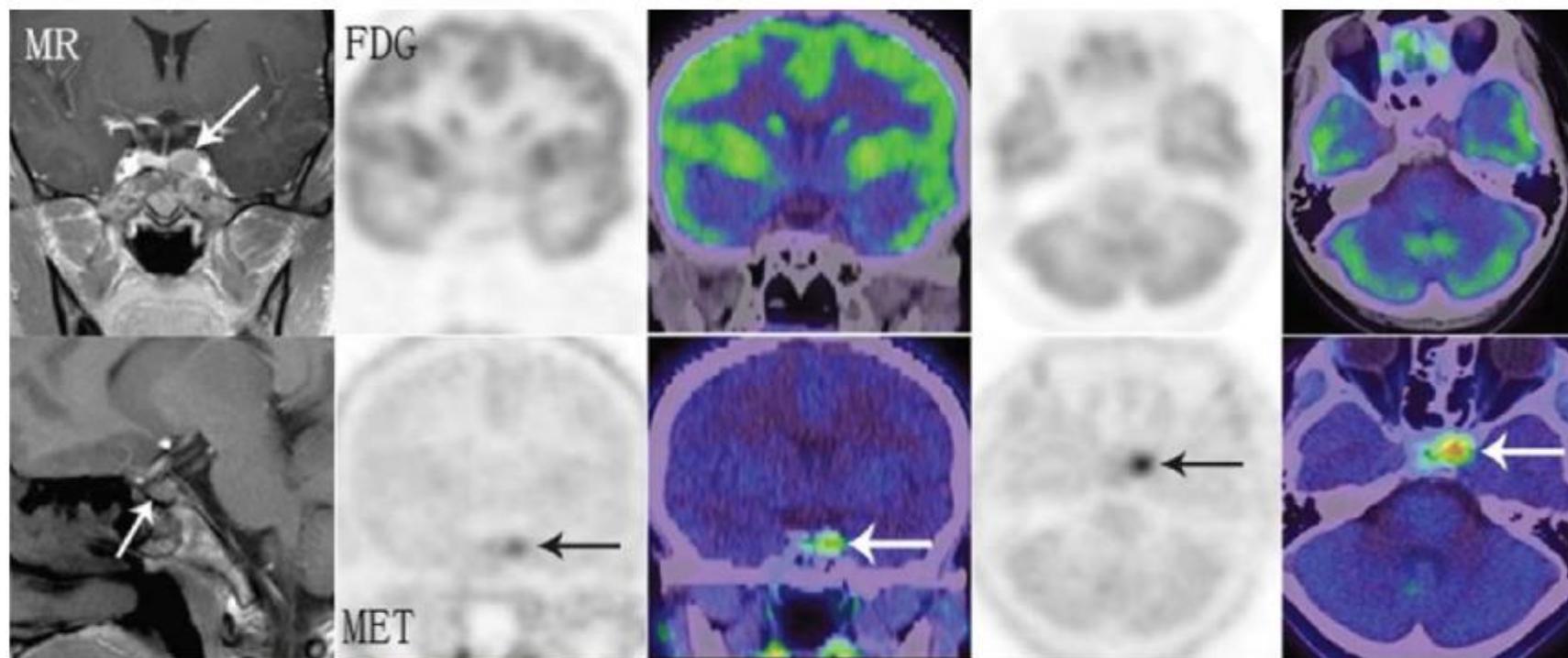
**40%以上的功能性垂体微腺瘤MRI检查为阴性结果**



**PET/MR准确性：<sup>11</sup>C-蛋氨酸为100%，<sup>18</sup>F-FDG为73%**

# Utility of $^{11}\text{C}$ -Methionine and $^{18}\text{F}$ -FDG PET/CT in Patients With Functioning Pituitary Adenomas

Zize Feng, MD,\* Dongsheng He, MD,\* Zhigang Mao, MD,\* Zongming Wang, MD,\*  
Yonghong Zhu, PhD,† Xiangsong Zhang, MD,‡ and Haijun Wang, MD, PhD\*

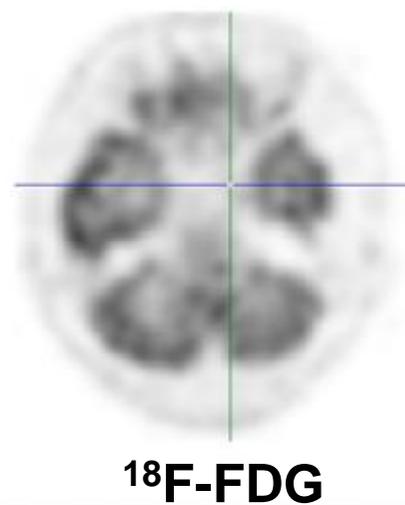
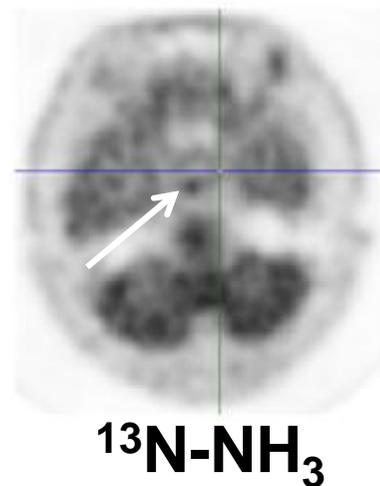
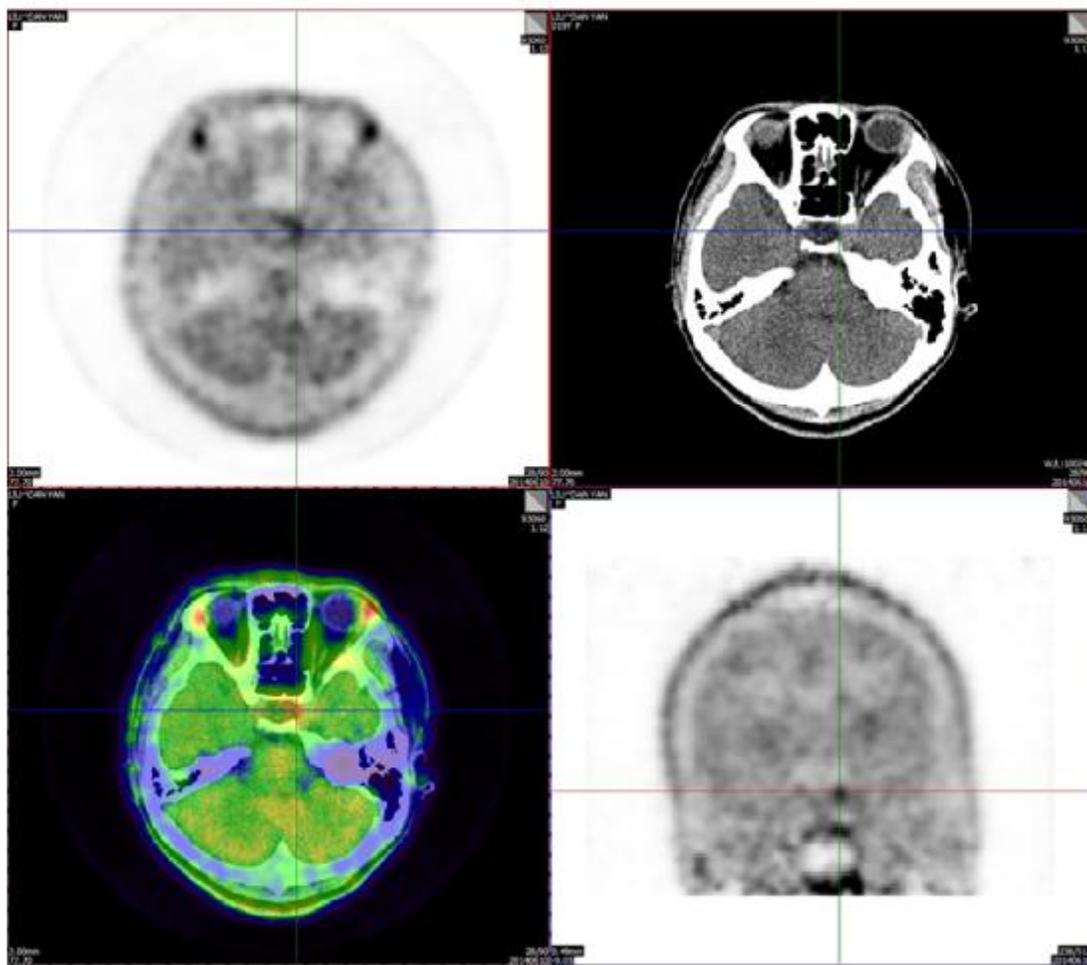


Correlation Factors	History of Treatment			Size of Adenoma		Type of Adenoma		
	GK	Med	Surg	Micro	Macro	PRL	GH	ACTH
Positive rate of MET PET scan	1/2 (50%)	6/7 (86%)	12/12 (100%)	21/21 (100%)	16/18 (89%)	10/10 (100%)	12/14 (86%)	15/15 (100%)
<i>P</i>		—		NS			NS	
Positive rate of FDG PET scan	1/2 (50%)	5/8 (63%)	4/12 (33%)	10/21 (48%)	19/22 (86%)	6/12 (50%)	13/16 (81%)	10/15 (67%)
<i>P</i>		—		0.007			NS	

GK,  $\gamma$ -knife; Med, medicine; Surg, surgery; NS, not significant.

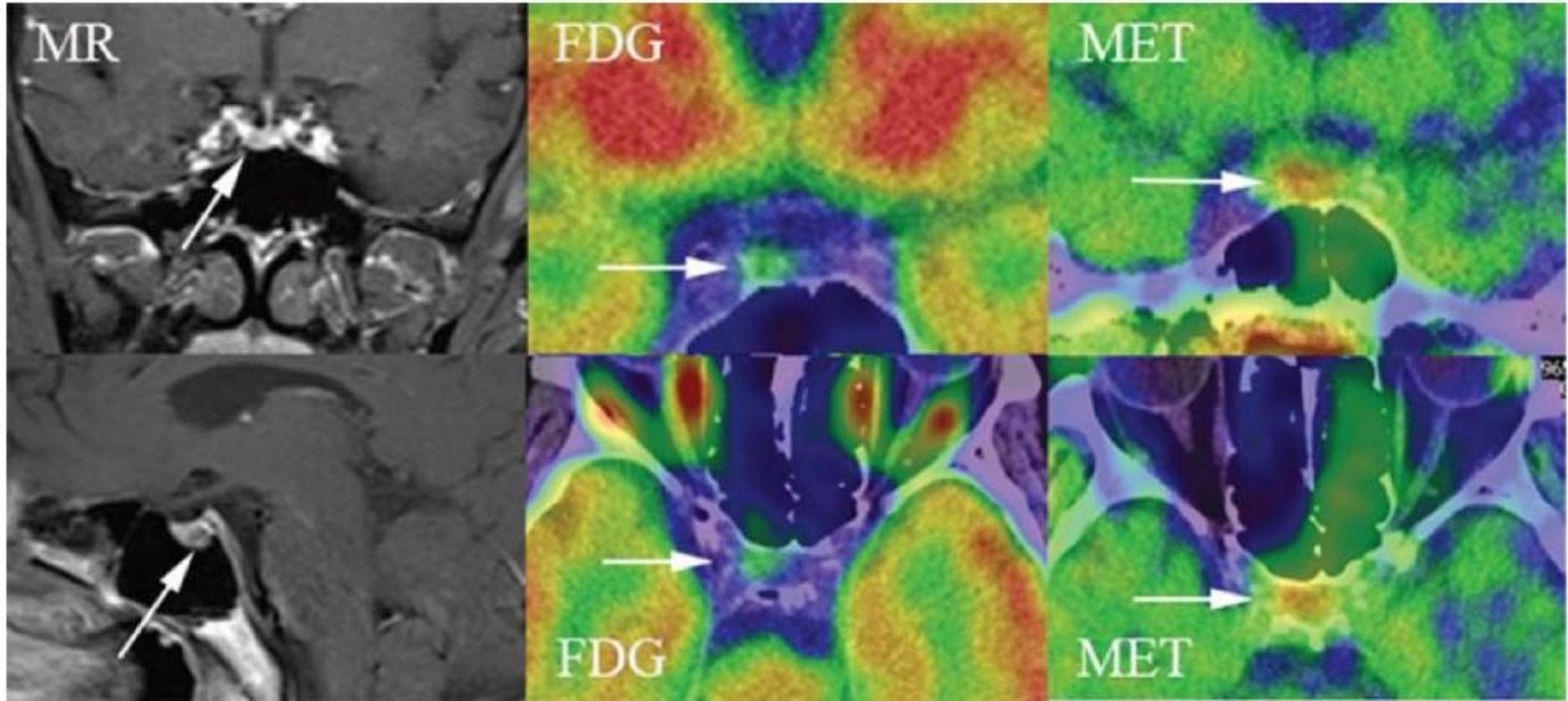
垂体瘤术后，MR检查阴性，  
PET/CT检查发现复发肿瘤，并显示残余垂体组织

刘丹燕，女，19岁



$^{11}\text{C-MET}$

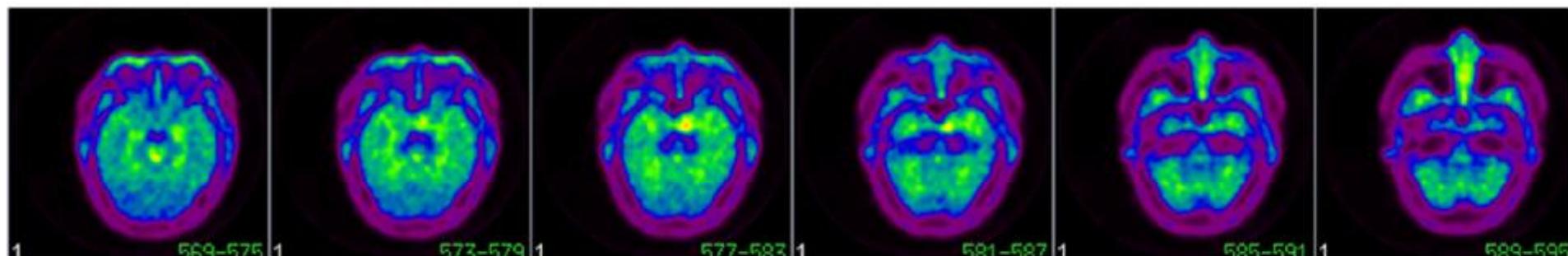
$^{18}\text{F-FDG}$



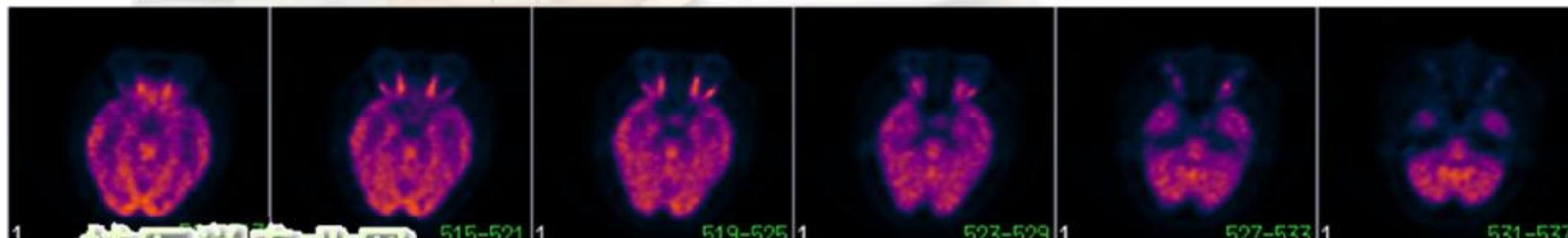
**ACTH分泌垂体微腺瘤，正常垂体摄取 $^{11}\text{C}$ -蛋氨酸影响观察**

黎惠红，女，37岁，17床

## 库欣病vs异位库欣综合征



$^{18}\text{F}$ -DOPA

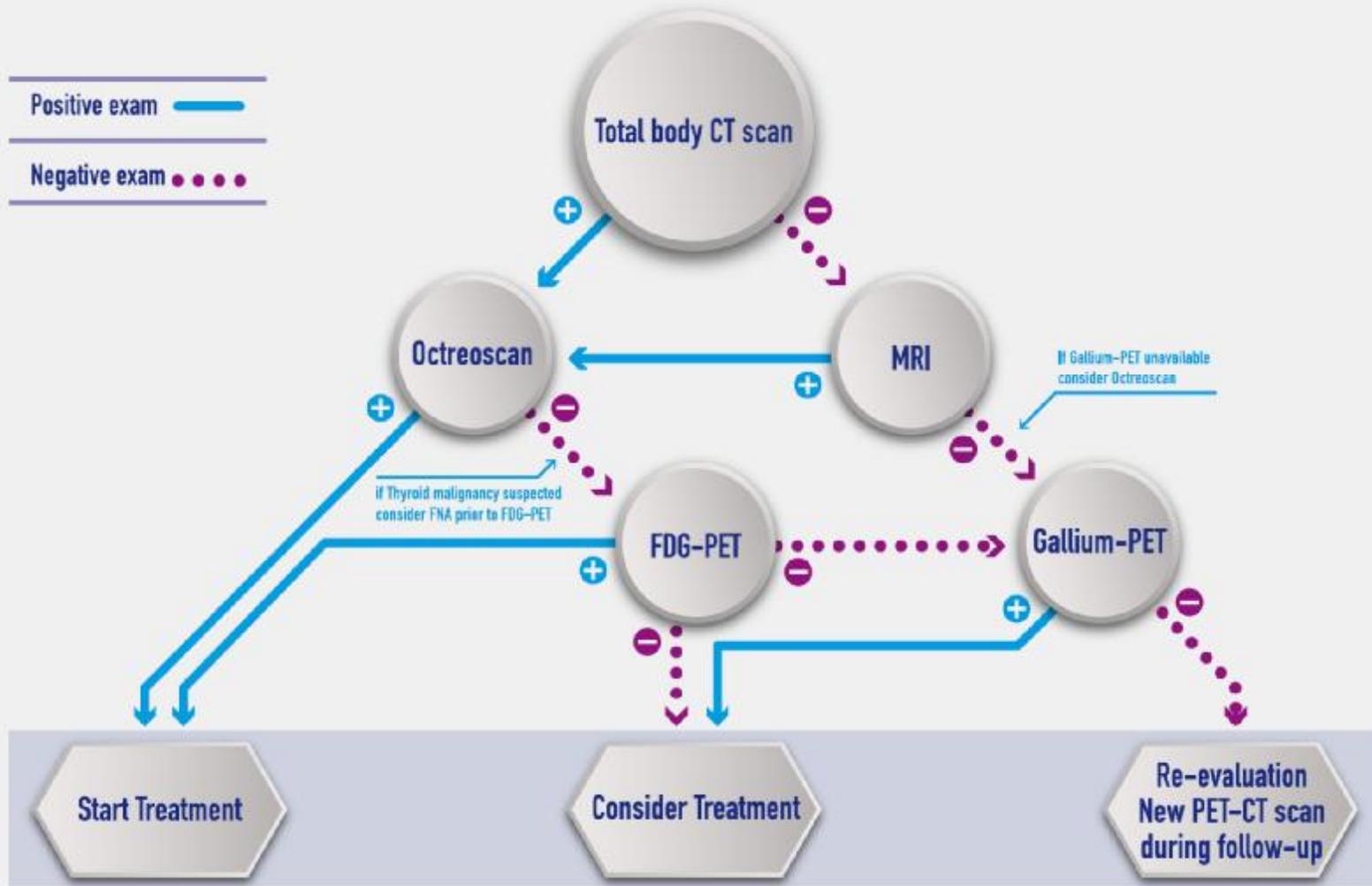


$^{18}\text{F}$ -FDG

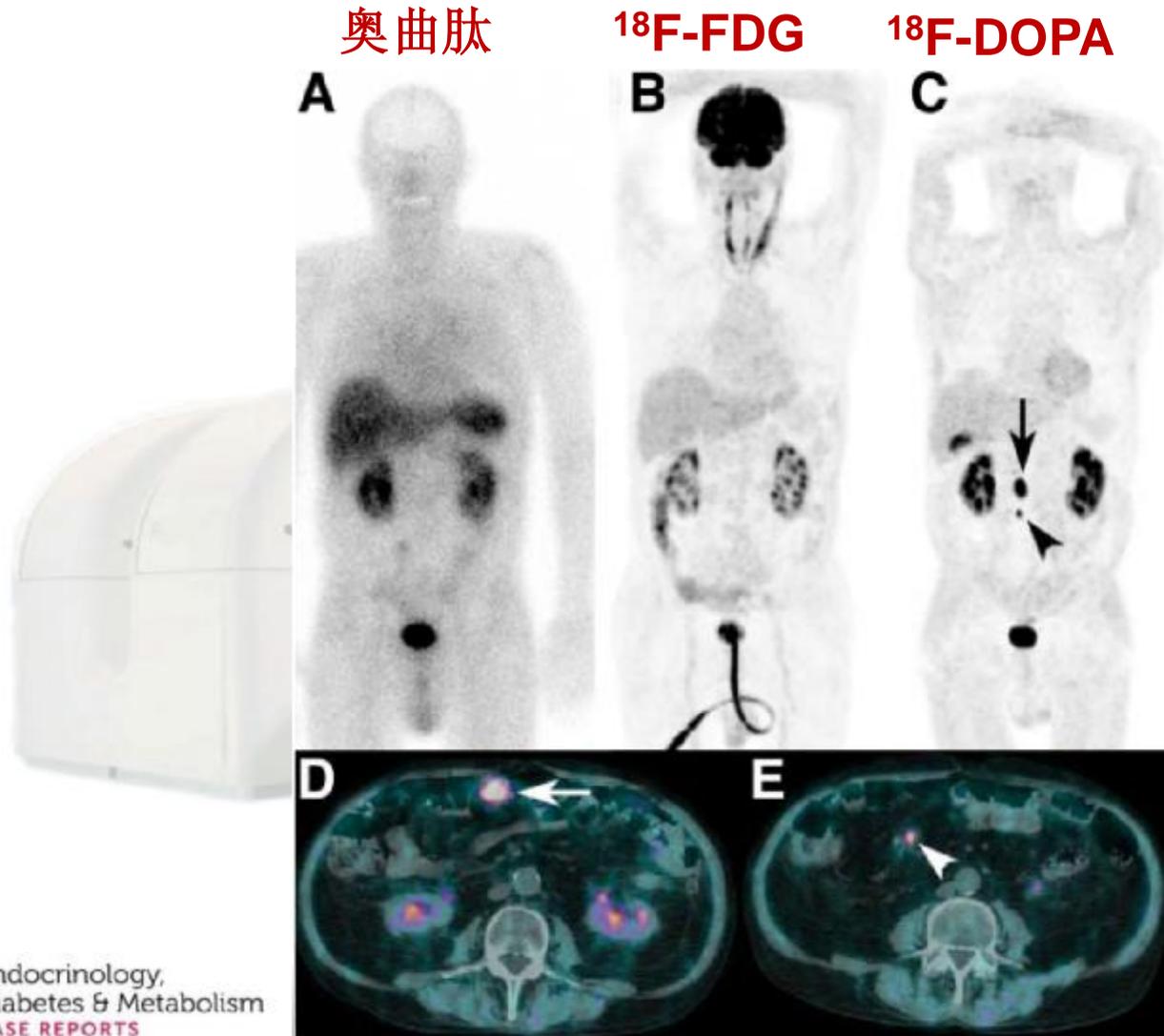
# Conventional and Nuclear Medicine Imaging in Ectopic Cushing's Syndrome: A Systematic Review

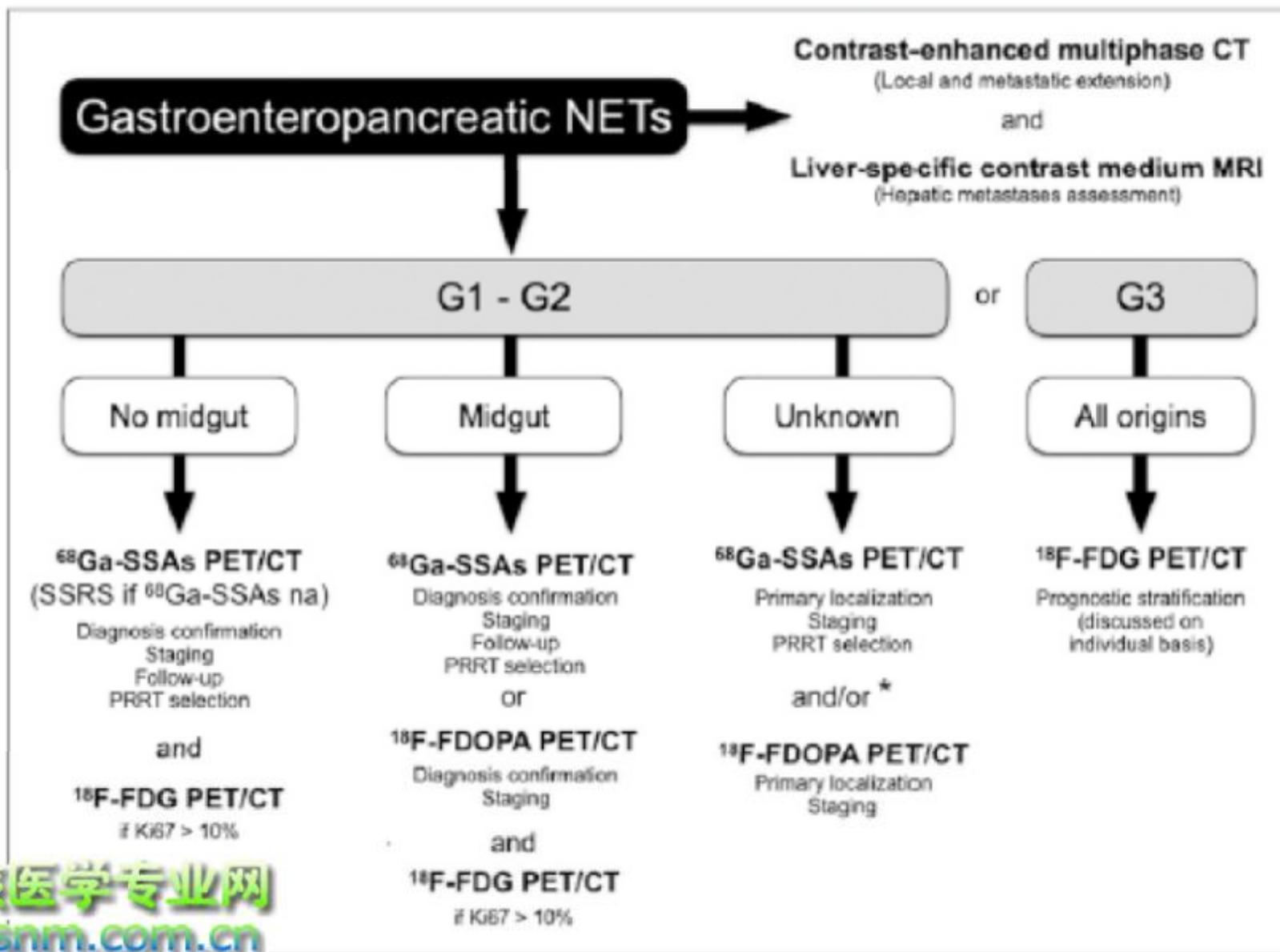
	CT	MRI	OCT	FDG-PET	F-DOPA-PET	MIBG	<sup>68</sup> Gallium-SSTR-PET/CT
<b>All patients (n = 231)</b>							
Sensitivity, % (95% CI)	66.2% (59.5–72.3)	51.5% (41.9–60.9)	48.9% (41.5–56.3)	51.7% (41.5–61.8)	57.1% (36.6–75.5)	30.8% (12.7–57.6)	81.8% (61.5–92.7)
n	137/207	53/103	84/172	46/89	12/21	4/13	18/22
True positive	63.7%	50.5%	48.3%	51.1%	54.5%	26.7%	78.3%
n	137/215	53/105	84/174	46/90	12/22	4/15	18/23
False negative	33.6%	47.6%	50.6%	47.8%	40.9%	60%	17.4%
n	70/215	50/105	88/174	43/90	9/22	9/15	4/23
False positive	3.7%	1.9%	1.1%	1.1%	4.5%	13.3%	4.3%
n	8/215	2/105	2/174	1/90	1/22	2/15	1/23
<b>Histologically confirmed (n = 188)</b>							
Sensitivity, % (95% CI)	81.1% (74.5–86.3)	73.4% (61.9–82.2)	62.9% (54.6–70.7)	65.7% (54–75.8)	65.0% (43.3–81.9)	40% (16.8–68.7)	81.8% (61.5–92.7)
n	137/169	52/71	85/135	46/70	13/20	4/10	18/22
True positive	77.4%	71.2%	62.0%	64.8%	61.9%	33.3%	78.3%
n	137/177	52/73	85/137	46/71	13/21	4/12	18/23
False negative	18.1%	26%	36.5%	33.8%	33.3%	50%	17.4%
n	32/177	19/73	50/137	24/71	7/21	6/12	4/23
False positive	4.5%	2.7%	1.5%	1.4%	4.8%	16.7%	4.3%
n	8/177	2/73	2/137	1/71	1/21	2/12	1/23
<b>Overt (n = 121)</b>							
Sensitivity % (95% CI)	98.3% (93.9–99.5)	92.9% (81.0–97.5)	63.5% (52.9–72.9)	71.1% (55.2–83)	53.9% (29.1–76.8)	37.5% (13.7–69.4)	70% (39.7–89.2)
n	113/115	39/42	54/85	27/38	7/13	3/8	9/13
True positive	97.4%	92.9%	62.1%	71.1%	50.0%	30%	69.2%
n	113/116	39/42	54/87	27/38	7/14	3/10	9/13
False negative	1.7%	7.1%	35.6%	28.9%	42.9%	50%	30.8%
n	2/116	3/42	31/87	11/38	6/14	5/10	4/13
False positive	0.9%		2.3%		7.1%	20%	
n	1/116		2/87		1/14	2/10	
<b>Covert (n = 67)</b>							
Sensitivity, % (95% CI)	43.6% (31.4–56.7)	44.8% (28.4–62.4)	64.0% (50.1–75.9)	59.4% (42.3–74.5)	85.7% (48.7–97.4)	50% (9.5–90.6)	100% (61–100)
n	24/55	13/29	32/50	19/32	6/7	1/2	9/9
True positive	39.3%	41.9%	64.0%	57.6%	85.7%	50%	90.0%
n	24/61	13/31	32/50	19/33	6/7	1/2	9/10
False negative	50.8%	51.6%	36.0%	39.4%	14.3	50%	
n	31/61	16/31	18/50	13/33	1/7	1/2	
False positive	9.8%	6.5%		3.0%			10.0%
n	6/61	2/31		1/33			1/10

### Clinical Suspicion of Ectopic Cushing's Syndrome



# Mid-gut ACTH-secreting neuroendocrine tumor unmasked with $^{18}\text{F}$ -dihydroxyphenylalanine-positron emission tomography





## 库欣综合征PET/CT显像

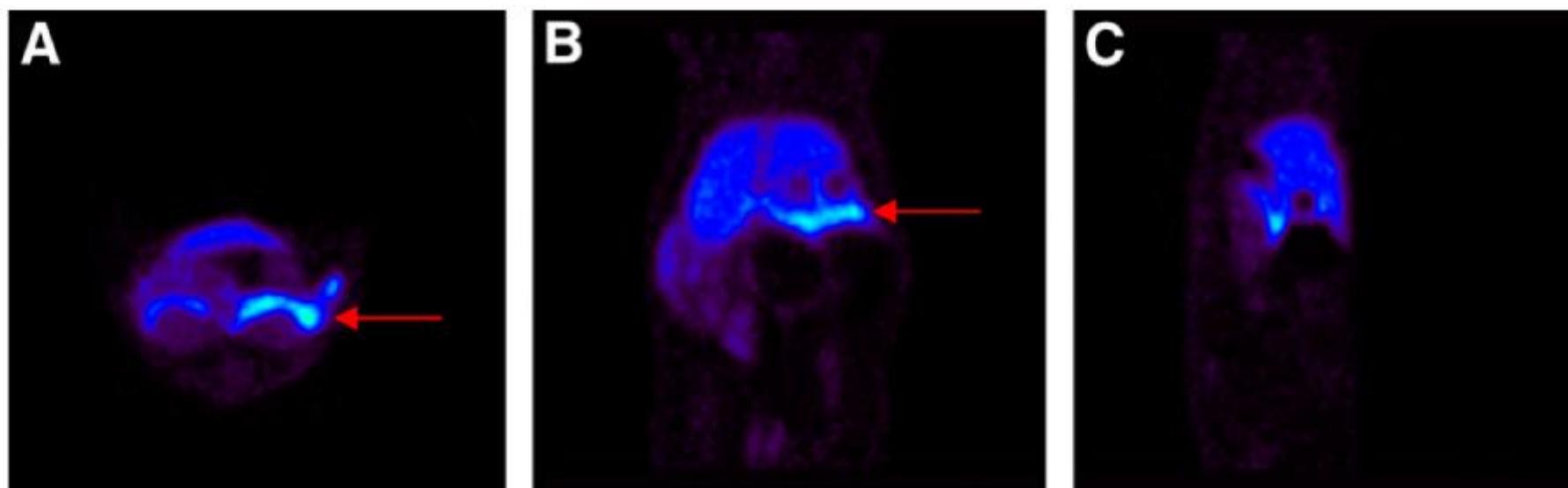
- $^{68}\text{Ga}$ -生长抑素
- $^{18}\text{F}$ -DOPA
- $^{18}\text{F}$ -FDG

下丘脑---垂体---异位

---

---

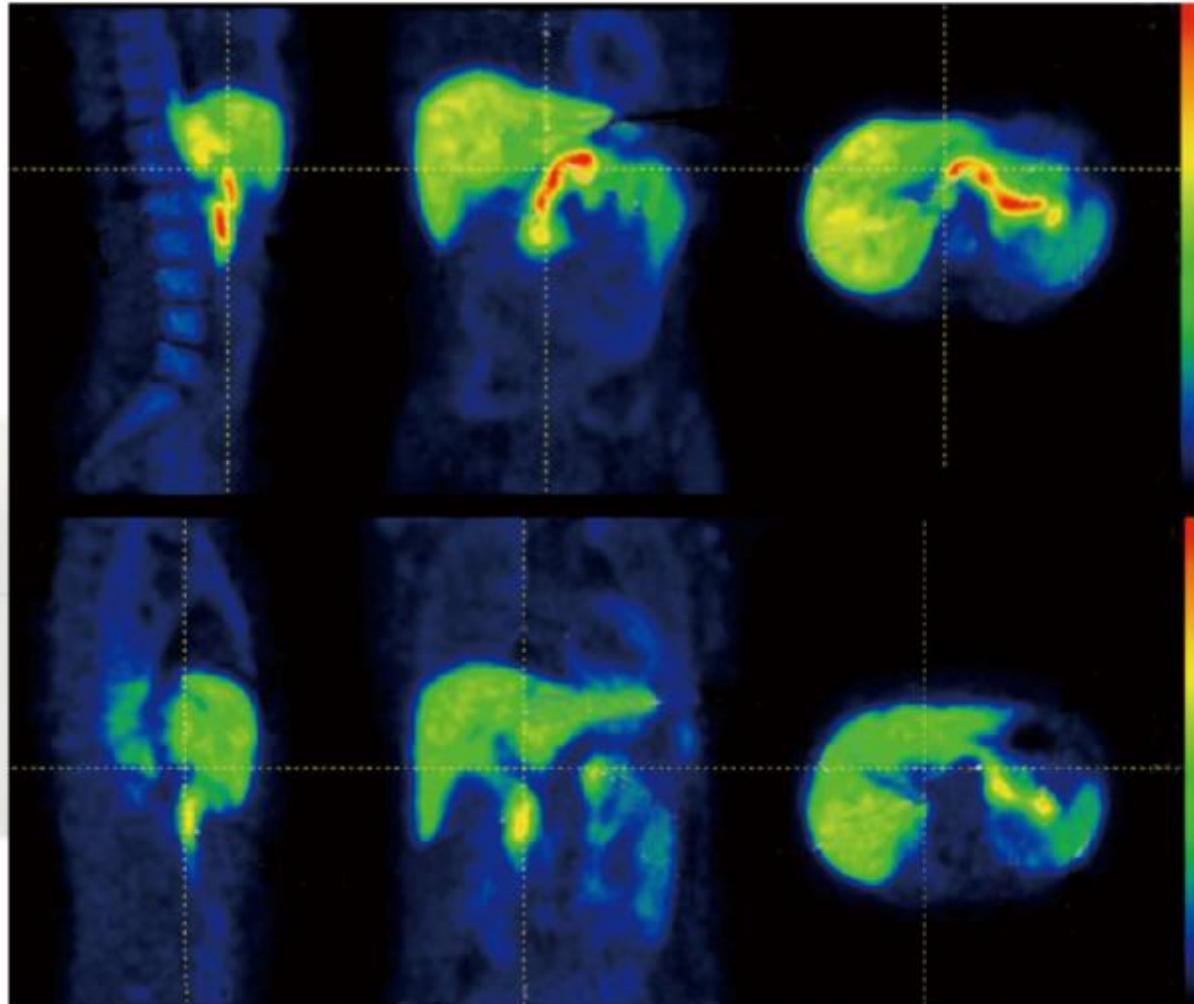
# In Vivo Imaging of $\beta$ -Cell Mass in Rats Using $^{18}\text{F}$ -FP-(+)-DTBZ: A Potential PET Ligand for Studying Diabetes Mellitus



# $^{18}\text{F}$ -FP-(+)-DTBZ positron emission tomography images in healthy control subject and type 1 diabetes patient

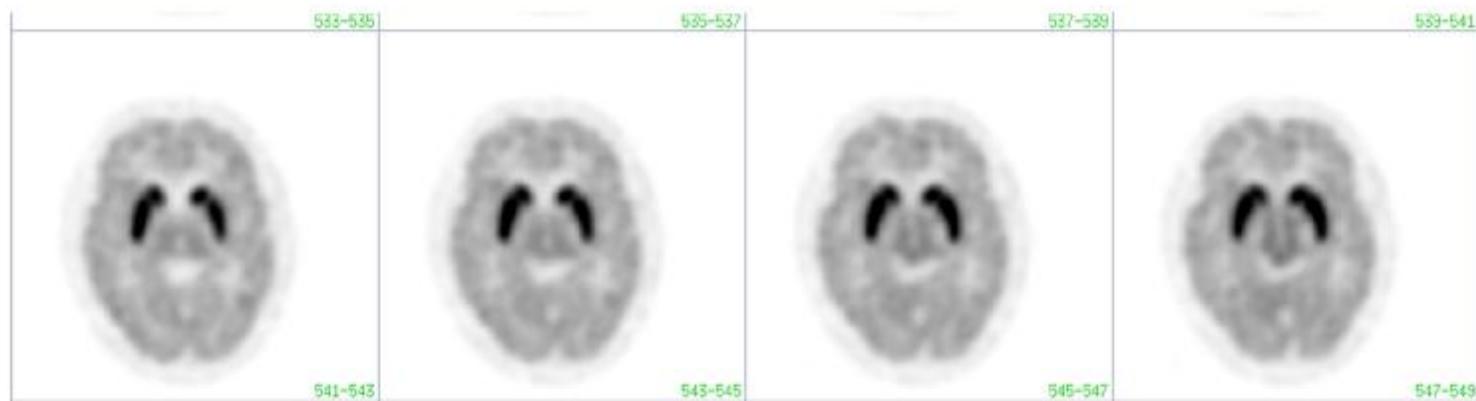
正常人

1型糖尿病患者

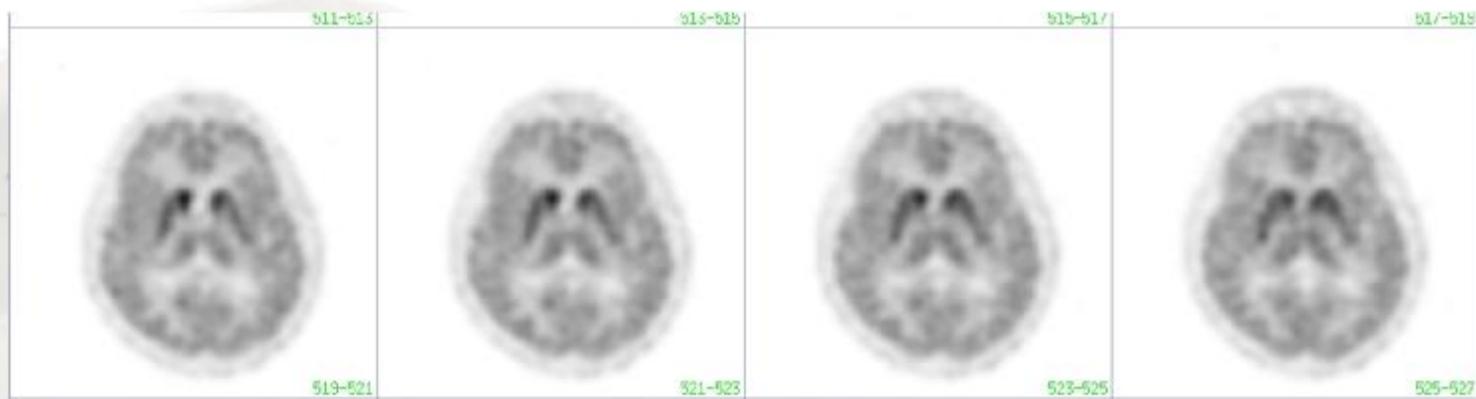


# 单胺转运体显像— $^{18}\text{F}$ -AV133

正常



帕金森病



产率>30%，首次合成产量：235mCi

# Thanks for your attention!

