

# 脳 SPECT の過去・現在・未来

埼玉医科大学国際医療センター 核医学

松田博史

## 脳SPECTの過去・現在・未来

埼玉医科大学国際医療センター核医学  
埼玉医科大学病院  
松田博史

## 職歴; 約10年ごとの漂流

- 1979～1992
  - 金沢大学医学部核医学診療科
  - モントリオール神経学研究所 (1984～1985)
- 1993～2004(Mar.)
  - 国立精神・神経センター武蔵病院放射線診療部
- 2004(Apr.)～
  - 埼玉医科大学病院核医学診療科
- 2007(Apr.)～
  - 埼玉医科大学国際医療センター核医学

## 脳SPECTに関する主な研究

- 金沢大学
  - IMP, HMPAO, ECDを用いた脳血流定量
    - Patlak plot
  - 幻聴の画像化 (刑部先生との共同研究)
  - 高分解能SPECT (GCA9300A)
- 国立精神・神経センター
  - 画像統計解析の臨床応用
    - 認知症
  - 部分容積効果補正法の開発

## IMP 持続動脈採血法

AMERICAN JOURNAL OF PHYSIOLOGIC IMAGING 1:186-194 (1986)

### Quantitative Cerebral Blood Flow Measurements Using N-isopropyl-(Iodine 123) p-iodoamphetamine and Single Photon Emission Computed Tomography With Rotating Gamma Camera

HIROSHI MATSUDA, MD, HIROYASU SEKI, MD, HISASHI SUMIYA, MD, SHIRO TSUJII, MD, NORIHISA TONAMI, MD, KINICHI HISADA, MD, HIROYUKI FUJII, MD, and  
HIDENORI KOBAYASHI, MD  
Department of Nuclear Medicine (H.M., H.S., S.S., N.T., K.H.), and Neurosurgery (H.F.),  
School of Medicine, Kanazawa University, Kanazawa City, Ishikawa, 920 and Department of  
Neurosurgery, Fukuoka Medical College (H.K.), Japan

# IMP 一回静脈採血法

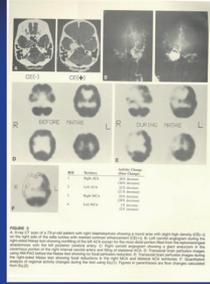
AMERICAN JOURNAL OF PHYSIOLOGIC IMAGING 2:49-55 (1987)

## A New Noninvasive Quantitative Assessment of Cerebral Blood Flow Using N-Isopropyl-(Iodine 123)p-Iodoamphetamine

HIROSHI MATSUDA, MD, SOTARO HIGASHI, MD, SHIRO TSUJI, MD,  
 HIROYASU SEKI, MD, HISASHI SUMIYA, MD, HIROYUKI FUJII, MD,  
 HIROSHI OBA, MD, HIROSHI TERADA, MD, KEIKO IMAI, MD,  
 NORIHISA TOMAMAI, MD, AND KINCHI HISADA, MD  
 Departments of Nuclear Medicine (H.M., S.T., H.S., H.O., H.T., K.I., A.T., K.H.) and  
 Neurosurgery (S.H., H.F.), School of Medicine, Kanazawa University, Kanazawa, 920, Japan

標準入力曲線の採用一失敗

# Split dose technique



# Auditory Hallucination

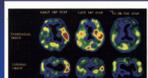


Figure 4. Early IMP scan. IMP scan and IMP-TOPO image (CM) in a patient with auditory hallucinations. The IMP scan shows high uptake in the left auditory cortex and the IMP-TOPO image shows high uptake in the left auditory cortex and the IMP-TOPO image shows high uptake in the left auditory cortex.

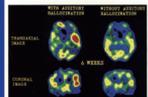


Figure 5. Top-down IMP scan. IMP scan and IMP-TOPO image (CM) in a patient with auditory hallucinations. The IMP scan shows high uptake in the left auditory cortex and the IMP-TOPO image shows high uptake in the left auditory cortex.

# <sup>99m</sup>Tc-HMPAO 頻回動脈採血法

Journal of Cerebral Blood Flow and Metabolism  
 8:501-508 © 1988 Raven Press, Ltd., New York

## Determination of Flow and Rate Constants in a Kinetic Model of [<sup>99m</sup>Tc]-Hexamethyl-Propylene Amine Oxime in the Human Brain

Hiroshi Matsuda, Hiroshi Oba, Hiroyasu Seki, \*Sotaro Higashi, Hisashi Sumiya, Shiro Tsuji, Hiroshi Terada, Keiko Imai, \*Kazuhiro Shiba, \*Hirofumi Mori, and Kinichi Hisada

Departments of Nuclear Medicine and \*Neurosurgery, School of Medicine, and †Radioisotope Center, Kanazawa University, Kanazawa City, Japan

# GCA-9300A

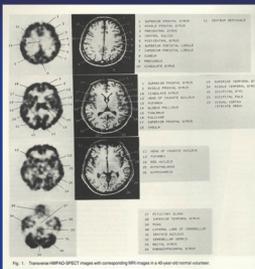


Fig. 7. Normalized HMPAO-SPECT images with compensating IMP images in a 40-year-old normal volunteer.

# Image of the year (SNM;1990)

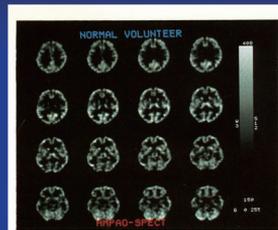


Figure 10.

## SNM Highlights

**Scientific Highlights 1990: The Universe Within**

The Society of Nuclear Medicine 37th Annual Meeting

Matsuda's Brain

## Patlak Plot

Brain  
Right Left  
Cortic Arch

R(t)/A(t)  
Time (min)

Fig. 3. Graph of the ratio of brain activity to the injected times (corrected) versus the ratio of injected activity times (corrected) to assess each activity at the respective times (abscissa). A straight line is a plot in front of a semi-square transfer in the closed circle during 30% percent within the first 30 s after injection of the tracer. The slope of the line,  $V_{max}$  (initial volume of distribution, brain perfusion index (BPI) that is a corrected  $K_1$  value for the rate of  $^{99m}Tc$  flow in  $ml_{100g}^{-1}min^{-1}$ ), and the correlation coefficient (r) for the fit are given for  $\times 10^2$  plot.

## NeuroSPECT symposium (1995)

**NEURO SPECT**  
SPECT IN CLINICAL  
NEUROLOGY AND PSYCHIATRY

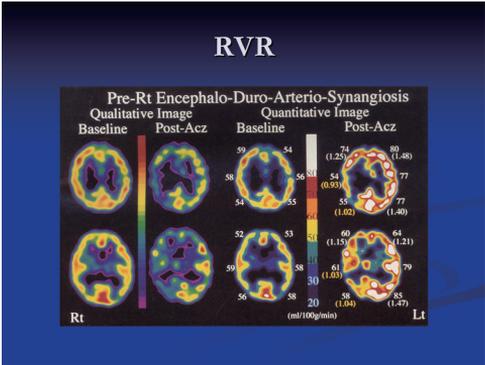
## Rest Vascular Reserve (RVR)

Journal of Cerebral Blood Flow and Metabolism  
17(10):1012-1017 The International Society of Cerebral Blood Flow and Metabolism  
Published by Lippincott-Raven Publishers, Philadelphia

### Noninvasive Quantitative Measurements of Regional Cerebral Blood Flow Using Technetium-99m-L,L-ECD SPECT Activated With Acetazolamide: Quantification Analysis by Equal-Volume-Split $^{99m}Tc$ -ECD Consecutive SPECT Method

Ryo Takeuchi, \*Hiroshi Matsuda, †Yoshiharu Yekura, ‡Harumi Sakahara, and †Junji Konishi

*Department of Internal Medicine and Division of Nuclear Medicine, Nihi-Kobe Medical Center, Kobe; †Division of Radiology, National Center Hospital for Mental, Nervous, and Muscular Disorders, NCNP, Tokyo; ‡Biomedical Imaging Research Center, Fukui Medical School, Fukui; and †Department of Nuclear Medicine and Diagnostic Imaging, Kyoto University Graduate School of Medicine, Kyoto, Japan*



- ## レジデント・シニアレジデント 9施設14人
- 東京医科大学老年内科
    - 中野正剛(SPECT) 木暮大嗣(SPECT) 坂本茂貴 金高秀和(SPECT) 平尾健太郎(SPECT)
  - 横浜市立大学医学部放射線科
    - 今林悦子(PLT現, 埼玉医大核医学講師)
  - 東邦大学医学部大橋病院放射線科 国弘敬之 加藤麻子
  - 大阪大学医学部精神科 上岡 武
  - 東京大学医学部心療内科 西川哲巳
  - 京都大学医学部放射線核医学科
    - 田中富美子(現, 河内富美子)
  - 東京大学医学部精神科 森 健之
  - 筑波大学医学部精神科 根本清貴
  - 慶應義塾大学医学部精神科 高野晴成

## 医療・技術研究生 14施設17人

- 東京都立神経病院神経内科 廣木昌彦
- 関東連信病院精神科 飯高哲也
- 広島大学医学部神経内科 井門ゆかり
- 中国医科大学第2病院核医学 李志傑
- 東京大学医学部神経内科 岡部慎吾(SPECT) 新井憲俊(PET)
- 国立精神・神経センター精神保健研究所心身医学研究部 守口善也
- 神戸大学医学部精神科 河内 崇
- 東京芸術大学打楽器科 平形真紀子(fMRI)
- 東京大学医学部心療内科 栗栖 麗 鏡 洋二郎(PET) 安田朝子
- 群馬大学医学部精神科 相原雅子
- 東京医科歯科大学歯学部 石川高行
- 東京慈恵医科大学歯科 伴 幸子
- 東邦大学医学部大橋病院脳神経外科 平田裕子(MRI)
- 放射線医学総合研究所 山田 実

国立精神・神経センター武蔵病院内  
での他科からのレジデント 2科8人

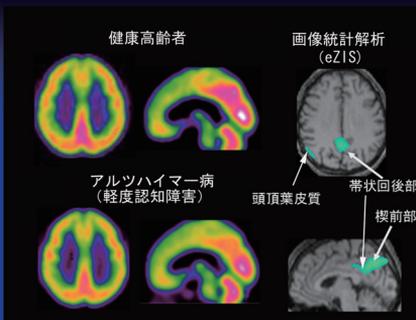
- 精神科
  - 福智寿彦(SPECT)、白浜康弘、寺田 倫、平木直子、北山徳行(SPECT,MRI)、熱田英範、中村真人
- 小児科
  - 高橋純也

## Impact Factor; 5以上の論文

- Lancet (SPECT/MEG, 1)
- J Neurosci (PET, 1)
- Ann Neurol (PET, 1)
- Biological Psychiatry (PET, 1)
- Am J Psychiatry (PET, 1)
- Cerebral Cortex (fMRI, 1)
- Brain (SPECT, 1)
- Neurology (SPECT, 1)
- Neuroimage (SPECT, 2; fMRI, 2)
- J Nucl Med (SPECT, 0)

## アルツハイマー型認知症 の早期診断

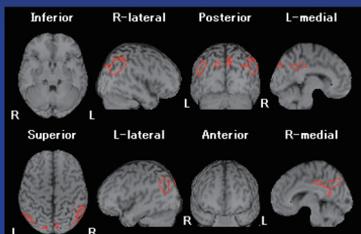
- 脳血流SPECTのeZIS解析



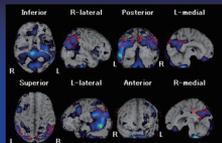
## 早期アルツハイマー病の脳血流SPECTの eZIS自動解析に関する多施設共同研究

- 健常高齢者; 40人
  - 症例提供: 国立精神・神経センター武蔵病院、都立荏原病院
- 軽度認知機能障害の時期のアルツハイマー病; 40人
  - 症例提供: 国立精神・神経センター武蔵病院、都立荏原病院、順天堂大学附属順天堂医院、複十字病院

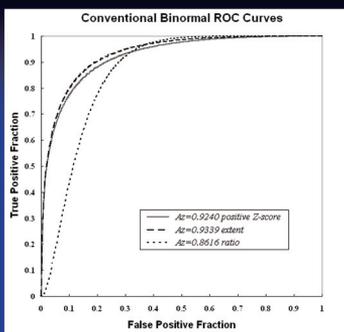
## 早期アルツハイマー病の血流低下ROI



## Information inside the mask



- Positive Mean: マスク内Z-scoreの正の平均値 (関心領域の血流低下度)
- Extent: マスク内に占めるvisible Z-score (2以上)の割合 (関心領域での血流低下率)
- Ratio: Extentと全脳でのvisible Z-score (2以上)の比 (関心領域の特異的血流低下率)



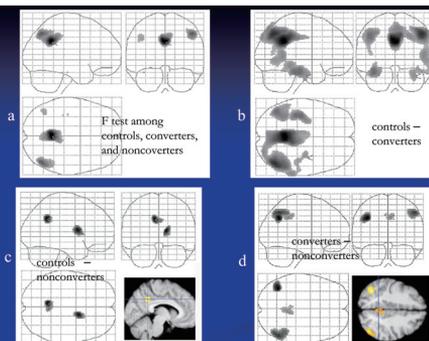
## The prediction of rapid conversion to Alzheimer's disease in mild cognitive impairment using regional cerebral blood flow SPECT

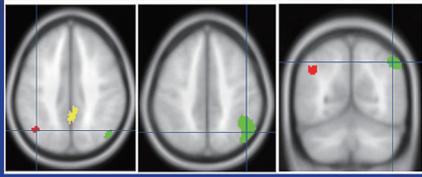
Hirao K, Ohmishi T, Hirata Y, Yamashita F, Mori T, Moriguchi Y, Matsuda H, Nemoto K, Imabayashi E, Yamada M, Iwamoto T, Arima K, Asada T

Neuroimage 2005;28(4):1014-1021

## Studied subjects

- 76 MCI subjects
  - MMSE 24~29 (初診時),  $26.5 \pm 1.6$
  - 48~86歳,  $69.0 \pm 8.6$
  - 男性37、女性39
  - 52 converters to AD (3年以内)
  - 24 nonconverters to AD (3年)
- 57 age and gender matched healthy volunteers
  - MMSE 25~30,  $28.8 \pm 1.5$
  - 56~86歳,  $70.4 \pm 7.3$
  - 男性30、女性27





ROIs for logistic regression model

Results of logistic regression model

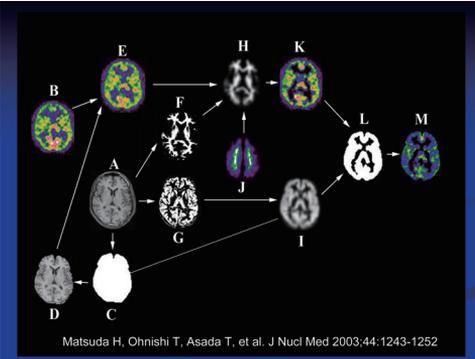
SPECT imaging test	Odds ratio	95% CI	P value	Sensitivity	Overall accuracy
Regions					
L Angular gyrus	2.174	1.39-3.43	<0.001	93%	69.0%
R IPL	2.130	1.85-3.35	<0.001	90%	73.3%
Precuneus	2.417	1.40-4.161	<0.001	88%	75.3%
Neuropsychological test					
Word learning (delayed recall)	1.413	1.118-1.786	0.004	90.3%	69.8%
Rey-Osterrieth Complex Figure Test (delayed recall)	1.167	1.045-1.303	0.008	86.2%	75%

CI: confidence interval, IPL: Inferior parietal lobule

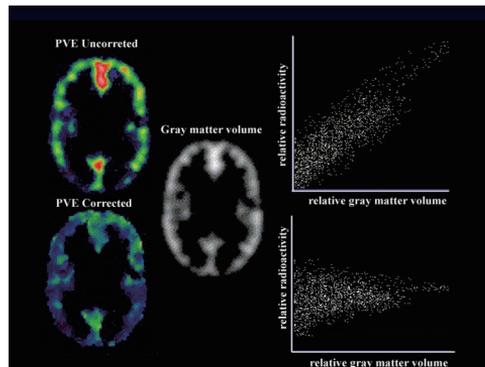
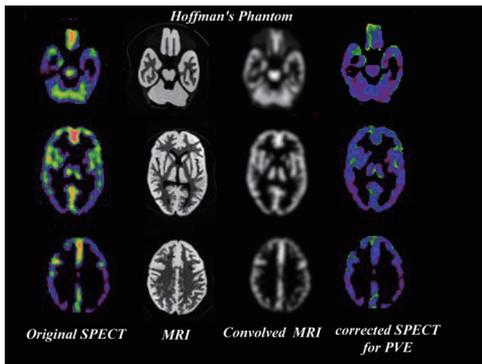
## Partial Volume Correction

### ■ MRIを用いた3 compartment model法

- SPECT
  - Matsuda H, et al, J Nucl Med, 2003 ;44:1243-1252.
- PET
  - Yanase D, et al, Eur J Nucl Med Mol Imaging, 2005;32:794-805



Matsuda H, Ohnishi T, Asada T, et al, J Nucl Med 2003;44:1243-1252



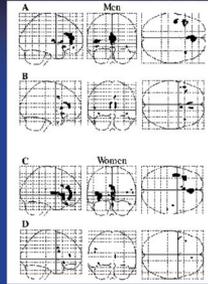
## SPECTでしている画像

生物学的分布



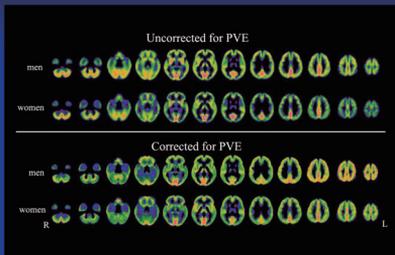
物理学的修飾  
部分容積効果  
散乱・吸収

## Partial Volume Correction前後の FDG-PETと正常加齢の関連



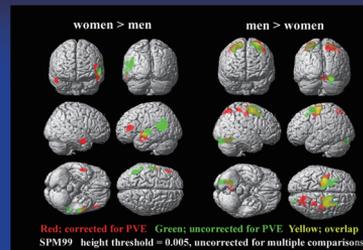
Yanase D, et al. Eur J Nucl Med Mol Imaging 2005;32:794-805

## Gender differences in rCBF



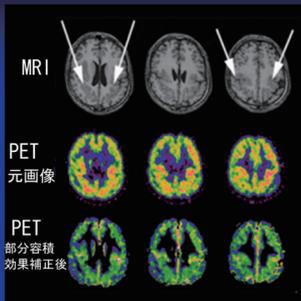
Li ZJ, et al. Nucl Med Commun 2004;25:999-1005

## Gender differences in rCBF



Li ZJ, et al. Nucl Med Commun 2004;25:999-1005

## Bilateral Perisylvian Syndrome



## これからの脳SPECT装置

- 高感度、高解像化
- SPECT/CT(今年度、導入予定)
  - CTによる正確な吸収補正
- SPECT/MRI(将来)
  - PET/MRIは既に実験機が作製されている
  - <sup>201</sup>TlCt集積とMRS(脳腫瘍)
  - 安静時脳血流とfMRIによる賦活の比較
  - SPECTの部分容積効果補正のルーチン化

## SPECT/CT

**True Integration** uses true transmission scans from the PET and SPECT modules to generate the attenuation maps for the SPECT. This allows for more accurate attenuation correction than the traditional CT-based method. The resulting SPECT images are more accurate and less noisy, providing a more reliable diagnosis.

**Together, a merger of true equals.**

A large medical scanner labeled SPECT/CT with a patient lying inside. The scanner has a large gantry and a patient bed. The text 'SPECT/CT' is visible on the side of the gantry.

## SPECT/CT

Three axial SPECT/CT brain scans showing perfusion defects. The scans are arranged horizontally. The first scan on the left shows a normal brain. The second scan in the middle shows a perfusion defect. The third scan on the right shows a perfusion defect with a registration artifact.

CT clearly demonstrating bleeding in the right brain. Coregistering <sup>99m</sup>Tc-SPECT/CT study shows a perfusion defect. Registration reveals that the SPECT perfusion defect includes bleeding as well as an aneurysmal rupture.

## PET/MRI

**MR PET Scanner**

- Magnet assembly coil
- Primary magnet coil
- Detector coil
- PET scanner
- MR body coil

**MR PET Scanner**

- Magnet cryostat
- PET module

**Position of MR PET module**

- MR body coil
- Primary magnet
- MR body coil
- MR body coil
- MR body coil
- MR body coil

A diagram of a PET/MRI scanner showing the integration of PET and MRI components. The diagram includes labels for various parts of the scanner, such as the magnet assembly coil, primary magnet coil, detector coil, PET scanner, MR body coil, magnet cryostat, PET module, and the position of the MR PET module. The diagram shows the PET scanner and MR body coil integrated with the MRI scanner.

## Avalanche photodiodes (APD)

A photograph of a photomultiplier tube and an APD array. The photomultiplier tube is a long, cylindrical tube with a label that reads 'PHOTOMULTIPLIER TUBE'. The APD array is a small, square chip with a grid of small squares.

(Figure 3) Photograph of a photomultiplier tube as it is used in PET scanners and an APD array suitable for operation in the magnetic field.

## これからの脳SPECT

- 解析法の発展
  - 疾患特異VOIによる認知症等の早期および鑑別診断の自動化(eZISの発展)
  - SPECTとMRIの画像統計解析手法のドッキング
- 新規薬剤の導入
  - <sup>123</sup>I-β-CIT
  - Amyloid imaging用薬剤