PROGRESS OF DIAGNOSTIC IMAGING in JAPAN

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Prof.em.OSAKA UNIVERSITY

HONORARY PRESIDENT

KAIZUKA CITY HOSPITAL

To Finnish Government & People

We would like to express our sincere appreciation for your warm sympathy and kind support concerning the earth-quake and tsunami in north-east Japan on March 11, 2011.

Communication Scandinavia-Japan

- PACS meeting
  - 3 times (1990-1992)
- Scandinavia Japan Radiological Society
  - Founded in 1985
  - Workshop since 1993, joint with PACS
    - Every 2 or 3 years
    - Next workshop will be held in Tokyo

Mutual Exchange of Young Radiologists Scandinavia and Japan

1989-1997

8 from Scandinavia to Japan, including

1 Finnish radiologist

1986-2010

33 from Japan to Scandinavia

including 1 to Finland(Turku Univ.Prof. Kormano)

Diagnostic imaging for lung cancer

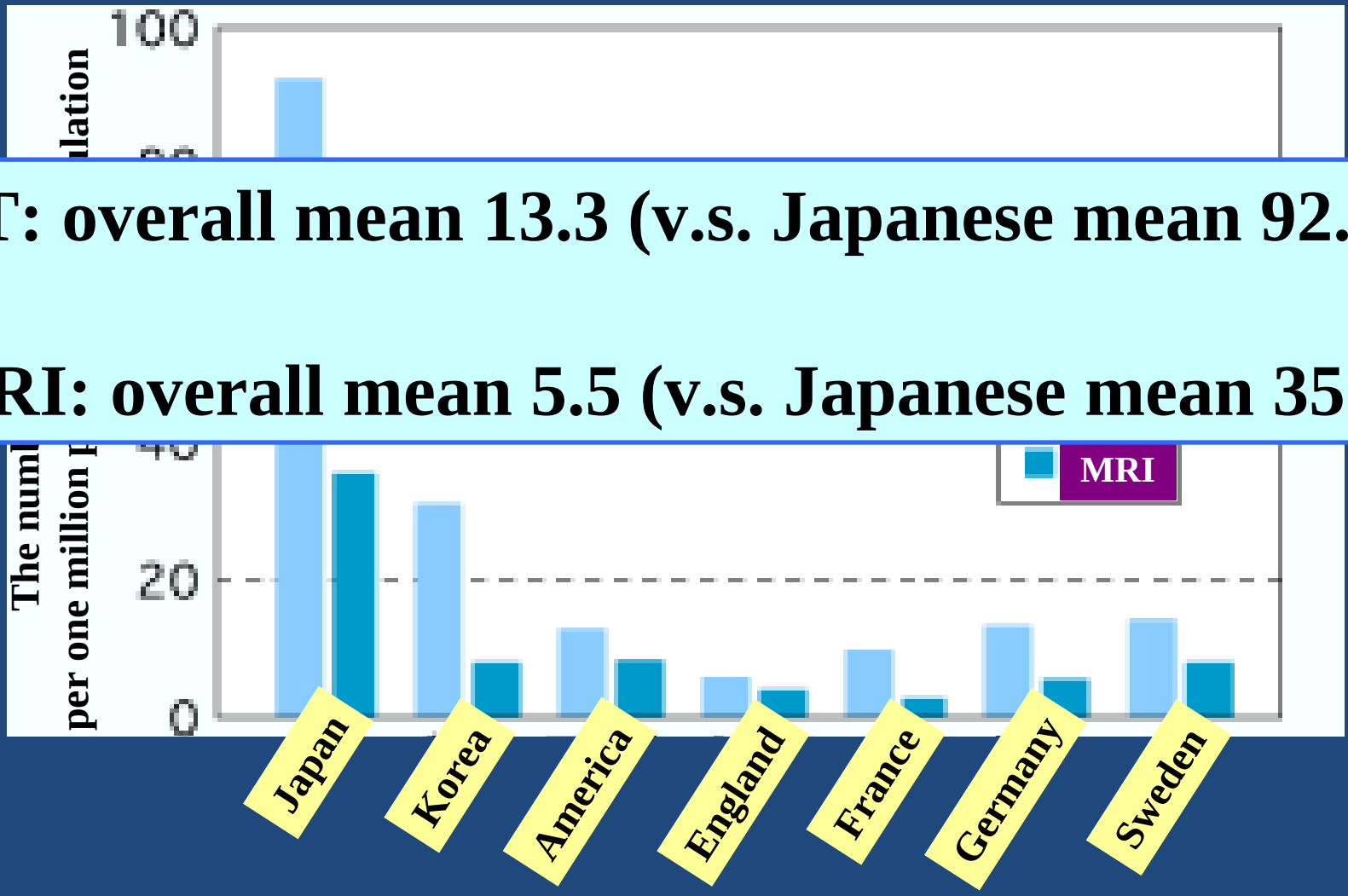
‘‘Clinical Application and Research’’

- **Three-dimensional software in lung cancer**

Lung cancer is the leading cause of cancer death in Japan since 1998. Its detection in its early stage is absolutely necessary. Adenocarcinoma (ADC) is the predominant subtype.

CT Penetration Rate in Japan

- Highest among the advanced countries



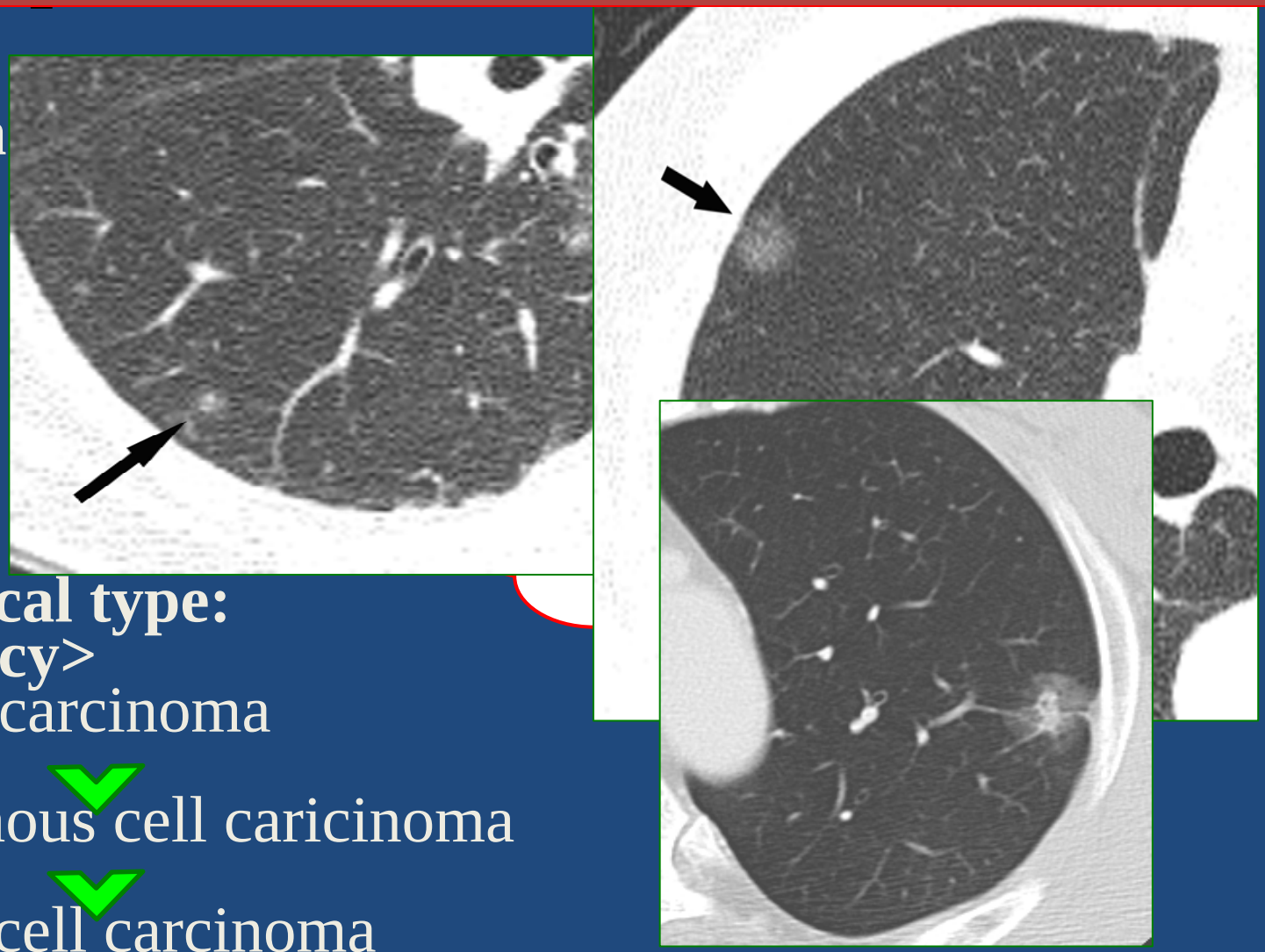
CT: overall mean 13.3 (v.s. Japanese mean 92.6)

MRI: overall mean 5.5 (v.s. Japanese mean 35.3)

Gerard F, et al. Health Affairs 2005; 24: 903-914

We have many chances to detect pulmonary nodules earlier.

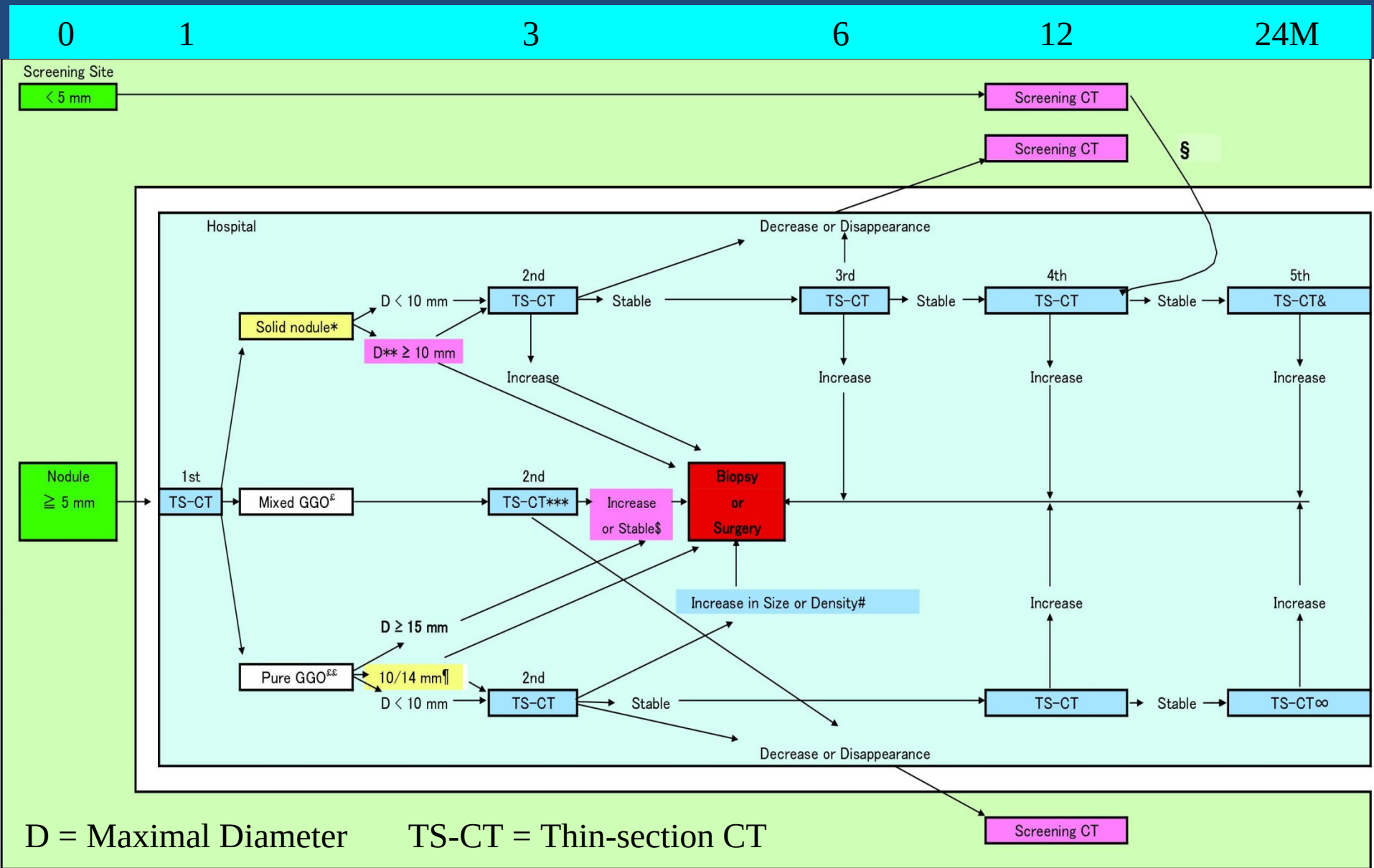
Examin



Histological type:
<frequency>

- # Adenocarcinoma
- # Squamous cell caricinoma
- # Small cell carcinoma
- # Large cell carcinoma

Low-dose CT Lung Cancer Screening Guidelines for Pulmonary Nodule Management in the Japanese Society of CT Screening



D = Maximal Diameter TS-CT = Thin-section CT

Many clinical studies about GGOs in Asia
“ Adenocarcinoma ”

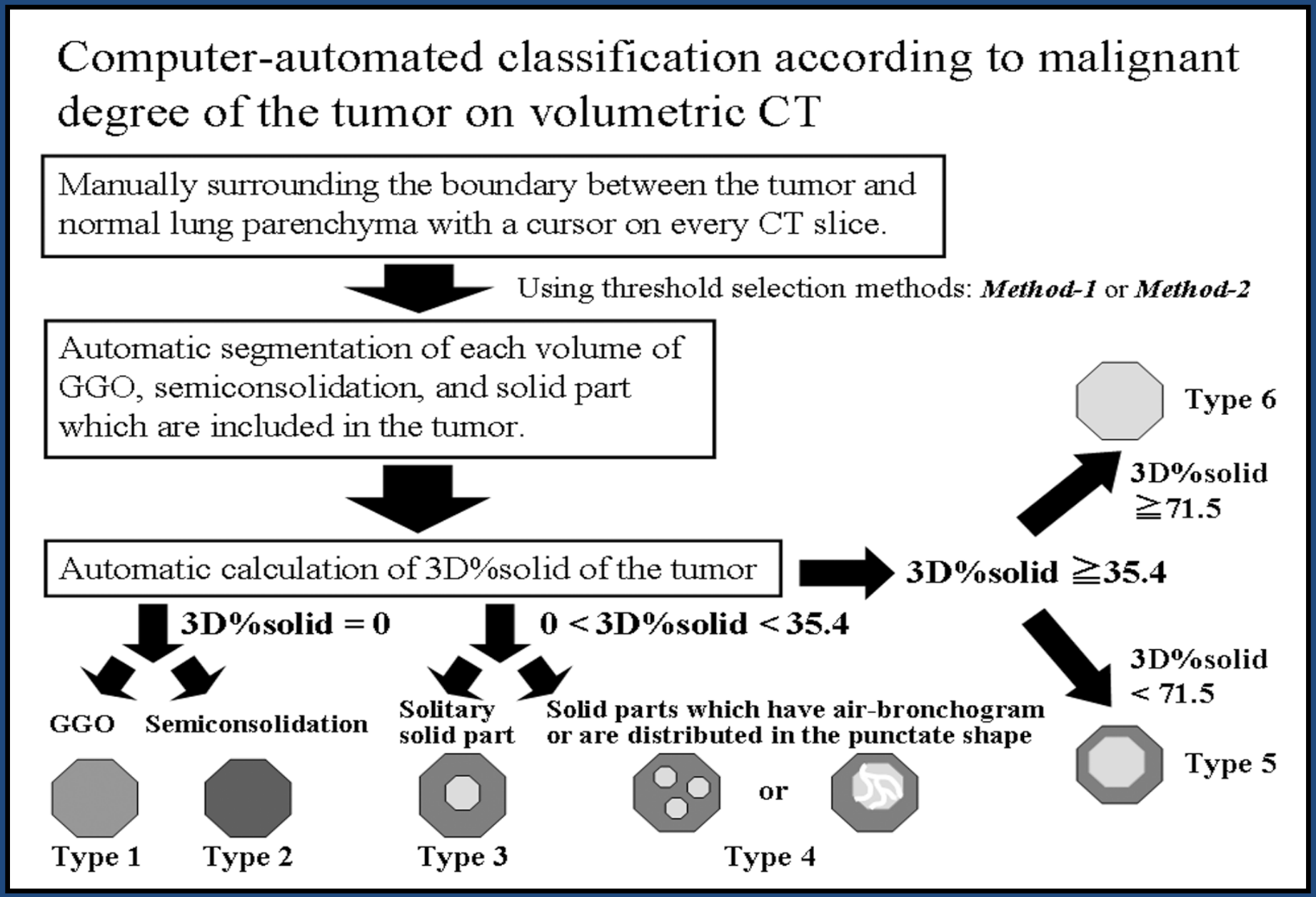
The size of the central collapse/fibrosis and the percentage of the bronchioloalveolar carcinoma (BAC) component can be used as prognostic indicators for small lung adenocarcinomas.

The BAC component = GGO on CT

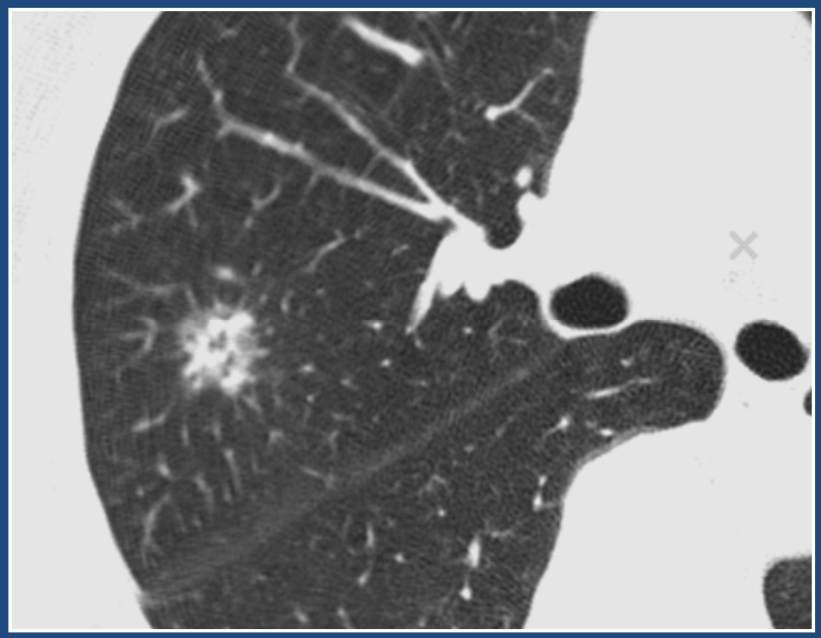
No quantitative definition!!!

No generally accepted method for measuring the area of GGO.

Outline of custom-developed software

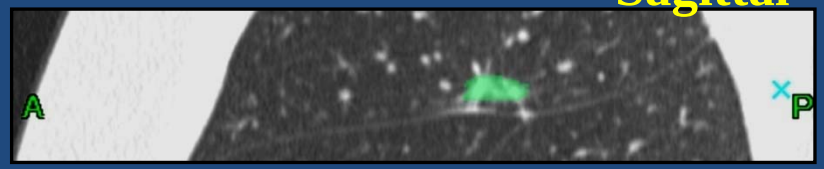


A lung cancer of a 68-year-old woman

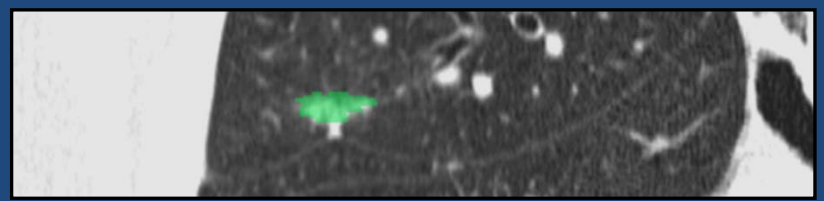


Axial

Sagittal



Coronal



Green area is the highlighted boundaries between tumors and normal lung parenchyma.

Automatic Analysis of Lung Cancer

- Volume of Tumor　　９．１３ml
- 　　(Otsu)　　(Kittler)
- ％Solid　　３０．４９３　　１５．６９６
- Classification
- 　Type（１～６）　　４　　４

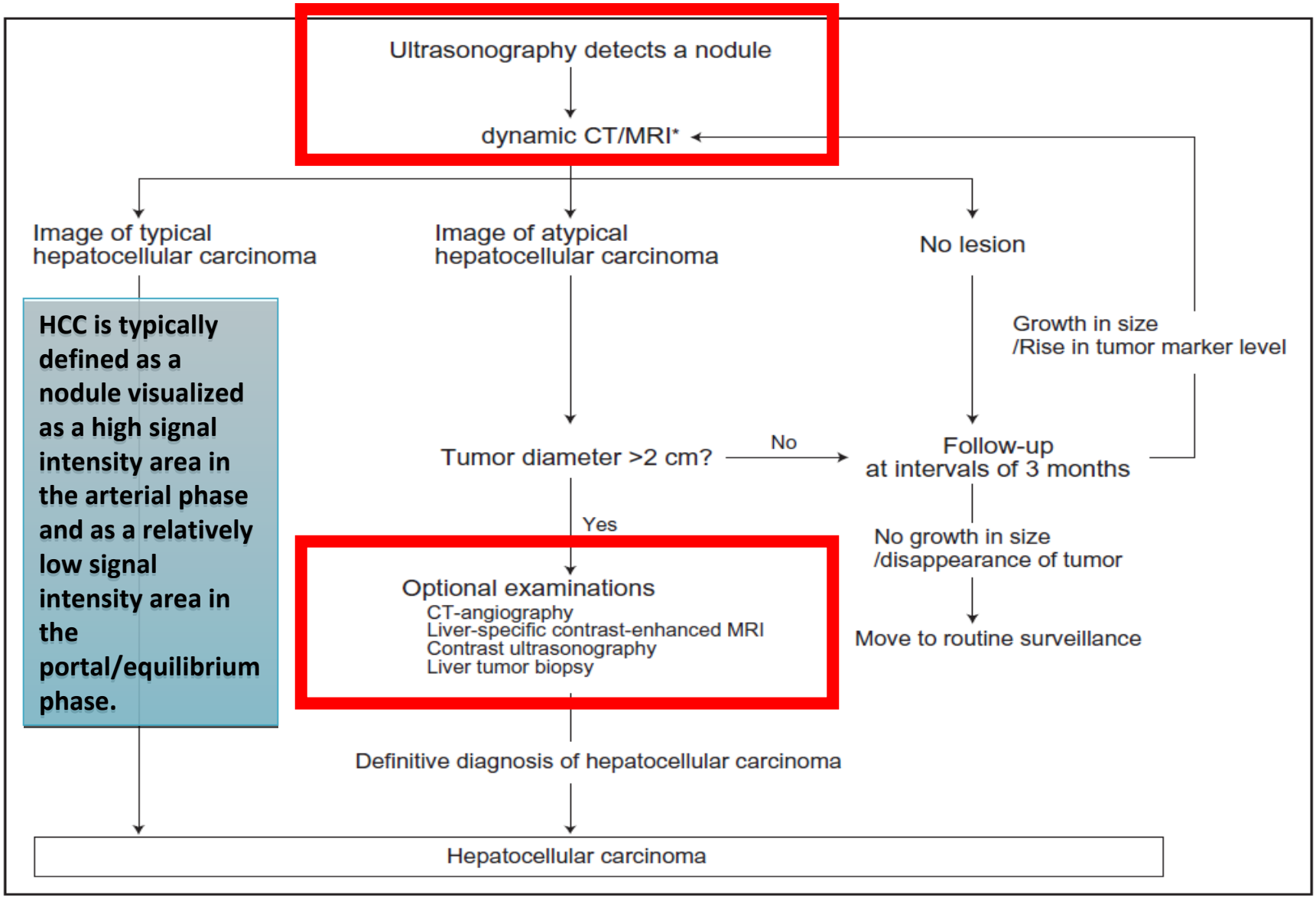
Diagnosis of Hepatocellular Carcinoma (HCC)

Imaging Modalities for HCC

1. Ultrasound
   (B mode, contrast enhanced US)
2. CT (multi-phasic contrast enhanced MDCT)
3. MRI (Gd-EOB-DTPA enhanced MRI)
4. CTAP: CT during arterial portography
   CTHA: CT during hepatic arteriography

Japanese Clinical Practice Guidelines for HCC 2009

Diagnostic algorithm for HCC

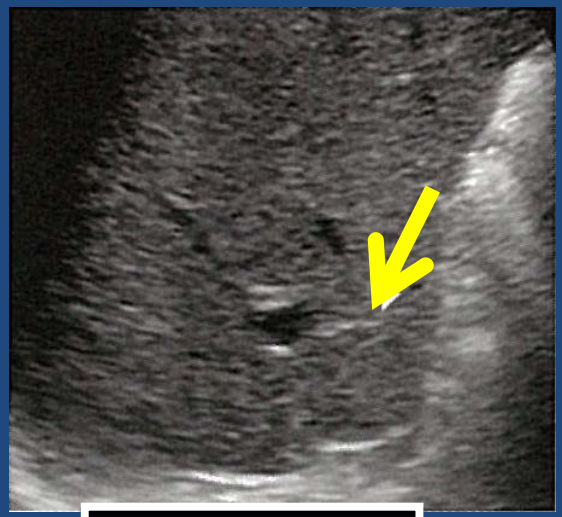


HCC is typically defined as a nodule visualized as a high signal intensity area in the arterial phase and as a relatively low signal intensity area in the portal/equilibrium phase.

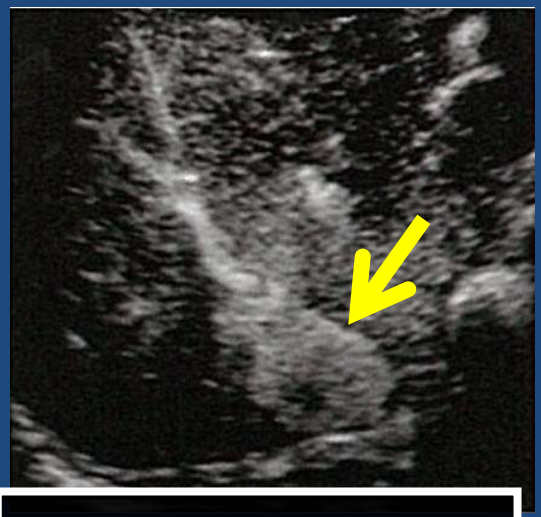
Contrast enhanced US

Sonazoid™ (perflubutane microbubbles; Diichi Sankyo, Tokyo, Japan)

- 2nd-generation US contrast
- Clinically available only in Japan
- Vascular Imaging and Kupffer Imaging



B-mode image



Vascular phase
17 sec after Sonazoid IV

Kupffer phase
15 min after Sonazoid IV

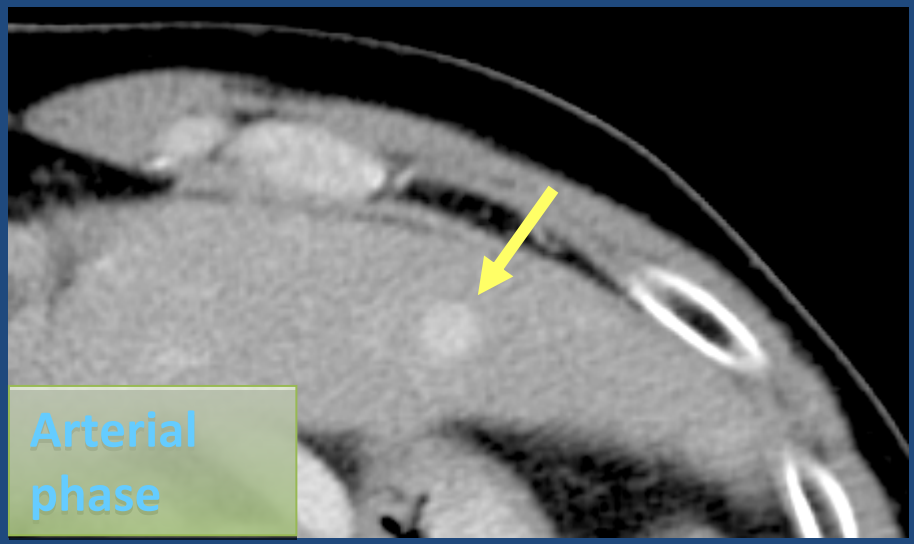
HCC

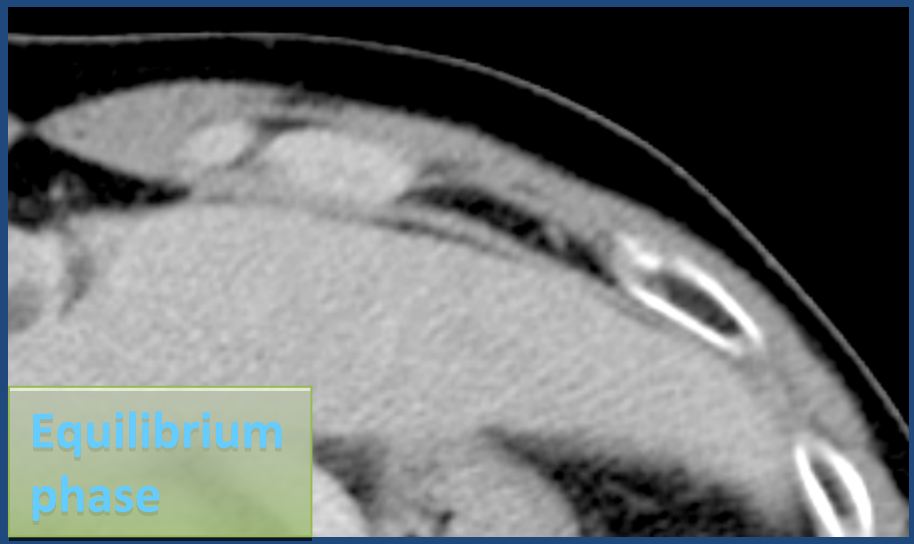
Hypervascular HCC is hyper-enhanced in the early vascular phase (10–30 s after Sonazoid IV)

Hypo-enhanced at Kupffer imaging in the post-vascular phase (after 10 min).

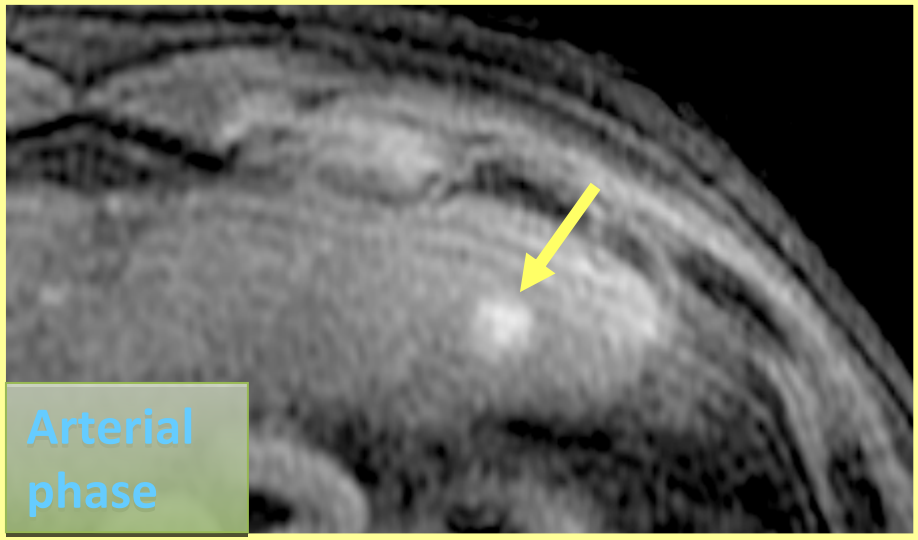
HCC

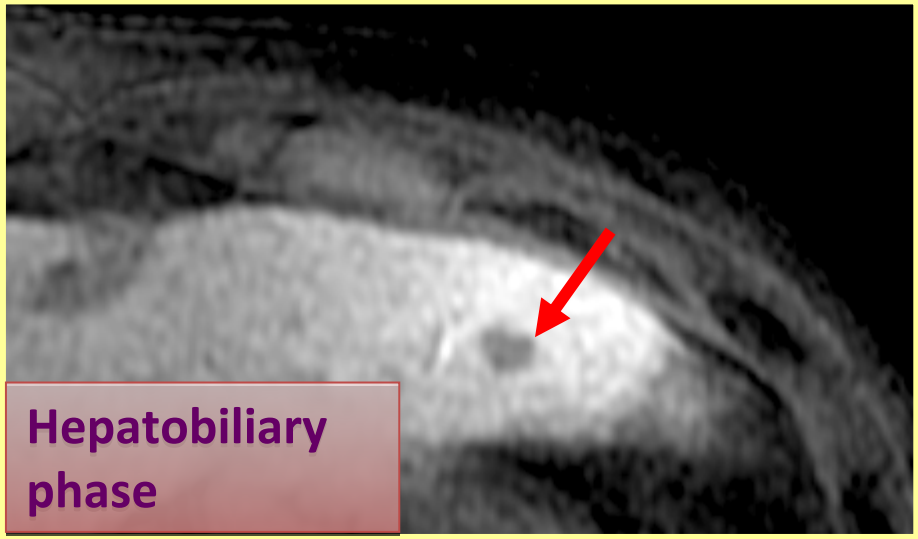
Multiphasic MDCT





Gd-EOB-DTPA-enhanced MRI

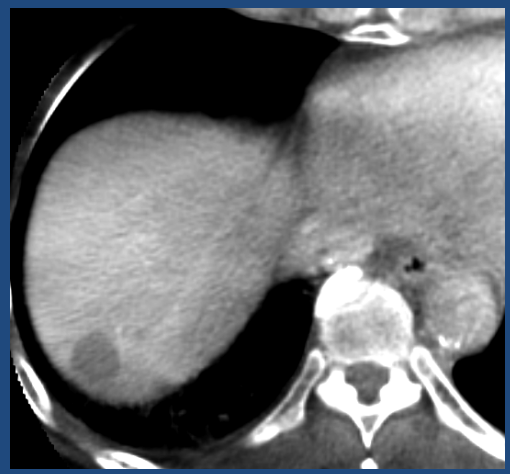




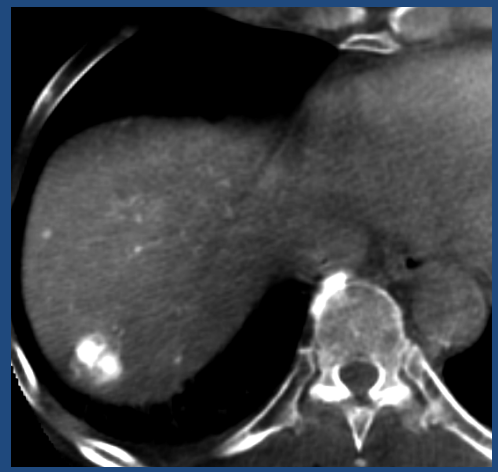
HCC

Combined CT-angiography system

Flat-panel C-arm

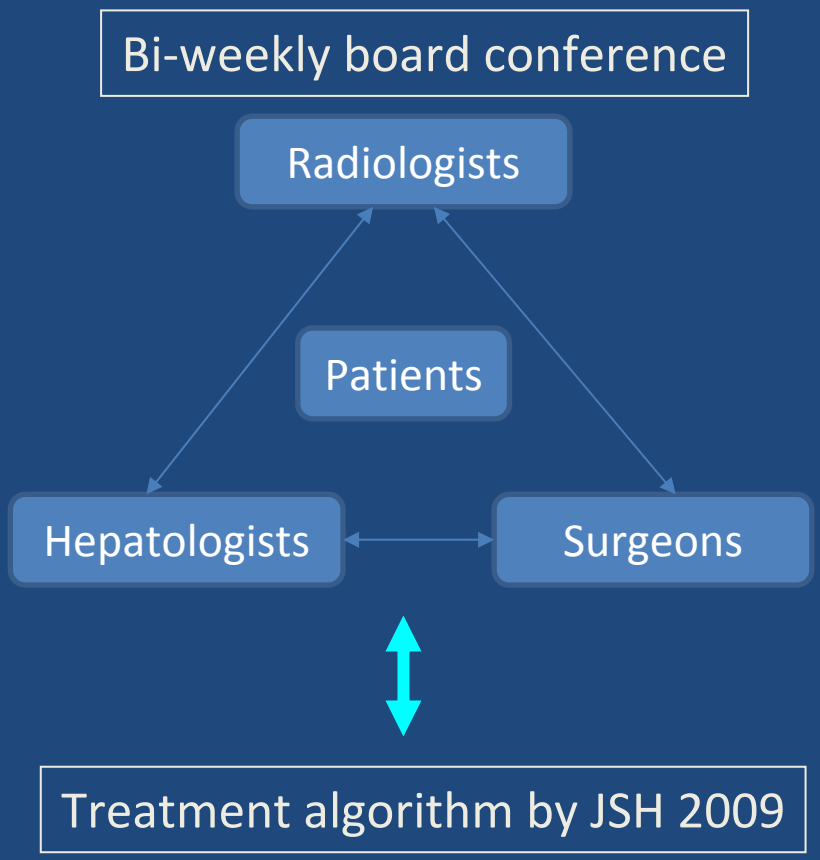


CTAP (CT during arterial portography)



CTHA (CT during hepatic arteriography)

Consensus-Based Treatment of HCC at Osaka University Hospital



Treatment options for HCC

1. Surgery
   - Resection, Transplantation
2. Needle ablation
   - Radiofrequency (RFA)
   - Ethanol injection (PEI)
3. Transcatheter therapy
   - Chemoembolization (TACE)
   - Arterial chemoinfusion (HAIC)
4. Systemic chemotherapy
   - Sorafenib

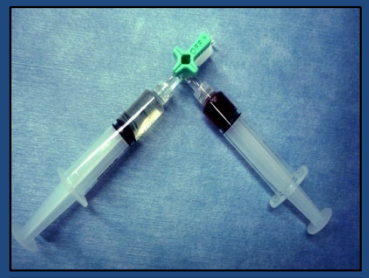
Super-selective TACE for localized HCC

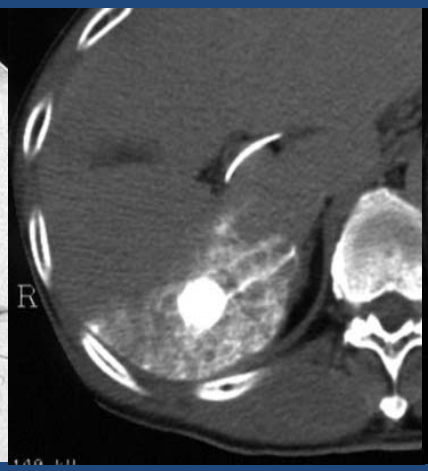
Concept

- Maximum effect & minimal damage
- Repeat on demand (residual or recurrence)

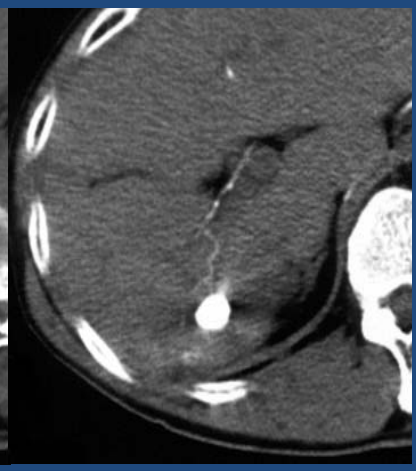
Techniques

- Lipiodol-chemo emulsion + Gelatin particles
- Highly selective microcatheter
- Assist with CTAP/CTHA





A7-CTHA



f/u 1yr

New generation beads for TACE

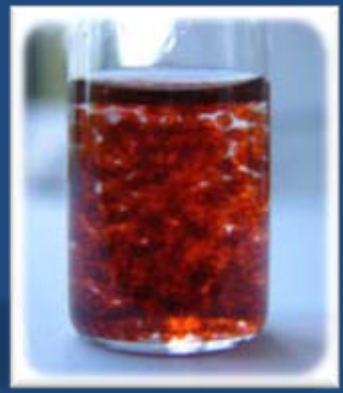
Bland Beads

Embosphere
(Merit)

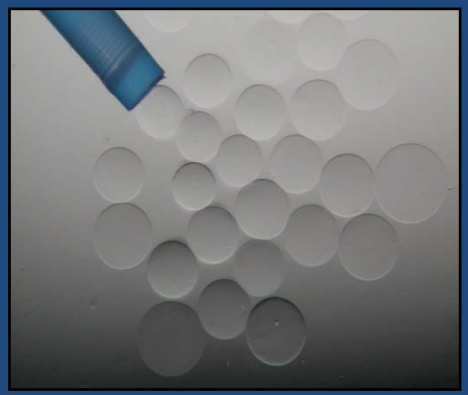
Embozene
(Celonova)

Drug Eluting Beads

HepaSphere
(Merit)

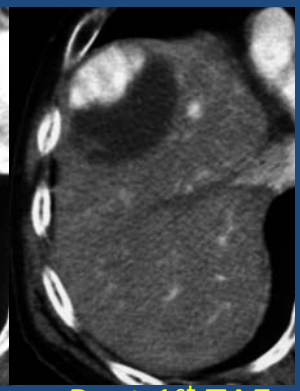


DC Bead
(Biocompatibles)

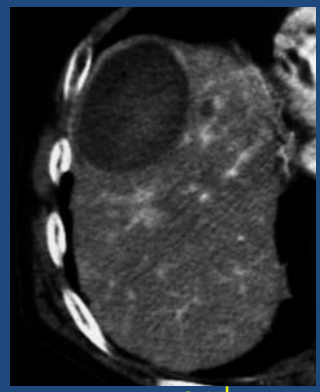


SAP (HepaSphere)

Pre



Post 1st TAE



Post 2nd TAE

Combination of TACE & RFA

Why ?

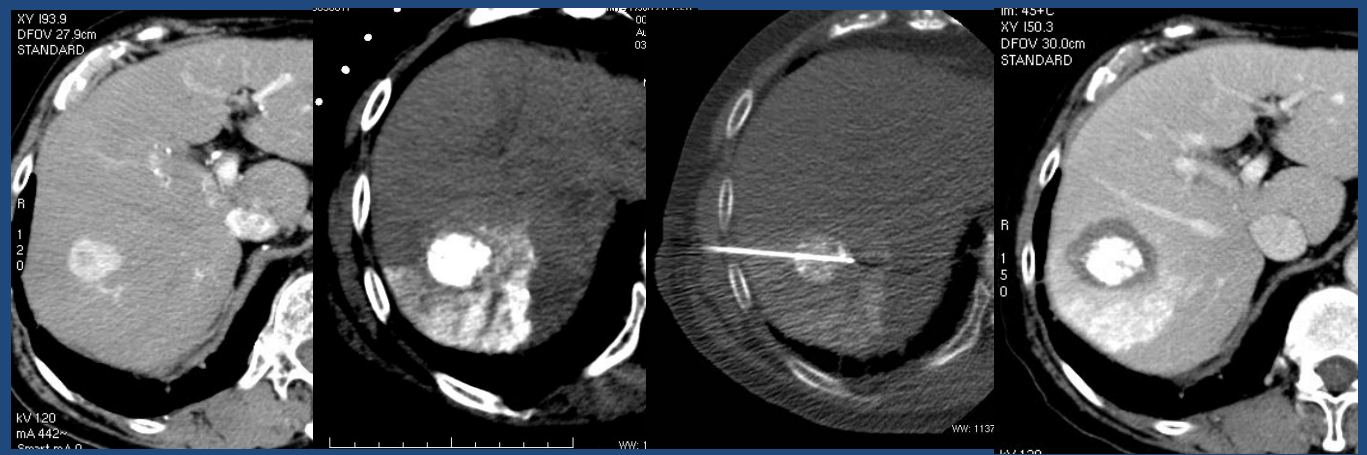
- Uncertainty to achieve complete coagulation (>2cm or adjacent to major vessels)

How ?

- RFA within 1 week after TACE
- CT guided to target Lipiodol

Aim ?

- To enhance local tumor control (cooling effect ↓ coagulation volume ↑)



Pre-TAE | Post-TAE (1w) | CTg-RFA | Post-RFA (1w)

Reservoir-HAIC for advanced HCC

Why ?

- Major portal vein invasion

How ?

- Radiological implantation of "Reservoir"
- FAIT: INF-α + 5-FU, at least 2 courses

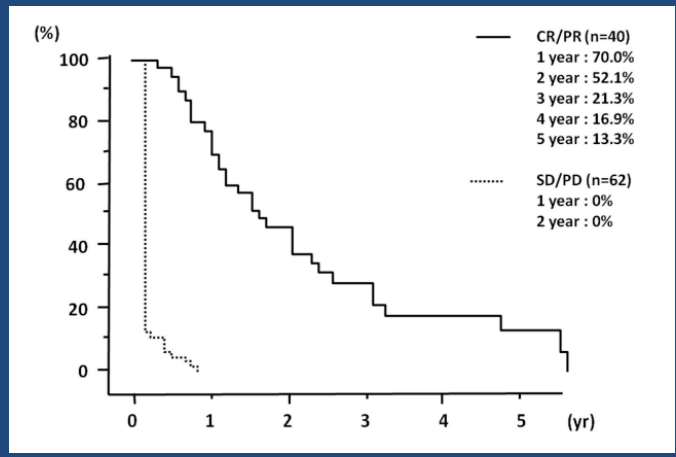
  INF-α 5 MU s.c. Days 1,3,5 x 4w

  5-FU 300 mg/m^2/day i.a. Days 1-5 x 2w

Portal & Hepatic vein invasion

Pre

f/u 6 mo

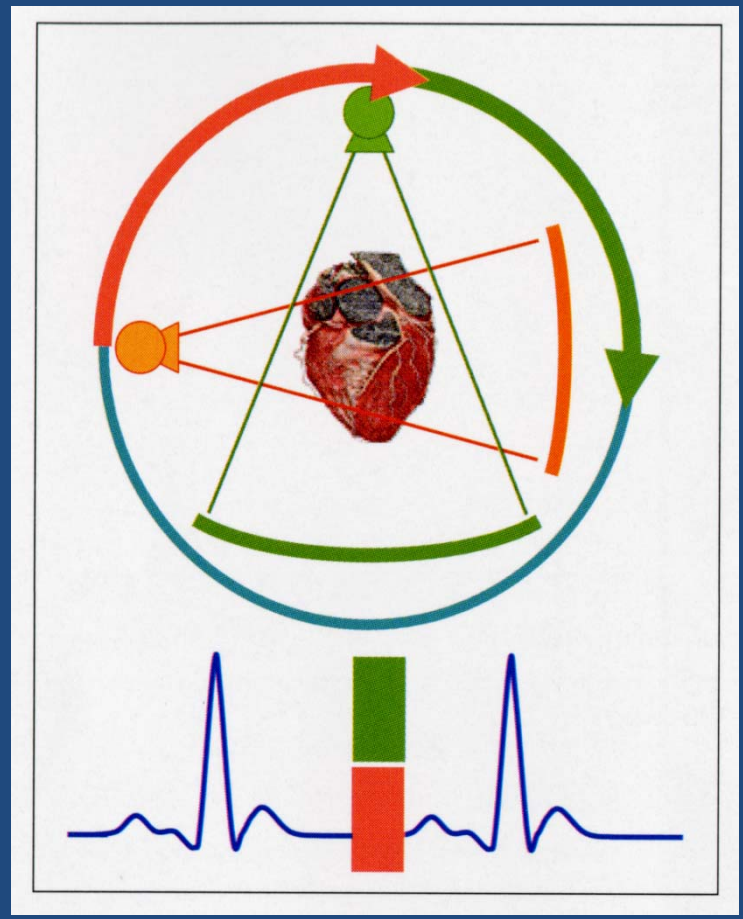


N=102, R.R.=39.2%

1yr PFS of responder = 70.0%

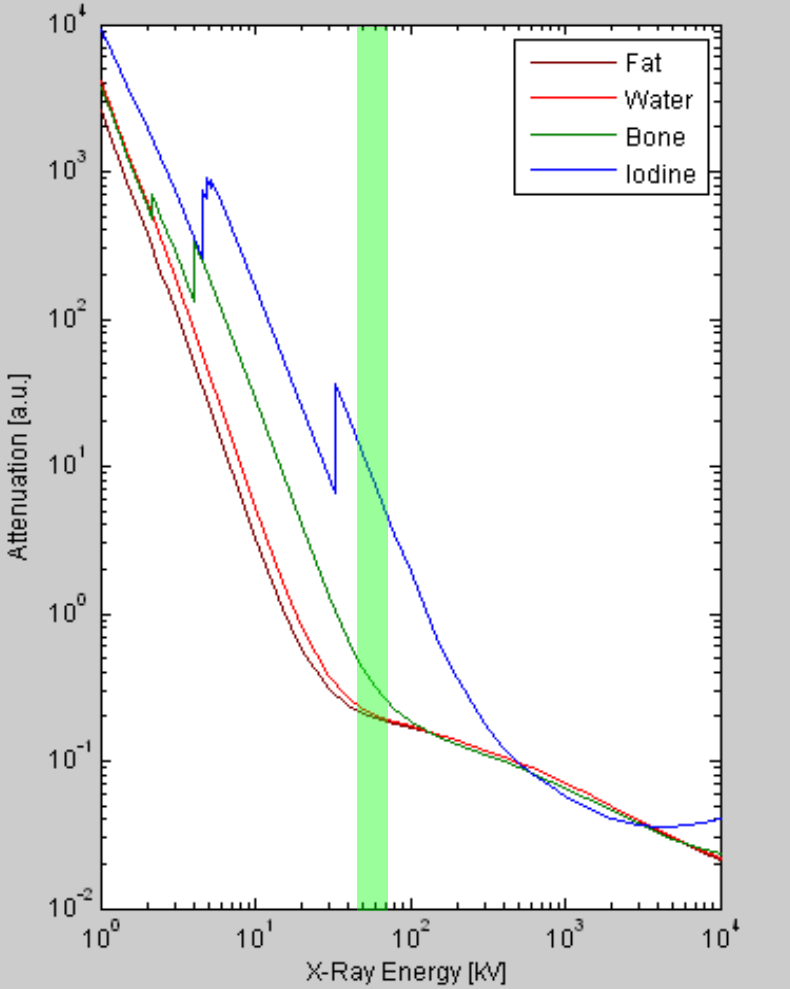
Nagano H, et al. Oncology 2011;80(1-2):63-9

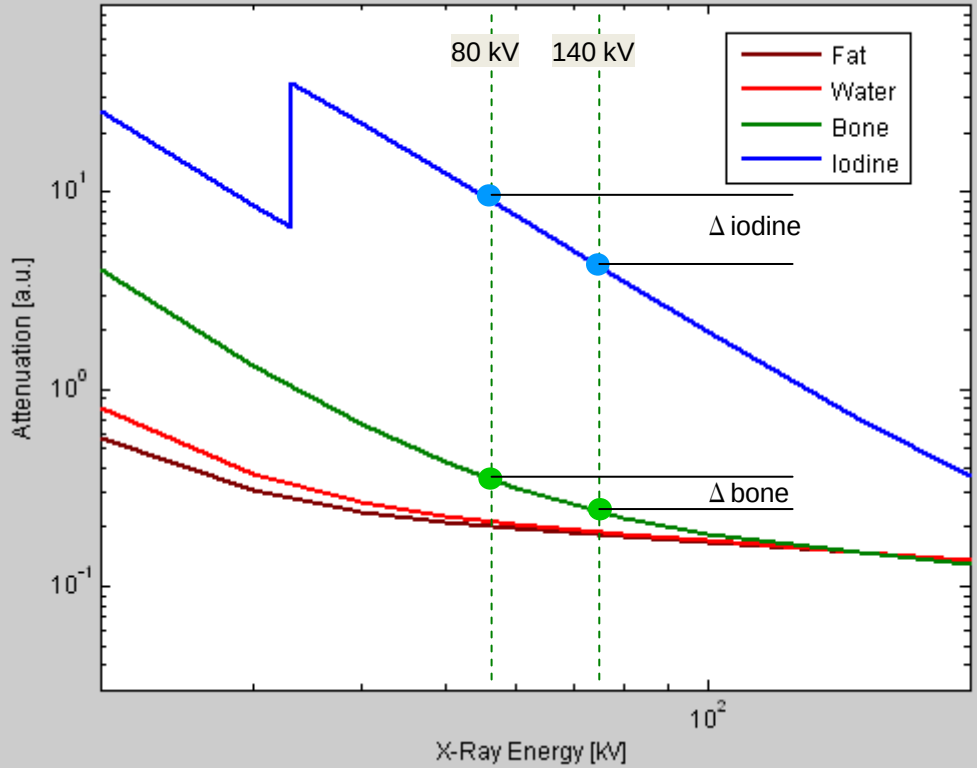
Dual-Source CT (SOMATOM Definition Flash)



SIEMENS

X-ray energy and materials attenuation

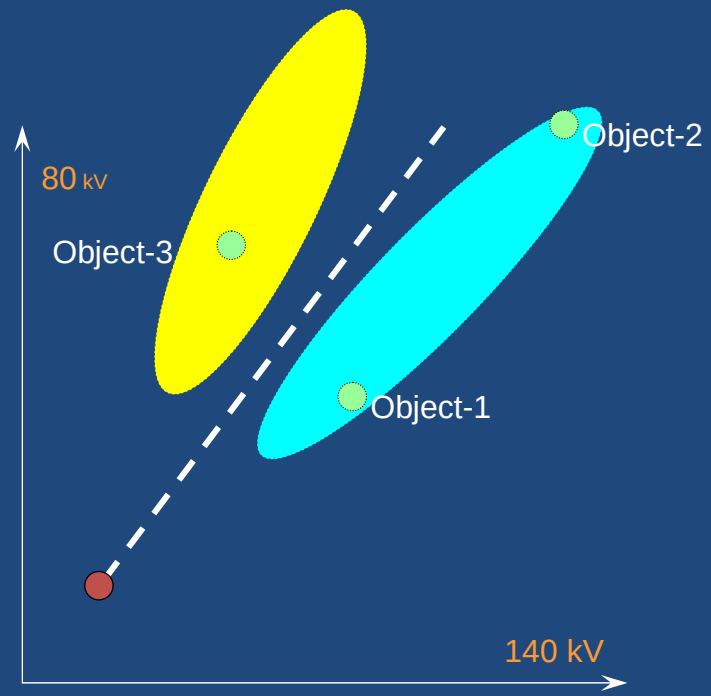




Dual Energy imaging algorithm: material decomposition

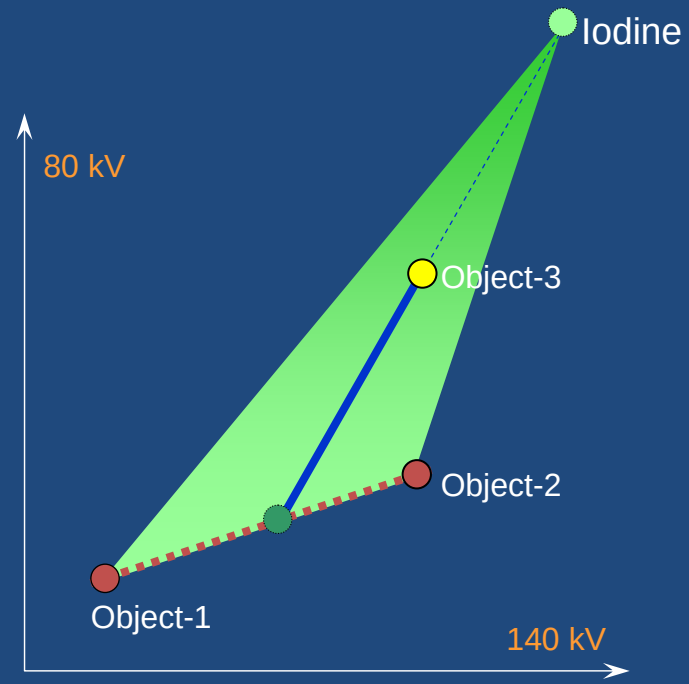
2-material decomposition

- bone removal

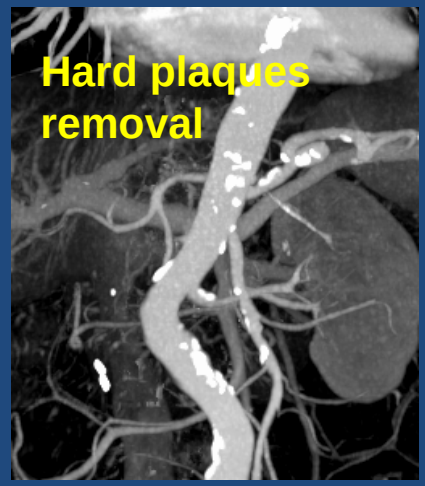


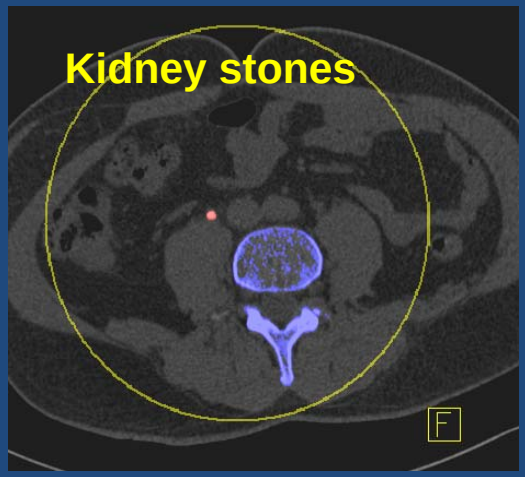
3-material decomposition

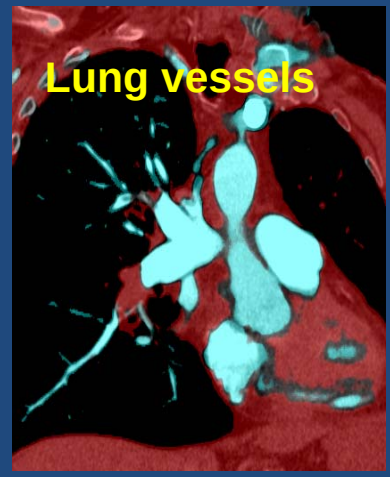
- VNC
- contrast map



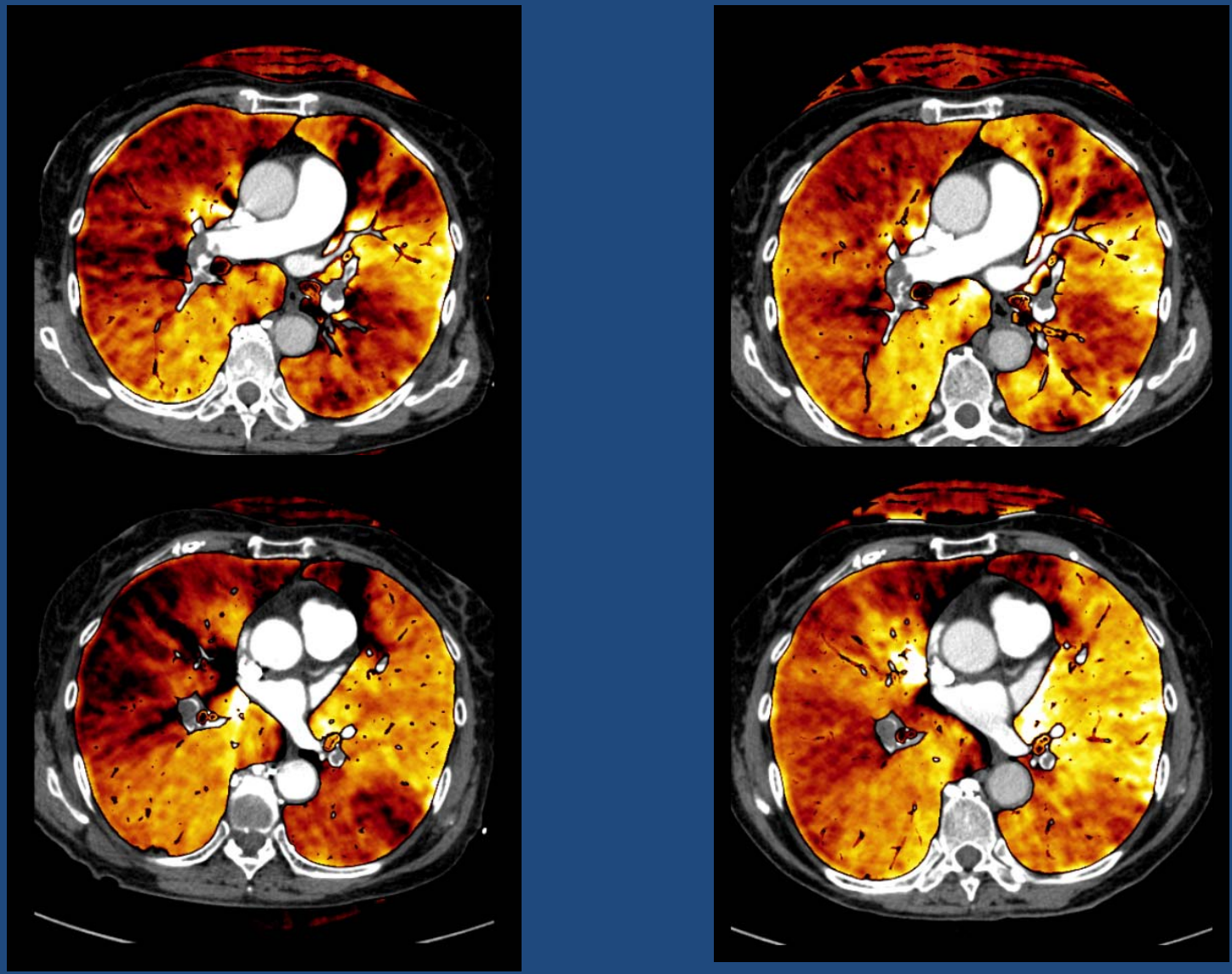
Dual Energy Applications for 2-material decomposition







Case 1 ; Acute PTE



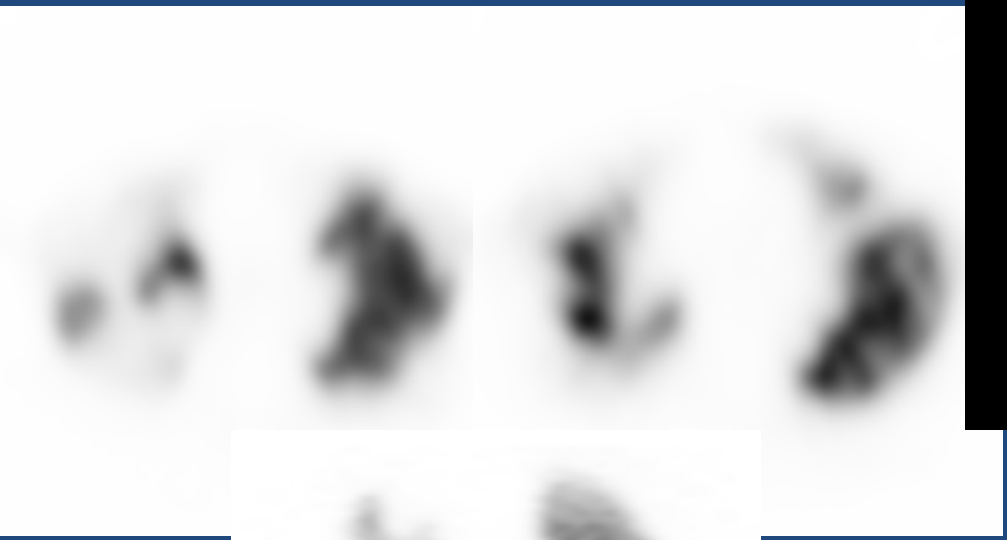
1st CT

LPBV ; WL=25, WW=55

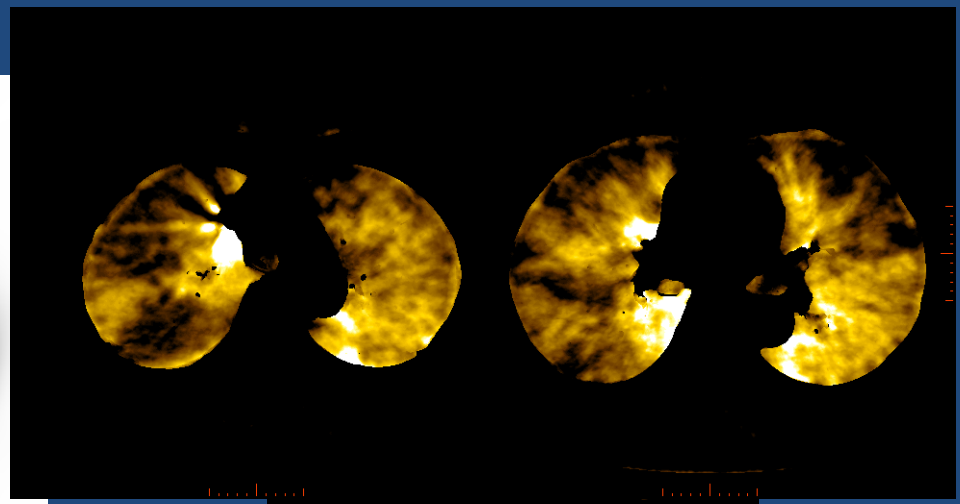
2nd CT
5 hours after arrival

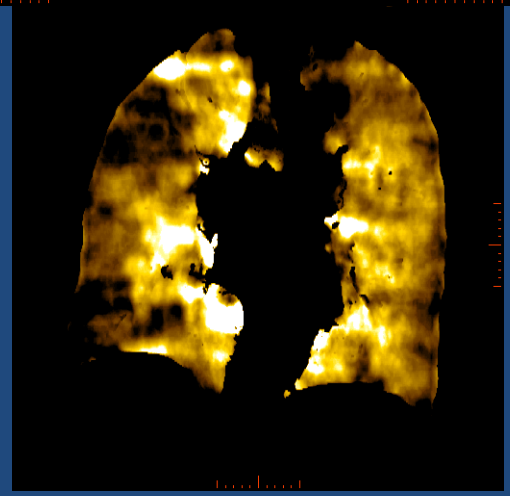
Case 2 ; CTEPH

70 F dyspnea on effort



No thrombus was detected in CE-CT



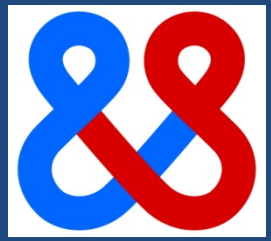


Wedge-shaped defect on PBV image

→ Wedge-shaped defect on scintigraphy

Characterization of Atherosclerotic Plaque by MRI

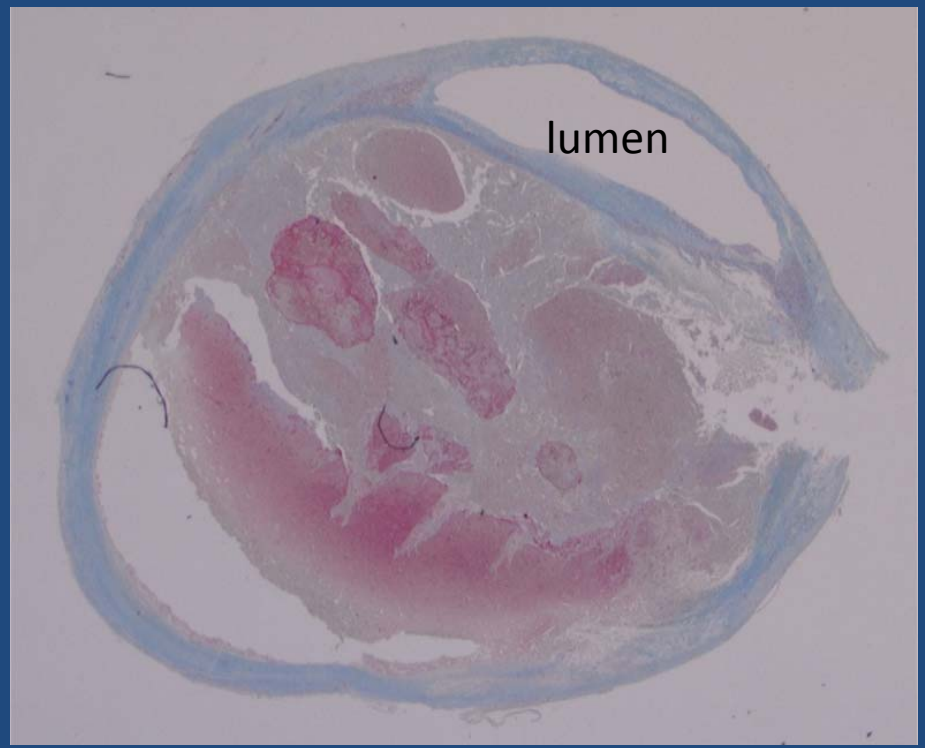
National Cardiovascular Center



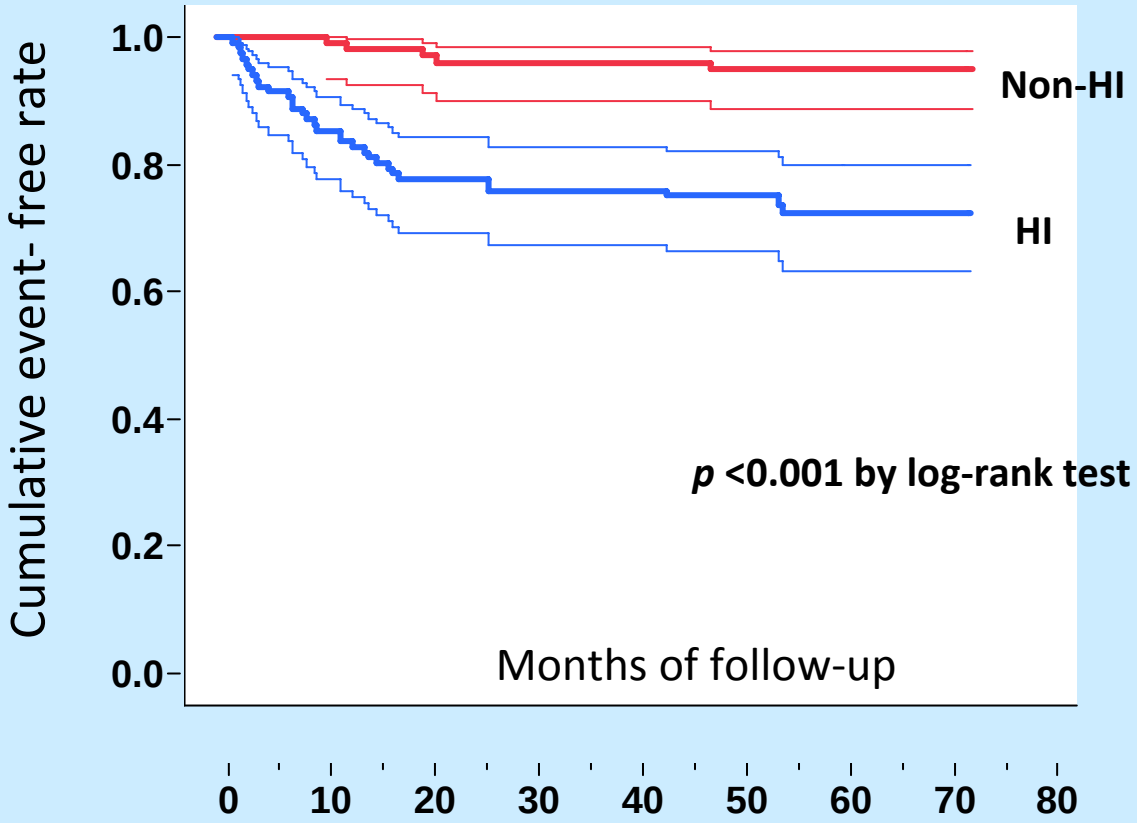
MPRAGE high signals (arrow) indicates a soft and hemorrhagic lipid-rich core

MPRAGE

Masson trichrome



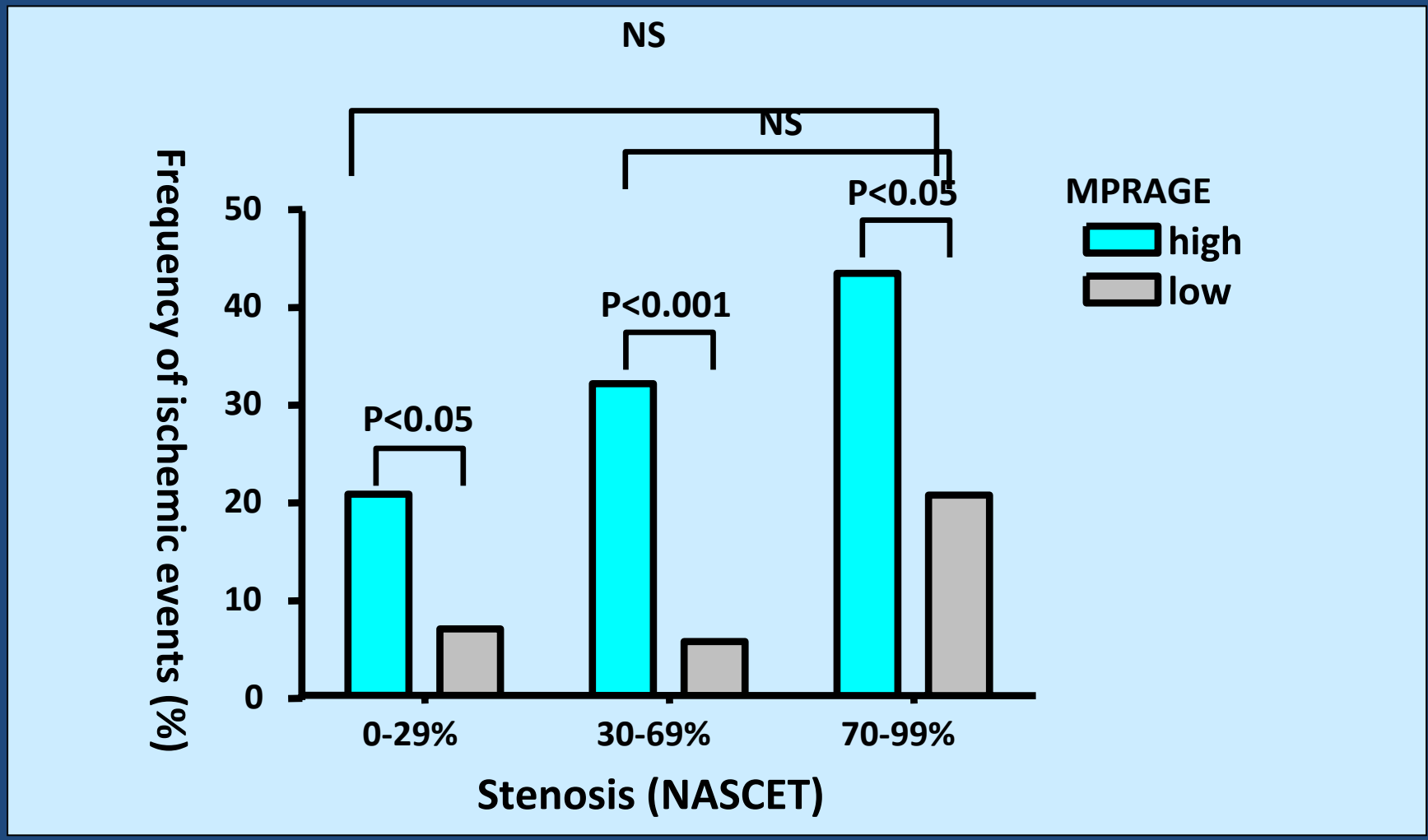
High-intensity (HI) signals in carotid plaques on T1-weighted magnetic resonance imaging predict coronary events in patients with coronary artery disease



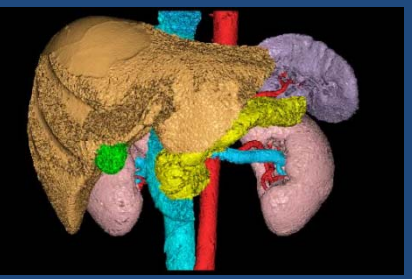
Noguchi T, Yamada N, Higashi M, et al. J Am Coll Cardiol 2011;58:416-422

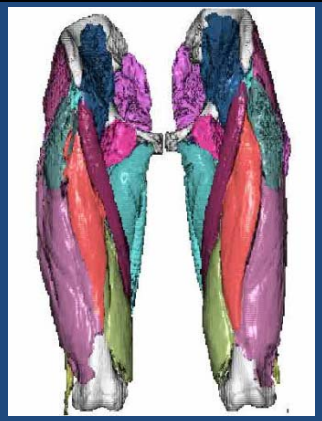
Risk of ipsilateral ischemia according to MPRAGE signal intensity and stenosis of carotid arteries

AJNR 2007;28:287-292, Yamada et al.



Automated Segmentation and Anatomical Identification of CT Data



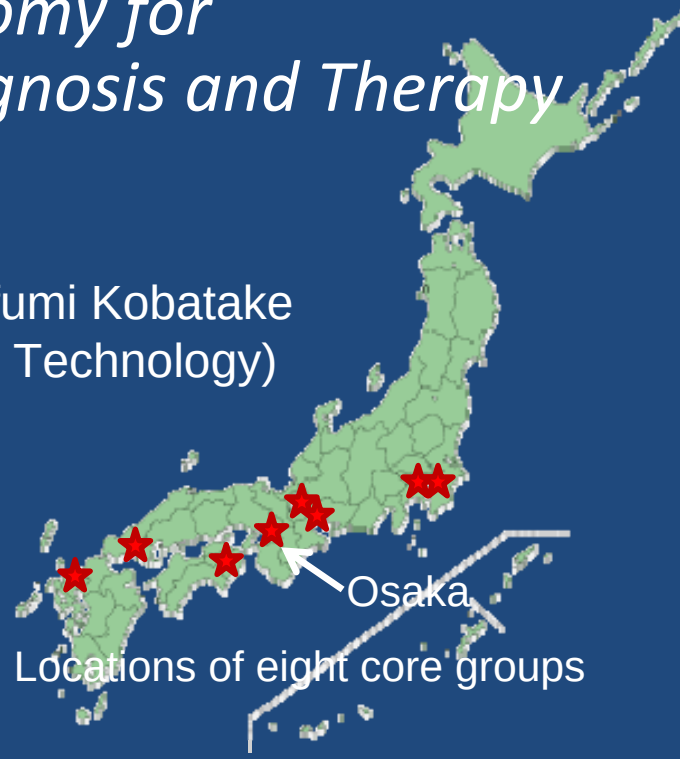


Grant-in-aid for Scientific Research, MEXT, Japan

Computational Anatomy for Computer-Aided Diagnosis and Therapy

Sep 2009 - Mar 2014
Fund: $10 million
Principal Investigator: Prof. Hidefumi Kobatake
(Tokyo University of Agriculture & Technology)
Eight core groups

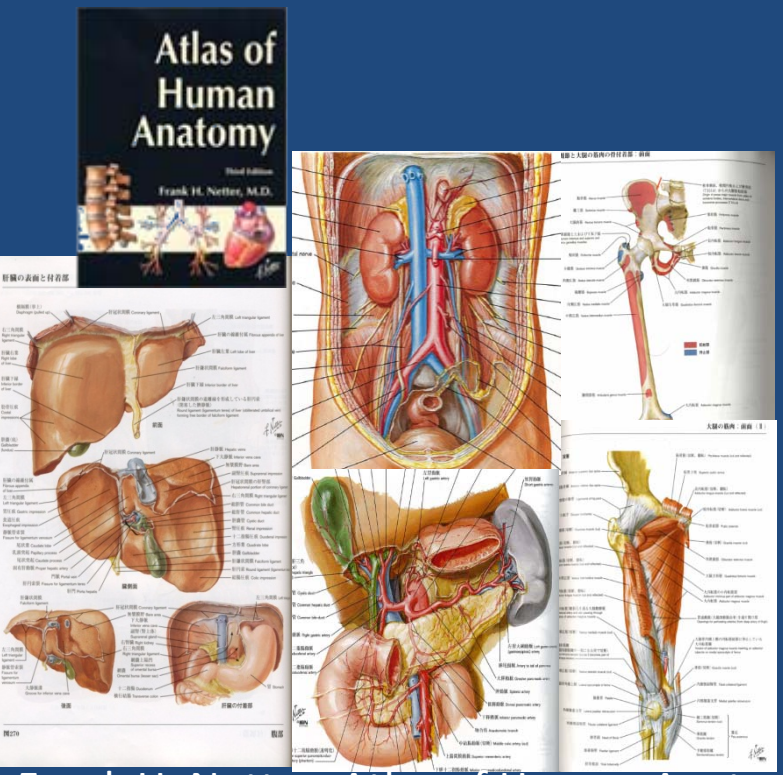
http://www.comp-anatomy.org/



Locations of eight core groups

Conventional Atlas of Human Anatomy

- Book Atlas
  - Detailed illustrations of typical anatomy



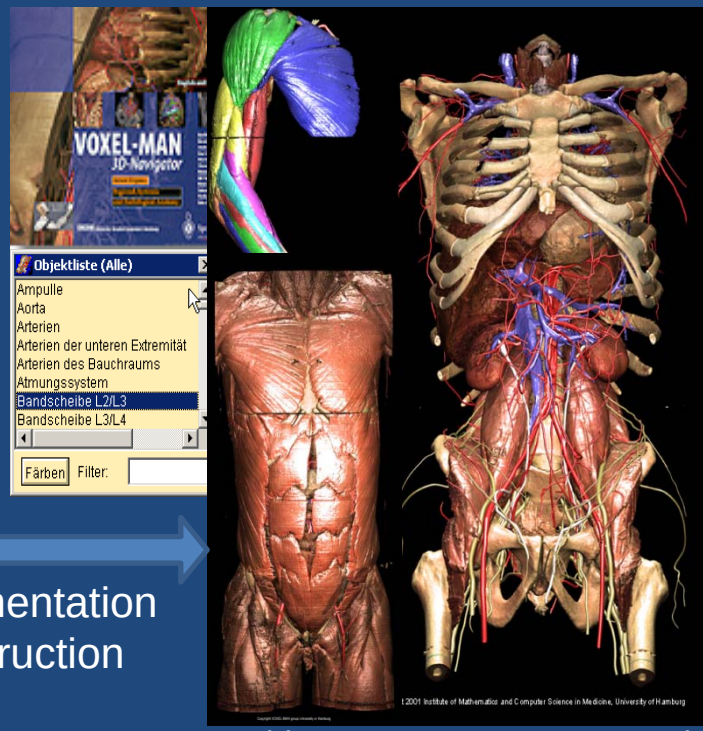
Frank H. Netter, Atlas of Human Anatomy

- 3D Digital Atlas
  - Detailed segmented 3D data of a specific subject

Visible Human data (NIH)

Manual segmentation & 3D reconstruction

VOXEL-MAN (Univ. Hamburg)



http://www.voxel-man.de/

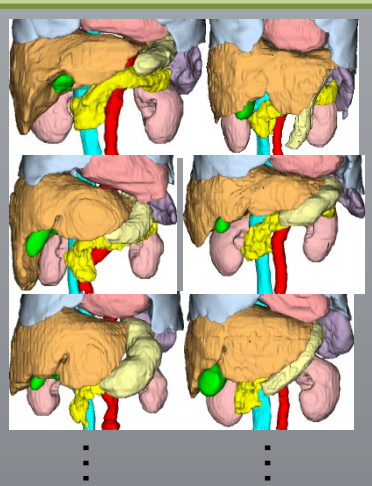
Not intended for utilization in reconstructing an individualized atlas from 3D data

Computational Anatomy Atlas

Representing Variability of Anatomy across Subjects

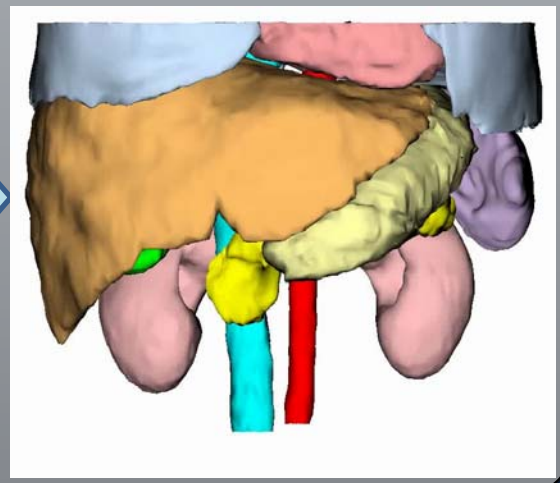
Suitable for reconstruction of ***individualized atlas*** from patient 3D data

Atlas Datasets



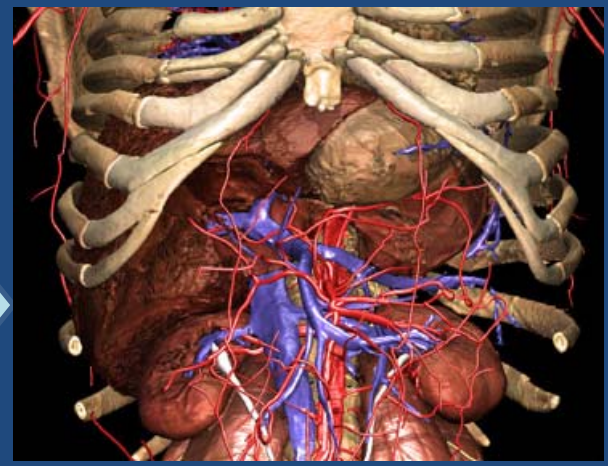
Statistical Analysis

Statistical Atlas



Individualized Atlas

(Patient-specific Atlas)



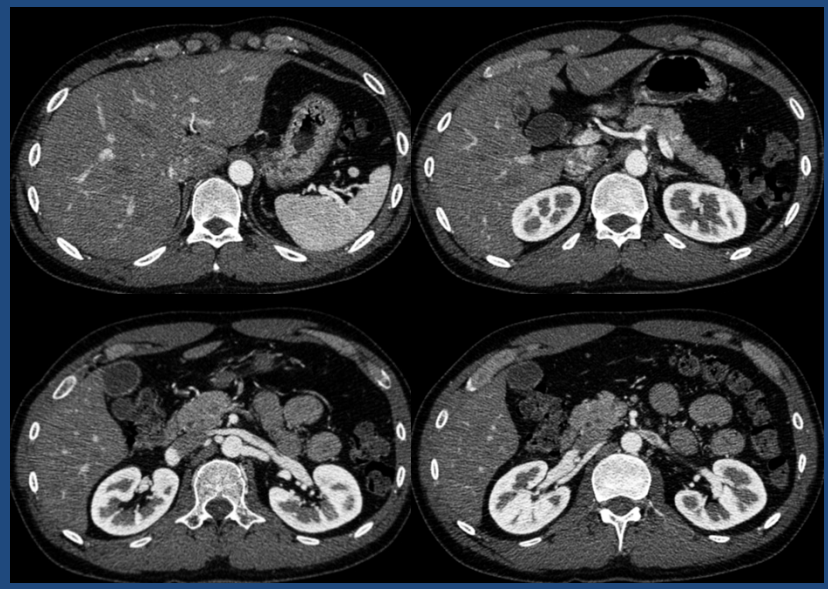
Patient 3D Data

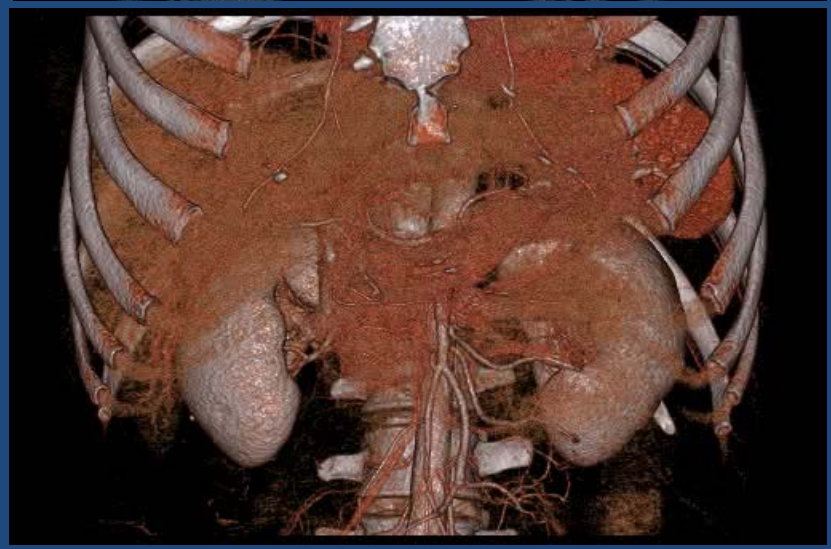
Deformable Matching

Automated Image Segmentation & Anatomical Identification

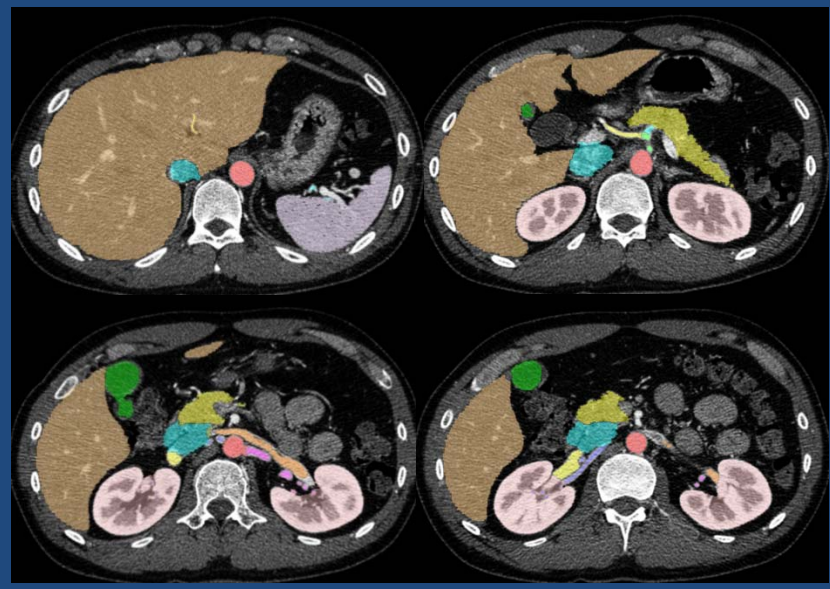
Abdominal CT Segmentation

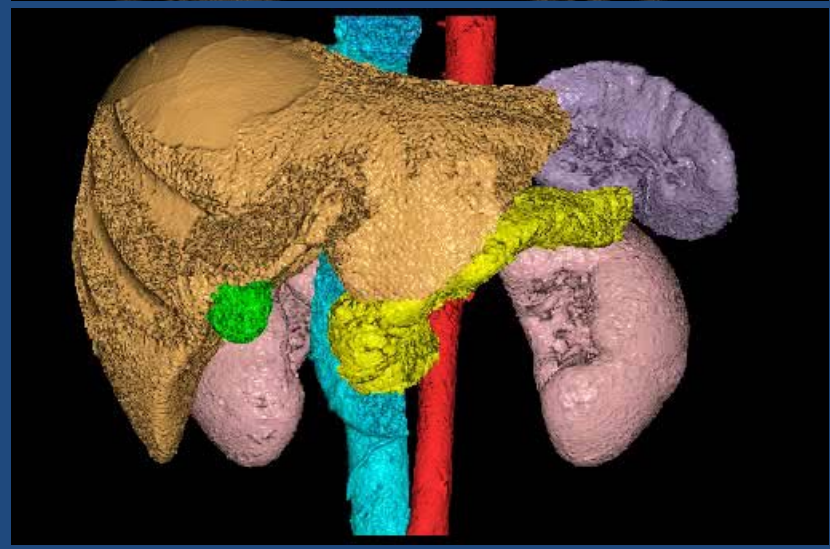
Original CT Data and Its Volume Rendering





Fully Automated Segmentation



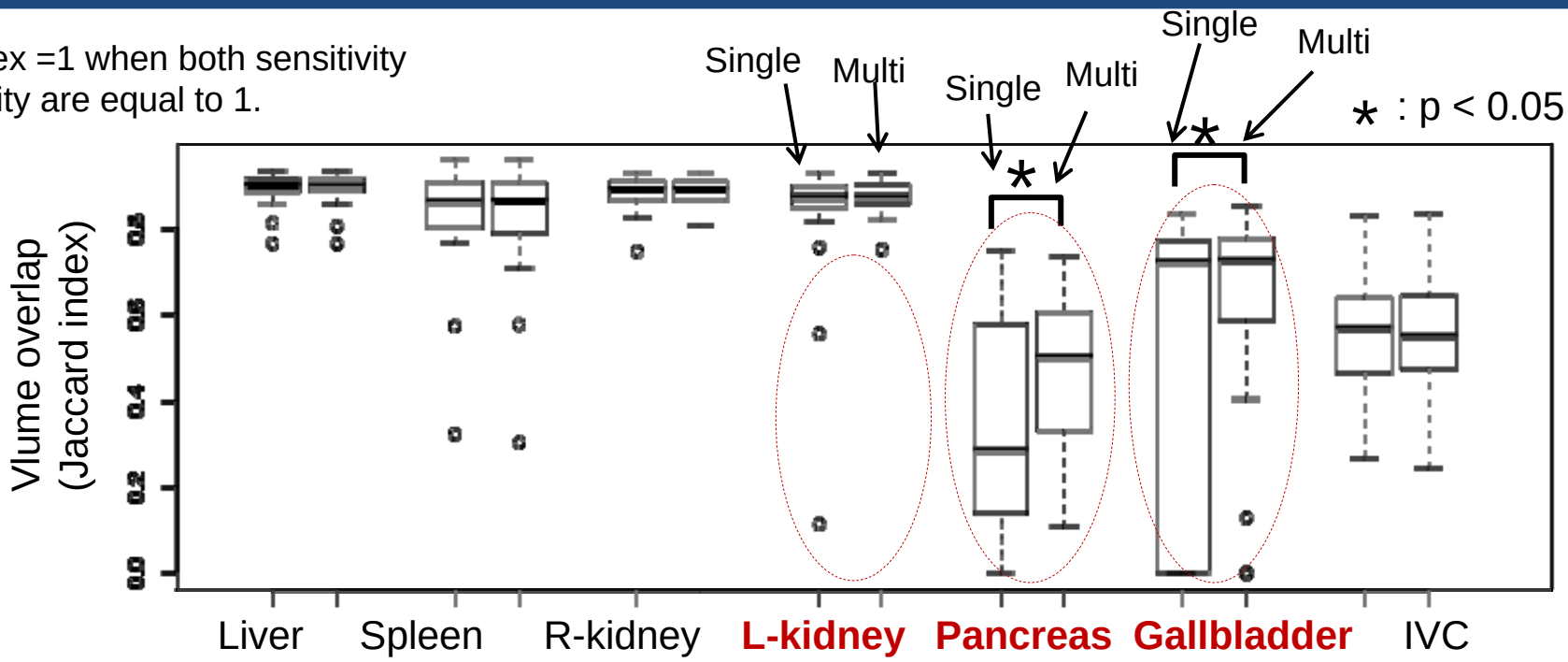


Abdominal CT Segmentation

Accuracy Evaluation: 28 Cases

A novel representation scheme for ***multi-organ atlas*** *was developed* and compared with conventional ***single organ atlas***.

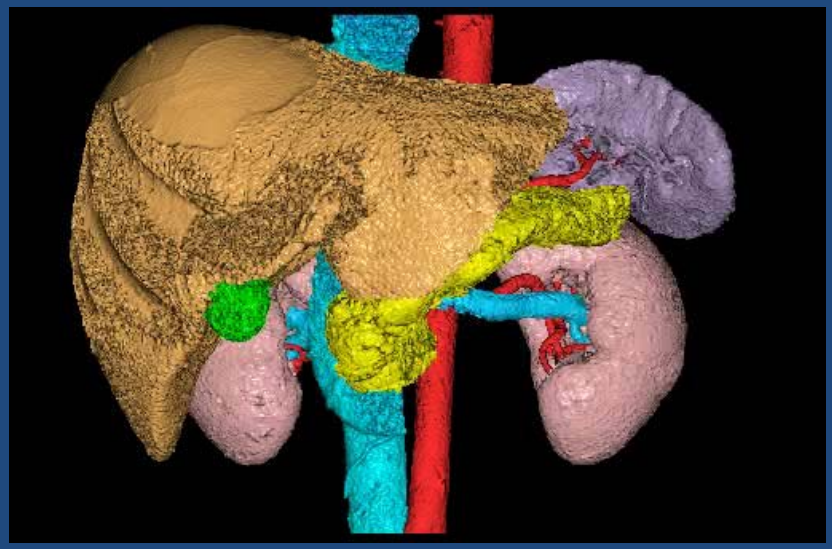
Jaccard index =1 when both sensitivity and specificity are equal to 1.

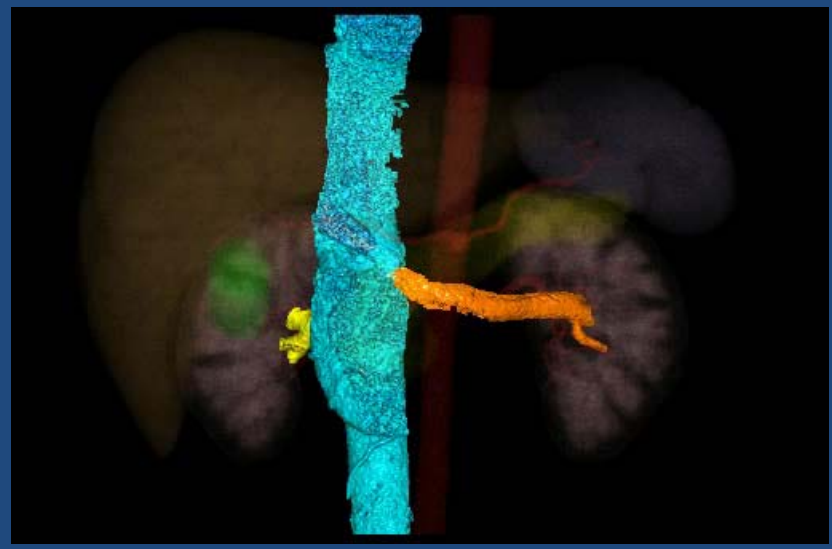


	Atlas Format	Liver	Spleen	Right kidney	Left kidney	Pancreas	Gallbladder	IVC
Average Jaccard index	Multi-Organ	0.891	0.825	0.882	0.874	0.466	0.634	0.549
	Single Organ	0.892	0.836	0.880	0.836	0.348	0.530	0.545

Automated Vessel Identification

Fully automated vessel identification by finding vessel branches between segmented great vessels and organs





Summary

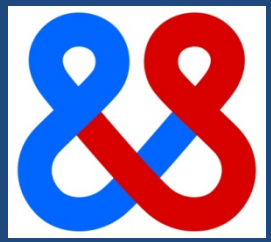
- Fully automated segmentation and anatomical identification of CT data were demonstrated.
- ***Automated multi-organ segmentation and anatomical identification*** in the abdominal and musculoskeletal domains has not been reported so far, excepting a couple of preliminary reports.
- ***Computational anatomy atlas*** plays an important role for accurate automated segmentation.
- Segmentation accuracy is approaching to a clinically acceptable level.
- Therefore, it will become clinically useful in near future.

Thank you for your attention

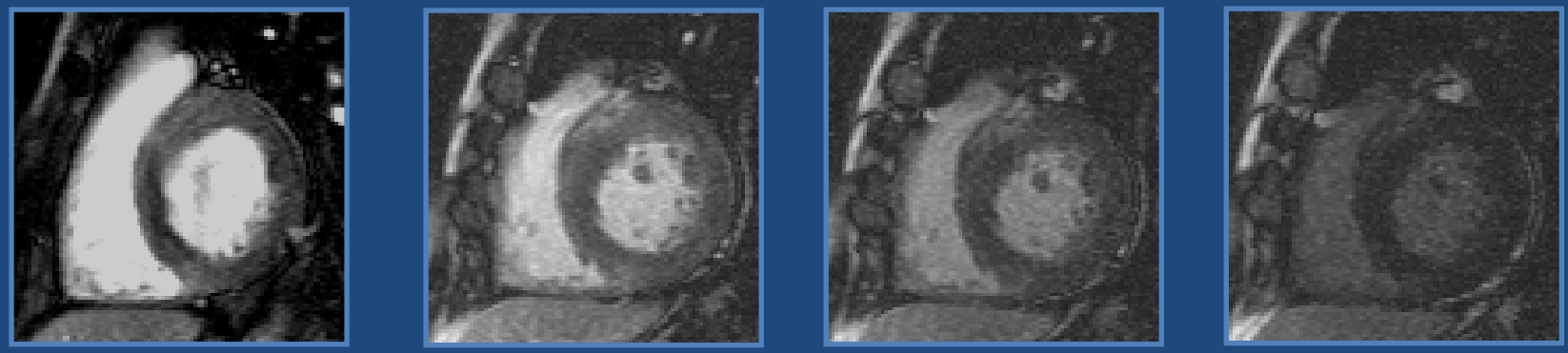
以下保留

Late Gadolinium Enhancement of Myocardium

National Cardiovascular Center

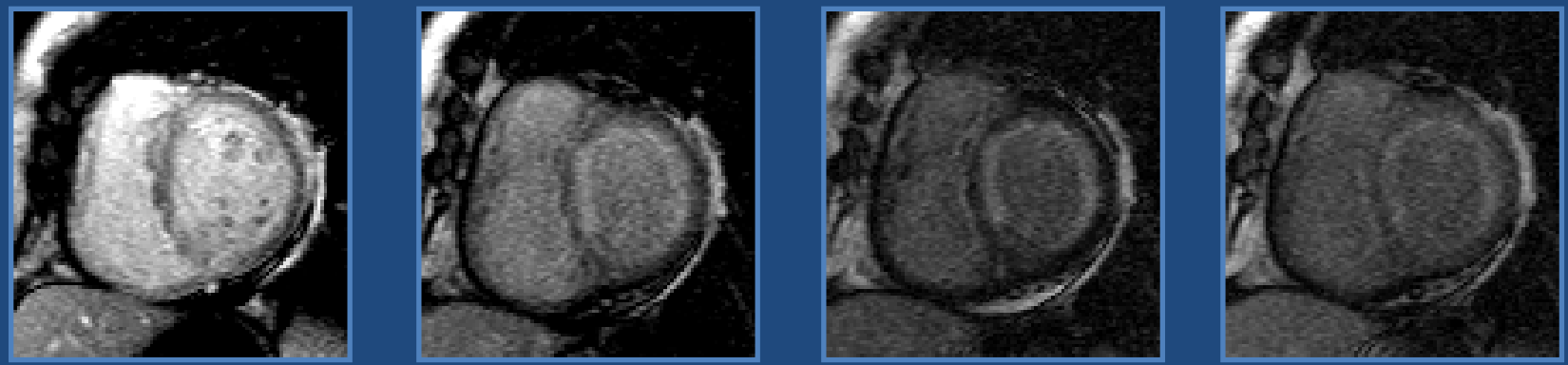


Examples of late gadolinium enhancement



HCM

M/L (average) 0.29 0.34 0.45 0.89

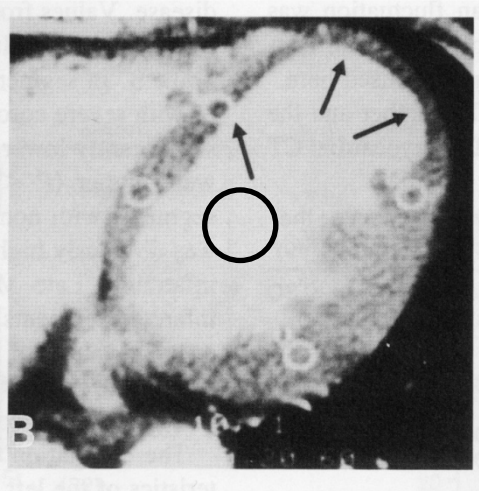


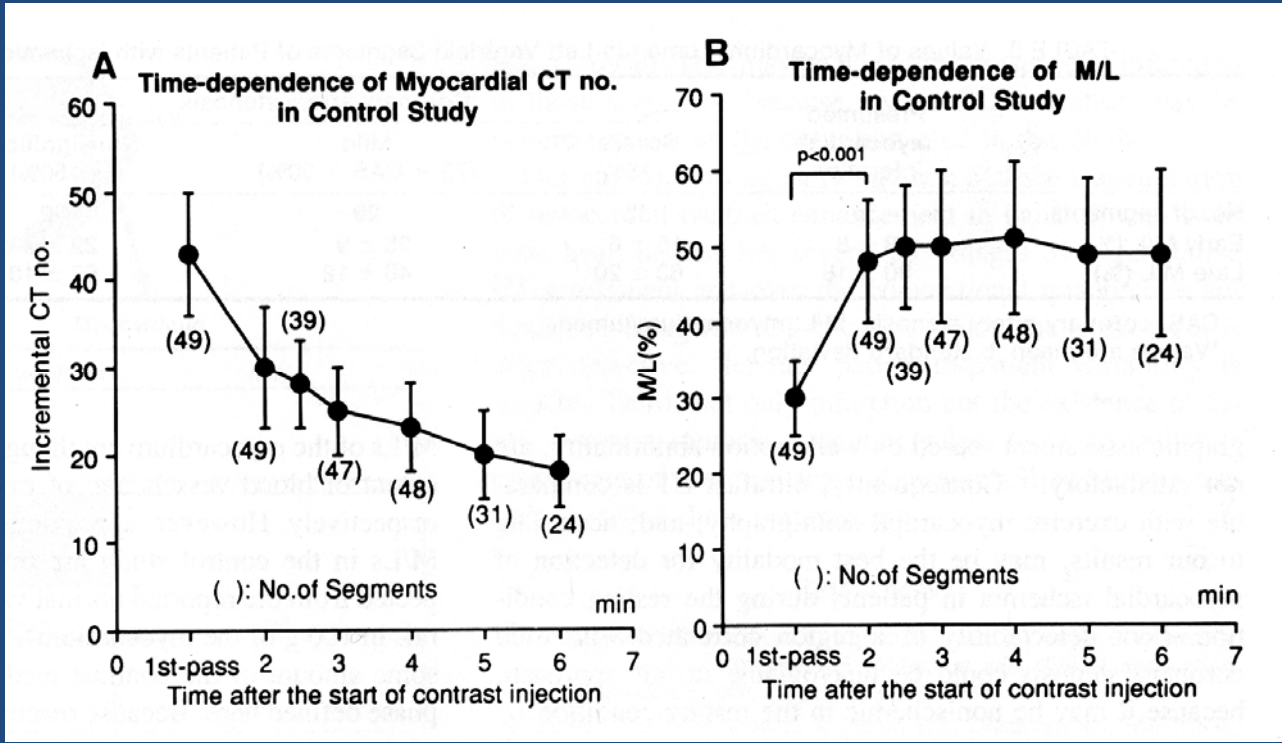
CA

M/L (average) 1.19 1.17 1.05 1.10

M/L: myocardium to lumen signal ratio

Distribution of contrast medium in normal myocardium as a function of time

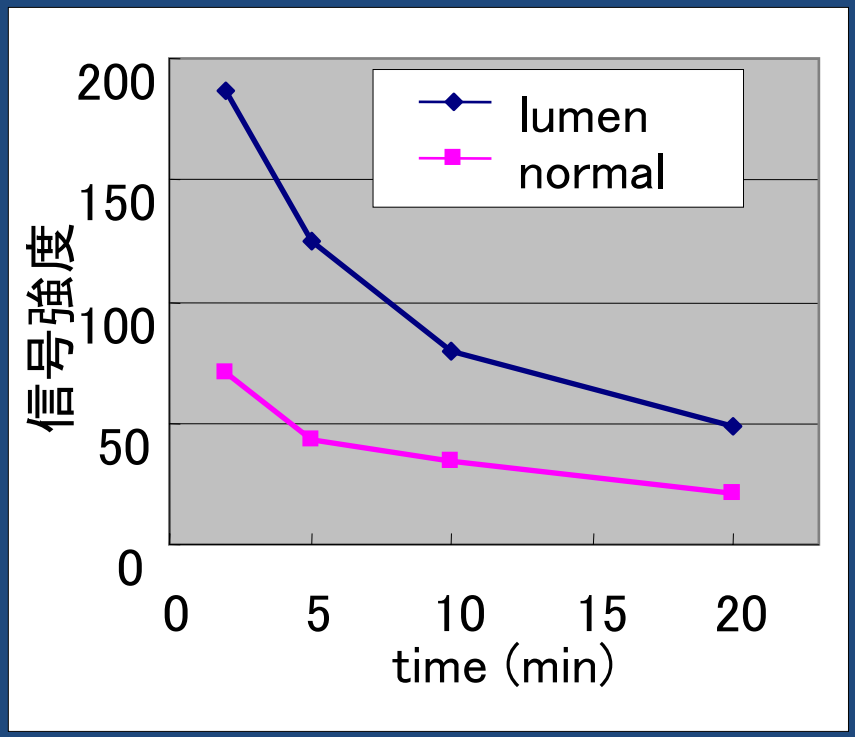


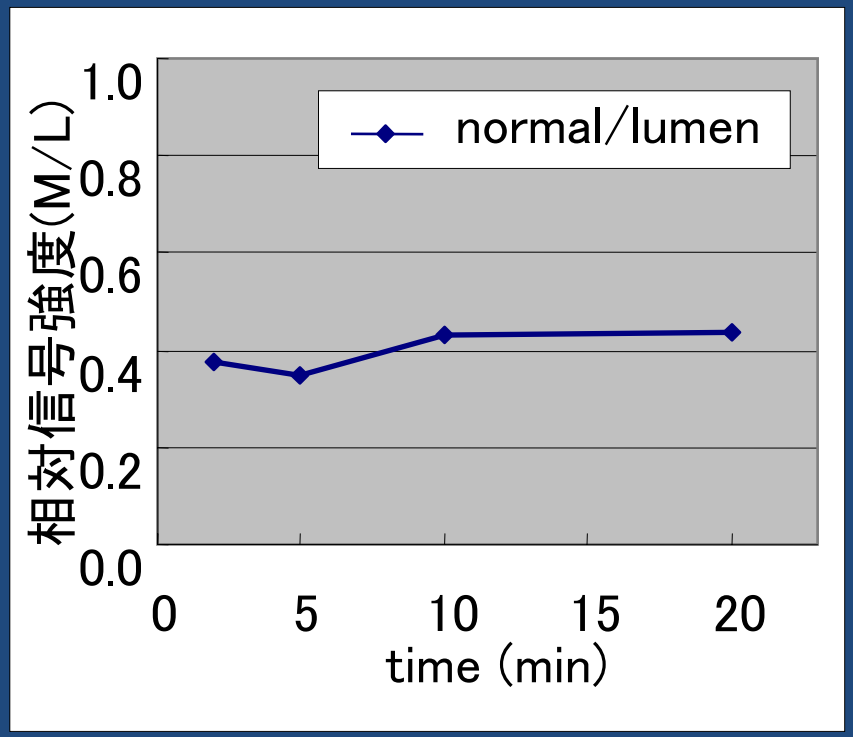


M/L = ΔM ／ΔL is in an equilibrium after 2 minutes of contrast injection.
ΔM(increment of CT value in myocardium)
ΔL (increment of CT value in blood)

Naito H, Invest Radiol 1992; 27:436-42.

MR contrast media have similar behavior to Iodine contrast media

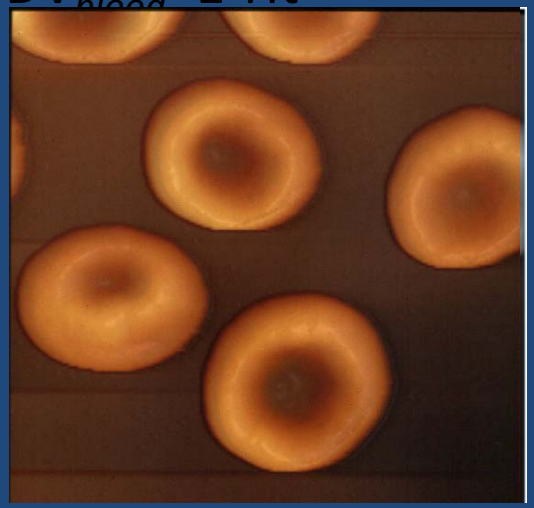




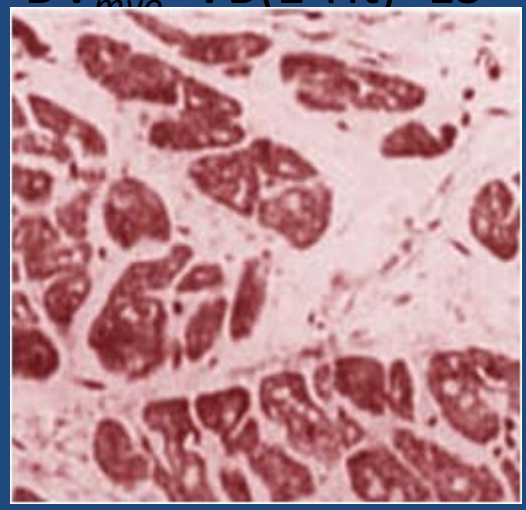
CT and MR contrast media distributes in the extracellular space

MR contrast media distributes in the extracellular space

血液中
（赤血球外）
DV_{blood}=1-Ht



心筋内
（血管内赤血球外＋細胞外液）
DV_{myo}=VB(1-Ht)+ES



DV: Distribution Volume (分布体積), VB: Vascular Bed (血管床)
ES: Extstra-cellular Space (細胞外液腔)
λ（分配係数）＝組織の造影剤濃度/血中造影剤濃度＝組織のDV/血液のDV

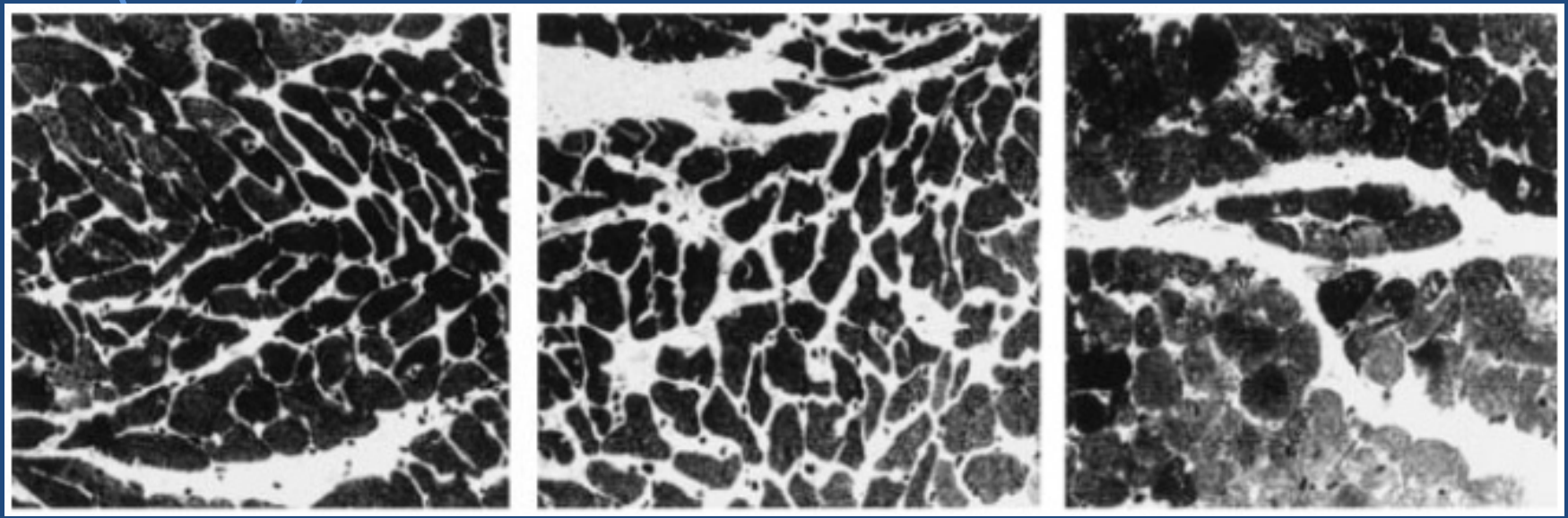
Normal and infarcted myocardiums in experimental rats

Arheden, Radiology 2000;215:520-8

Experimental rats, ischemia + 1hr reperfusion

1% toluidine blue dye染色

Pre (Normal) **20min ischemia** **60min ischemia**

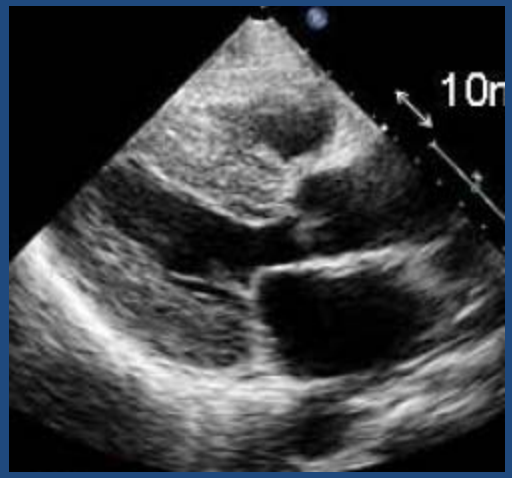


- 20min ischemiaでは染まりの薄い細胞有り（細胞壊死、浮腫）、心筋細胞がまとまりを失う。
- 60min ischemiaでは大半の細胞が壊死、腫脹し、染まりが薄い。

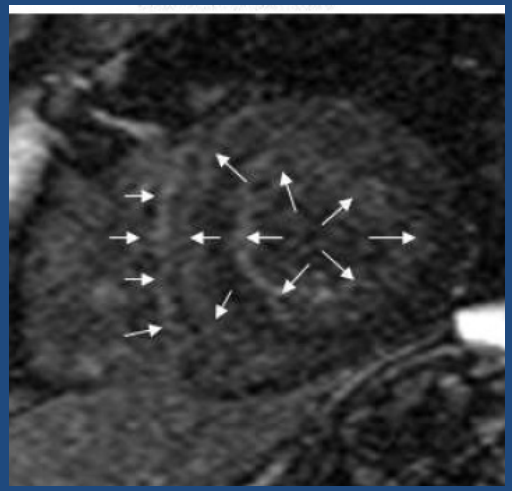
Cardiac amyloidosis

deposition of amyloid protein and enlargement of extracellular space

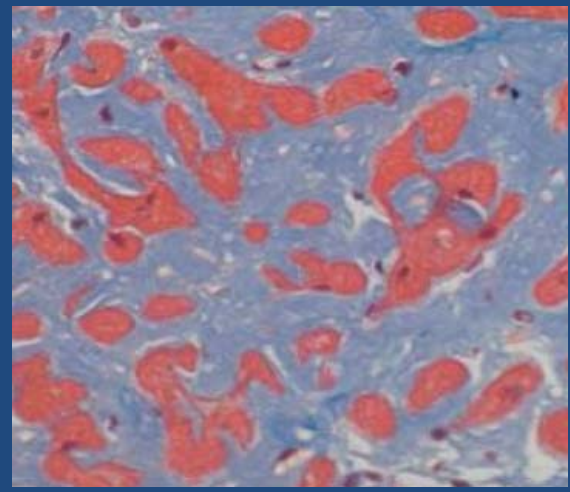
US



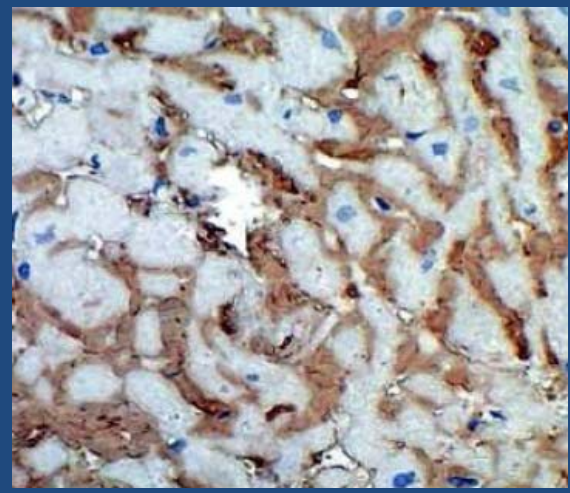
LGE



Masson

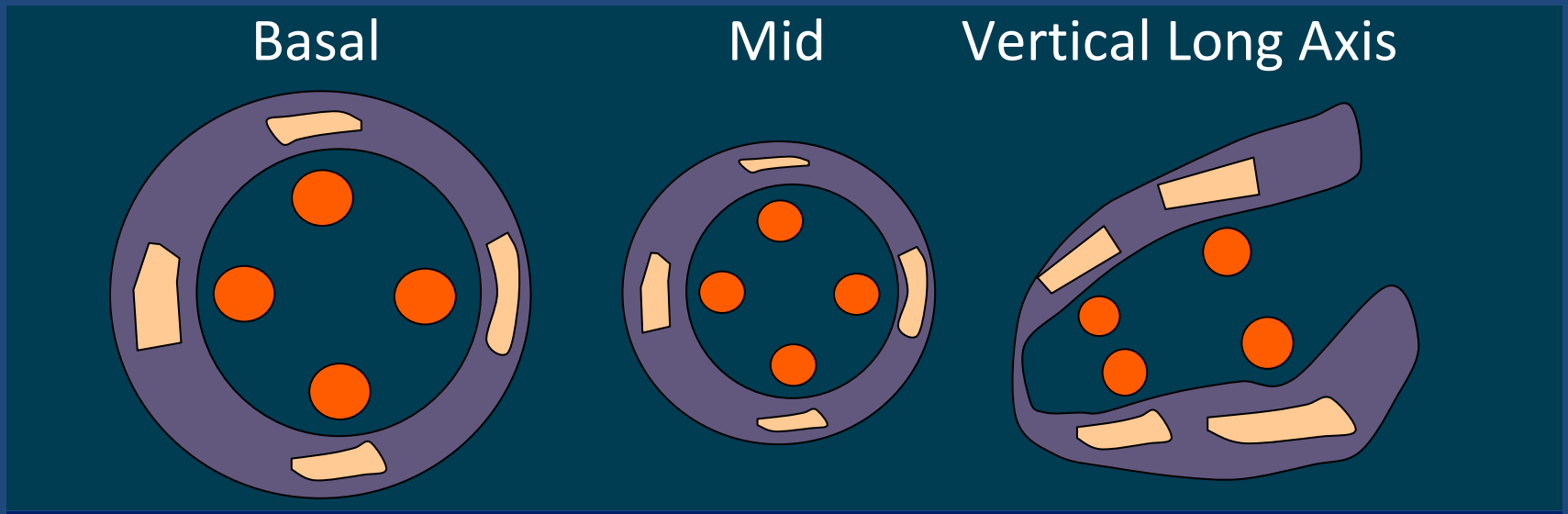


ATTR



Measurement of M/L

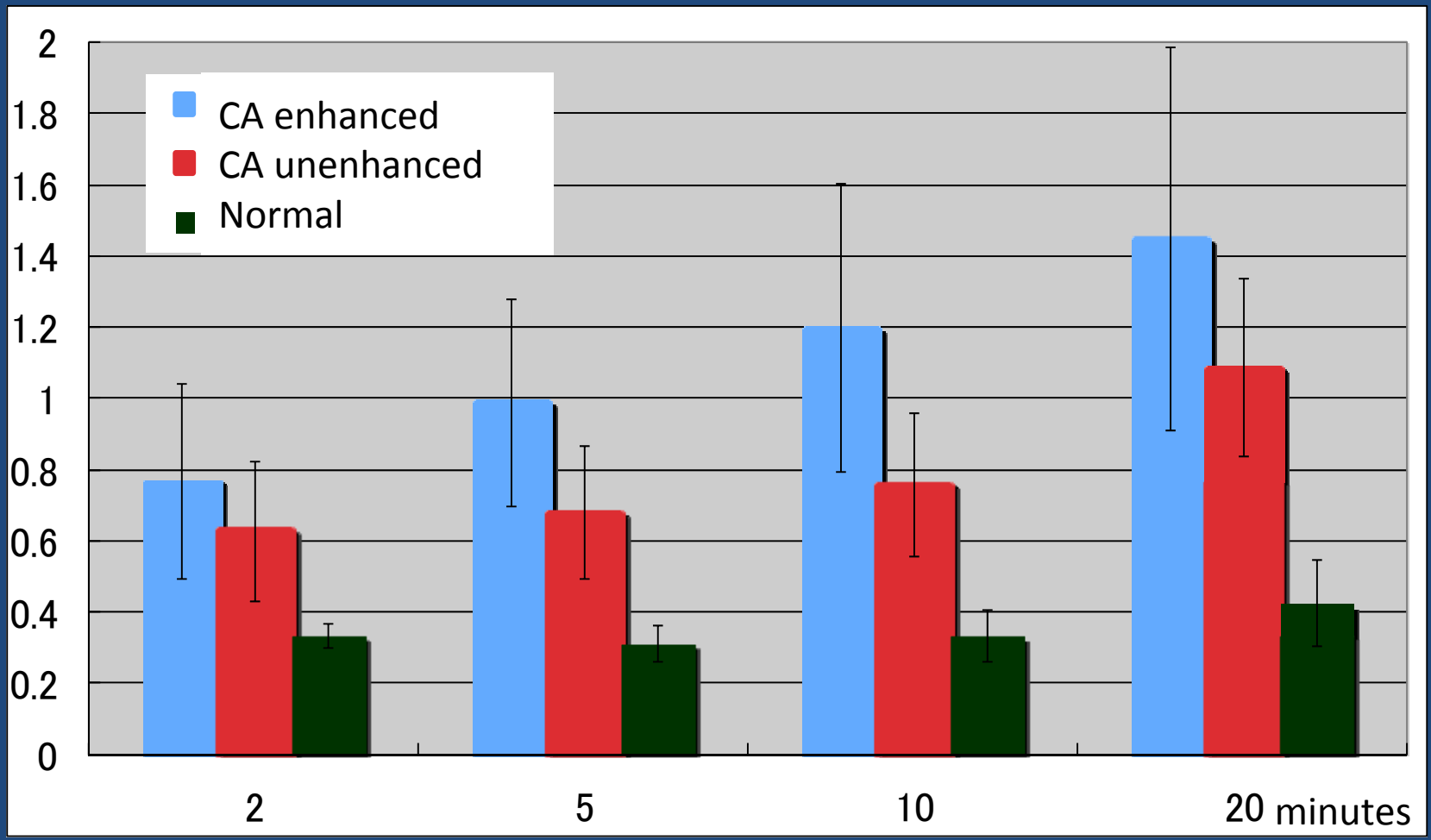
- Polygon ROI in the myocardium
- Circular ROI in the LV lumen nearby the myocardium



$M/L = SI_{myocardium} / SI_{lumen}$

Dynamic late gadolinium enhancement

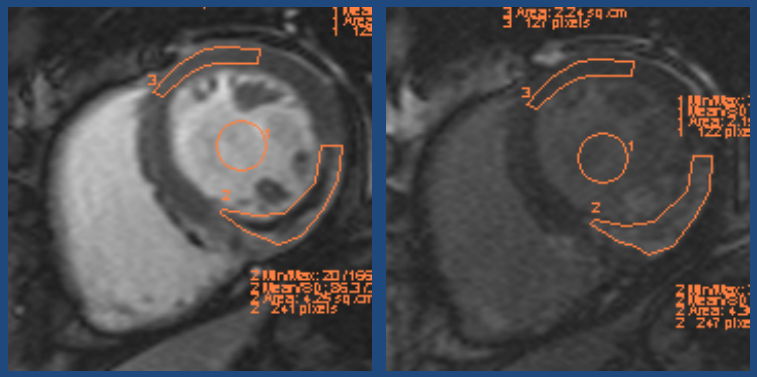
Kono AK, Yamada N, Higashi M, et al. *JMRI 2011;34:50-55*



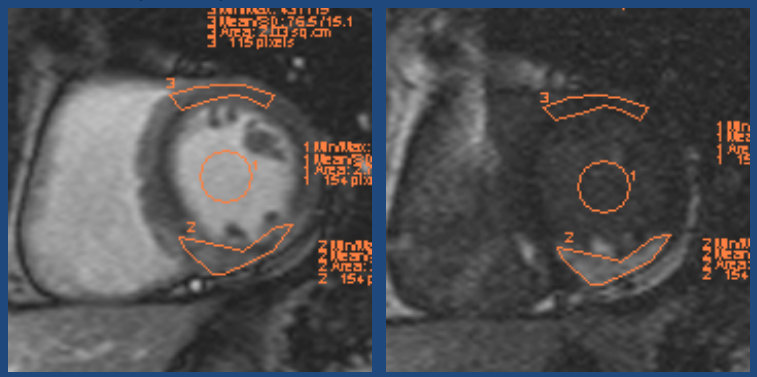
Kono AK, Yamada N, Higashi M, et al. JMRI 2011;34:50-55

Comparison of LGE between AMI and OMI

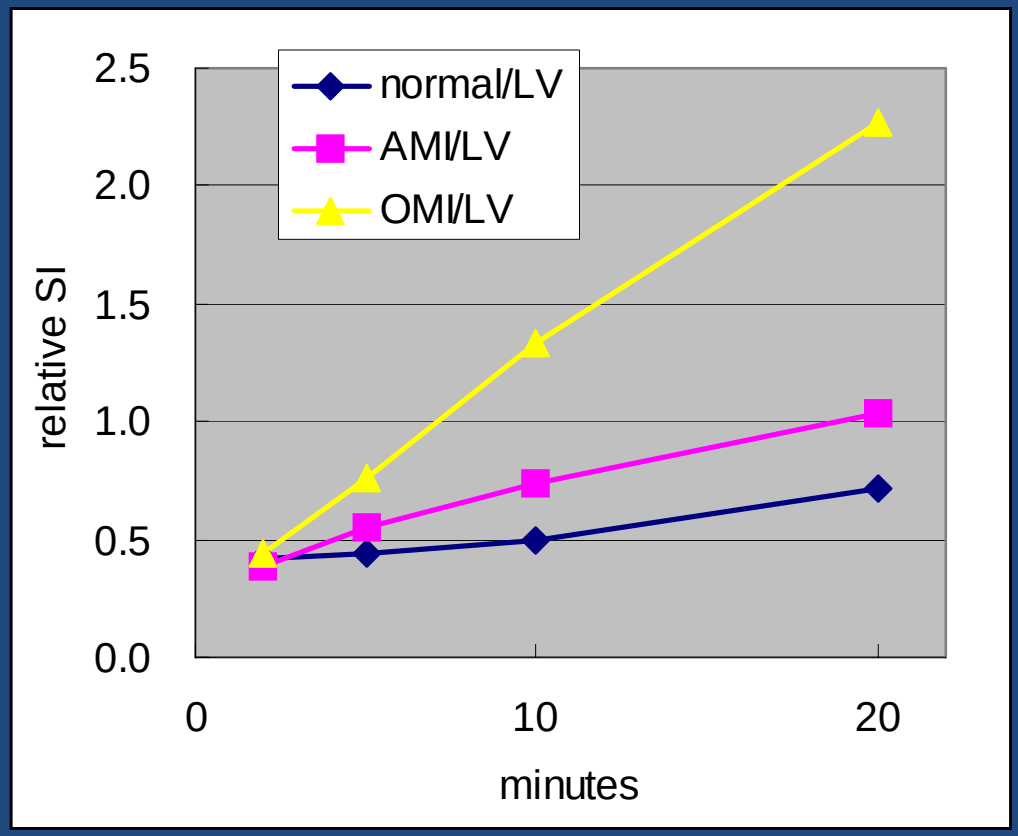
AMI (5d)



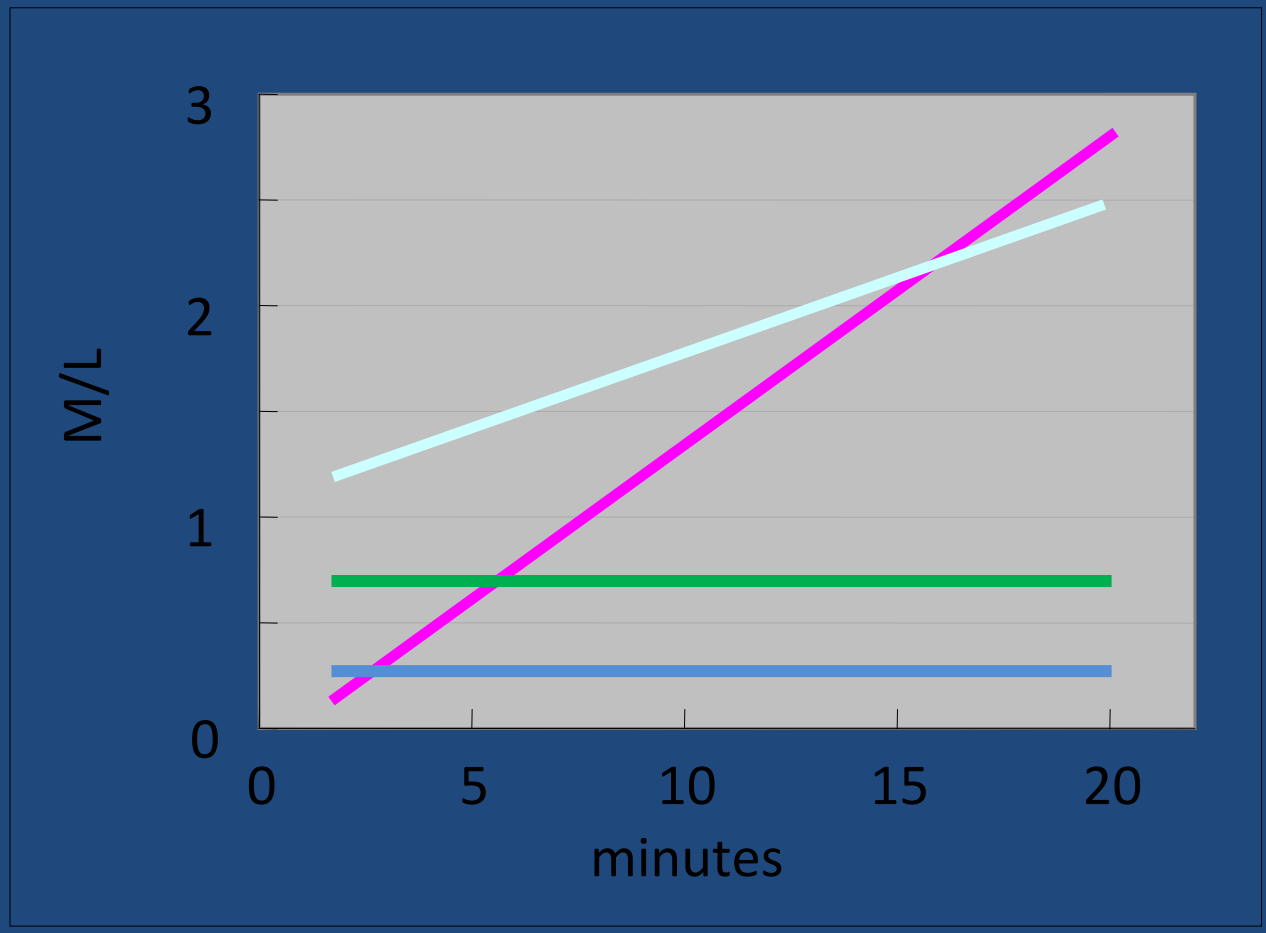
OMI (8m)



2min 3min



Dynamic LGE of various myocardial diseases



Fibroma, Fabry, MI

Amyloid, MI
Sarcoid, Fabry

Myocarditis,
Takotsubo, Peri-
infarct zone

Normal

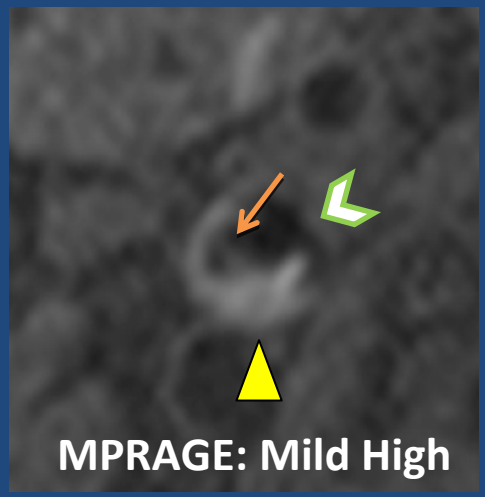
DV: Distribution Volume of contrast media

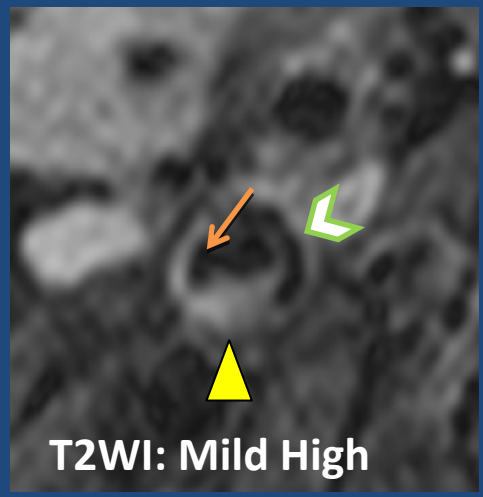
Mechanism of late gadolinium enhancement

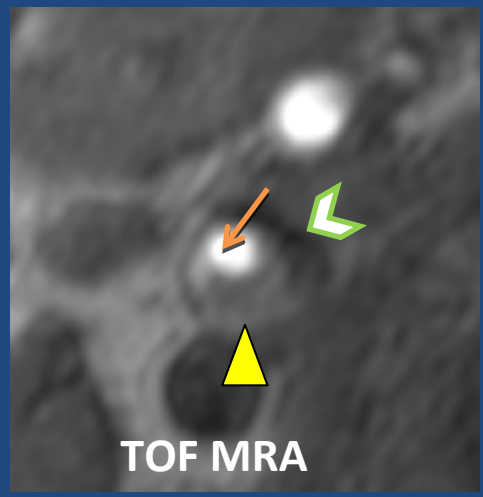
- Volume of extracellular space
- Vascularity
- Permeability of contrast medium through the capillary vessel wall

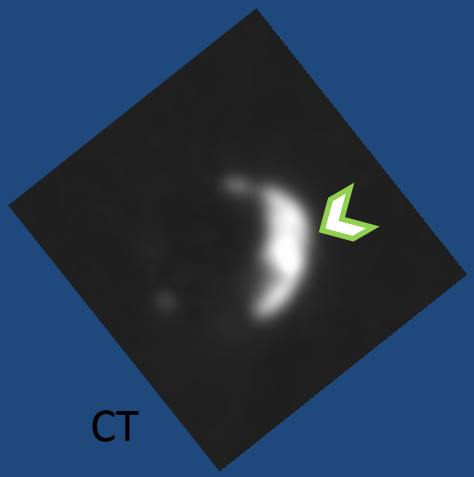
Complicated plaque (AHA type VI)

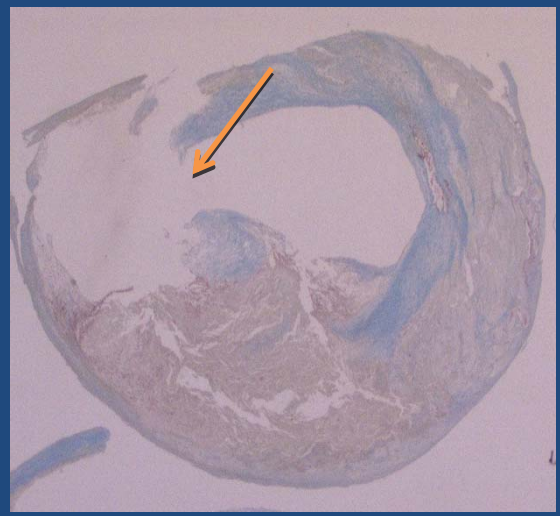
Rupture（arrows）、Lipid rich core（arrowheads）、Calcification

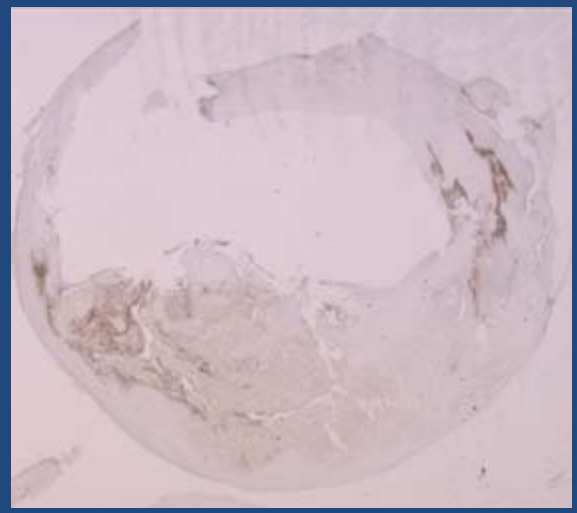






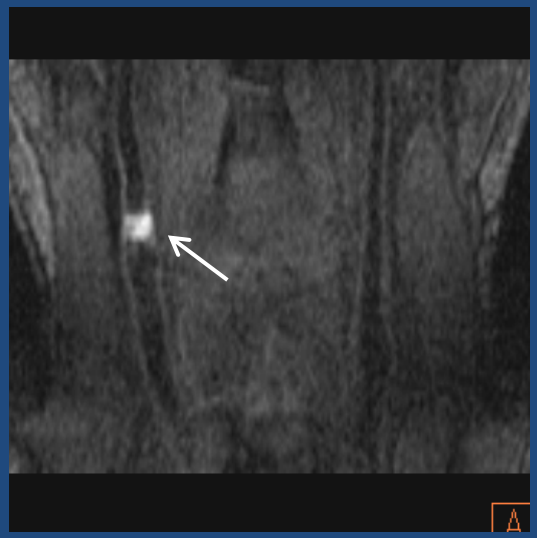



Masson

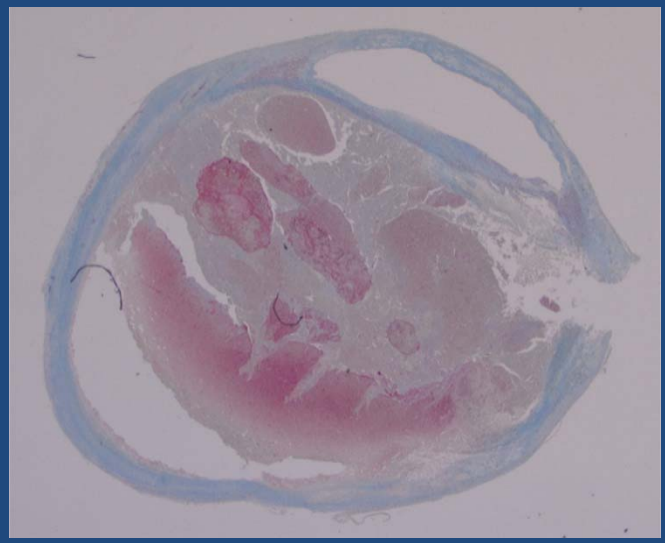

Anti-Glycophorin A

MPRAGE high signals indicates a soft and hemorrhagic lipid-rich core

MPRAGE

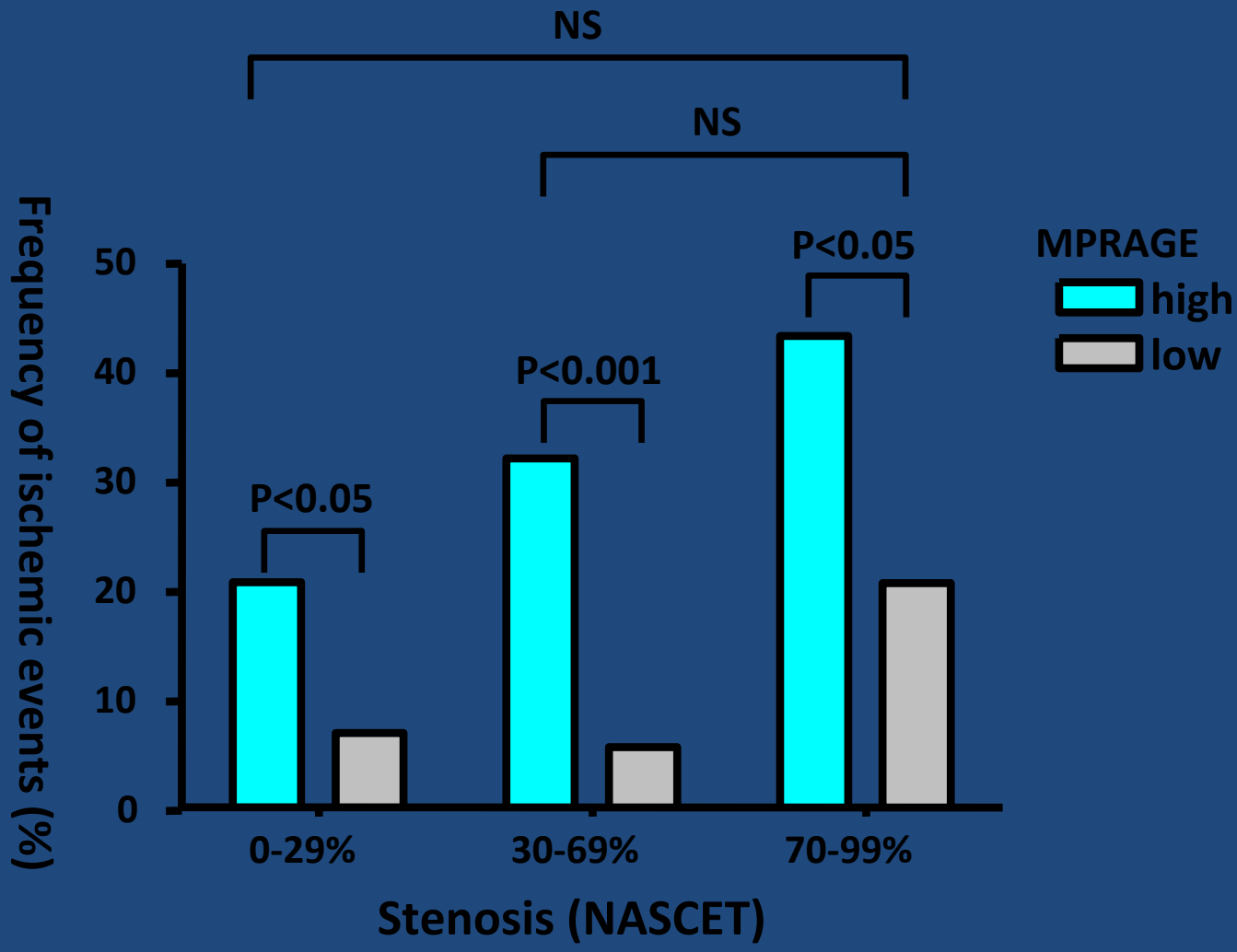


Masson trichrome



Risk of ipsilateral ischemia according to MPRAGE signal intensity and stenosis

AJNR 2007;28:287-292, Yamada et al.



1.拘束性障害（%VC＜80%）
2.拡散障害（%DLco＜80%）
3.低酸素血症（以下のうち1項目以上）
・安静時PaO2 ：80Torr未満
・安静時AaDO2 ：20Torr以上
・6分間歩行時SpO2 ：90%以下

4. 胸部X線画像所見としては、1を含む2項目以上を満たす場合に陽性とする。

1.両側びまん性陰影
2.中下肺野，外側優位
3.肺野の縮小

5. 病理診断を伴わないIPFの場合は、下記の胸部HRCT画像所見のうち(1)および(2)を必須要件とする。特発性肺線維症以外の特発性間質性肺炎に関しては、その病型により様々な画像所見を呈する。

1.胸膜直下の陰影分布
2.蜂巣肺
3.牽引性気管支炎・細気管支拡張
4.すりガラス陰影
5.浸潤影（コンソリデーション）

1.拘束性障害（%VC＜80%）
2.拡散障害（%DLco＜80%）
3.低酸素血症（以下のうち1項目以上）
・安静時PaO2 ：80Torr未満
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3.牽引性気管支炎・細気管支拡張
4.すりガラス陰影
5.浸潤影（コンソリデーション）