PROGRESS OF DIAGNOSTIC IMAGING in JAPAN

TAKAHIRO KOZUKA, MD
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 earthquake 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. Korman)
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)

We have many chances to detect pulmonary nodules earlier.

Examination environment:
Many CT scans

Histological type:
<frequency>
# Adenocarcinoma
# Squamous cell carcinoma
# Small cell carcinoma
# Large cell carcinoma

CT finding:
nodule with ground glass opacity
Low-dose CT Lung Cancer Screening Guidelines for Pulmonary Nodule Management in the Japanese Society of CT Screening

<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>3</th>
<th>6</th>
<th>12</th>
<th>24M</th>
</tr>
</thead>
<tbody>
<tr>
<td>Screening Site</td>
<td>Screening CT</td>
<td>TS-CT</td>
<td>Stable</td>
<td>TS-CT</td>
<td>Stable</td>
</tr>
</tbody>
</table>

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

Computer-automated classification according to malignant degree of the tumor on volumetric CT

Manually surrounding the boundary between the tumor and normal lung parenchyma with a cursor on every CT slice.

Using threshold selection methods: Method-1 or Method-2

Automatic segmentation of each volume of GGO, semiconsolidation, and solid part which are included in the tumor.

Automatic calculation of 3D%solid of the tumor

3D%solid = 0
- GGO (Type 1)
- Semiconsolidation (Type 2)

0 < 3D%solid < 35.4
- Solitary solid part (Type 3)
- Solid parts which have air-bronchogram or are distributed in the punctate shape or

3D%solid ≥ 71.5
- Type 6

3D%solid ≥ 35.4
- Type 5

3D%solid < 71.5
- Type 4
A lung cancer of a 68-year-old woman

**Green area** is the highlighted boundaries between tumors and normal lung parenchyma.
Automatic Analysis of Lung Cancer

- Volume of Tumor 9.13ml
- \( \text{(Otsu)} \) \( \text{(Kittler)} \)
- % 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
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.
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## 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
- Hypervascular HCC

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

### Kupffer phase
- 15 min after Sonazoid IV
- Hypo-enhanced at Kupffer imaging in the post-vascular phase (after 10 min)
Multiphase MDCT

Arterial phase

Equilibrium phase

Gd-EOB-DTPA-enhanced MRI

Arterial phase

Hepatobiliary phase

HCC
Combined CT-angiography system

Flat-panel C-arm

CTAP (CT during arterial portography)

CTHA (CT during hepatic arteriography)

HCC
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)

**Images:**
- Pre
- Post 1st TAE
- Post 2nd TAE
Uncertainty to achieve complete coagulation (>2cm or adjacent to major vessels)

RFA within 1 week after TACE
CT guided to target Lipiodol

To enhance local tumor control
(cooling effect ↓ coagulation volume ↑)
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/m²/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%

Dual-Source CT (SOMATOM Definition Flash)
X-ray energy and materials attenuation
Dual Energy imaging algorithm: material decomposition

2-material decomposition
- bone removal

3-material decomposition
- VNC
- contrast map

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material decomposition

2-material decomposition
- bone removal

3-material decomposition
- VNC
- contrast map
Dual Energy Applications for 2-material decomposition

- Head bone removal
- Tendon
- Hard plaques removal
- Body bone removal
- Kidney stones
- Gout
- Lung vessels
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 scintigraphy

Wedge-shaped defect on PBV image
Characterization of Atherosclerotic Plaque by MRI

National Cardiovascular Center
MPRAGE high signals (arrow) indicates a soft and hemorrhagic lipid-rich core.
High-intensity (HI) signals in carotid plaques on T1-weighted magnetic resonance imaging predict coronary events in patients with coronary artery disease.

$\text{Cumulative event-free rate}$

$\text{Months of follow-up}$

$p <0.001 \text{ by log-rank test}$

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


- 0-29%: P<0.05
- 30-69%: P<0.001
- 70-99%: P<0.03

NS
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

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

Visible Human data (NIH)

Manual segmentation & 3D reconstruction

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 → Automated Image Segmentation & Anatomical Identification → Deformable Matching
Abdominal CT Segmentation

Original CT Data and Its Volume Rendering

Fully Automated Segmentation
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.

Abdominal CT Segmentation Accuracy Evaluation: 28 Cases

<table>
<thead>
<tr>
<th>Atlas Format</th>
<th>Liver</th>
<th>Spleen</th>
<th>Right kidney</th>
<th>Left kidney</th>
<th>Pancreas</th>
<th>Gallbladder</th>
<th>IVC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Jaccard index Multi-Organ</td>
<td>0.891</td>
<td>0.825</td>
<td>0.882</td>
<td>0.874</td>
<td>0.466</td>
<td>0.634</td>
<td>0.549</td>
</tr>
<tr>
<td>Single Organ</td>
<td>0.892</td>
<td>0.836</td>
<td>0.880</td>
<td>0.836</td>
<td>0.348</td>
<td>0.530</td>
<td>0.545</td>
</tr>
</tbody>
</table>
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

CA
M/L (average) 1.19

M/L: myocardium to lumen signal ratio
Distribution of contrast medium in normal myocardium as a function of time

\[ \frac{M/L}{\Delta M/\Delta L} \] is in an equilibrium after 2 minutes of contrast injection.

\( \Delta M \) (increment of CT value in myocardium)

\( \Delta L \) (increment of CT value in blood)

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)
$DV_{\text{blood}} = 1 - \text{Ht}$

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

$DV$: Distribution Volume (分布体積), $VB$: Vascular Bed (血管床)
$ES$: Extra-cellular Space (細胞外液腔)
$\lambda$ (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

<table>
<thead>
<tr>
<th>Pre (Normal)</th>
<th>20min ischemia</th>
<th>60min ischemia</th>
</tr>
</thead>
</table>

- 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

Masson

LGE

ATTR
Measurement of M/L

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

\[ M/L = \frac{SI_{myocardium}}{SI_{lumen}} \]
Dynamic late gadolinium enhancement


![Bar chart showing dynamic late gadolinium enhancement](chart.png)
Comparison of LGE between AMI and OMI

AMI (5d)

OMI (8m)

2min  3min

Graph:

- normal/LV
- AMI/LV
- OMI/LV

Relative SI over time:

0  10  20
minutes

0.0  0.5  1.0  1.5  2.0  2.5
Dynamic LGE of various myocardial diseases

![Graph showing M/L distribution over time for different conditions](#)

- **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

MPRAGE: Mild High
T2WI: Mild High
TOF MRA

CT
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

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.牵引性気管支炎・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）
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