3D Imaging Service
and Tumor Imaging Metrics Core

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Presentation Overview

• Clinical 3D Imaging Service
• Tele3D
• 3D Imaging Research and Development
• Tumor Imaging Metrics Core
Services

• 3D Imaging Service
  – MGH Radiology, 12 years, started February 1, 1999

• Tele3D (New External Service)
  – National/International 3D Imaging Service, started 2009

• Tumor Imaging Metrics Core
  – Dana-Farber/Harvard Cancer Center (5 Harvard Hospitals), initiated 2004

• Neurofibromatosis Imaging Analysis Archive
  – National: MGH, JHU, UAB, CNMC, OSUMC, HEI, CTF
Grants

- Alcoholism Brain Imaging Research, NIH
  - Collaboration with BUSM, CNY, in 9\textsuperscript{th} year, renewed -> 2014
- SPOTRIAS, NIH Program Project, Neuroimaging Core
- Tumor Imaging Metrics Core (DF/HCC)
- Neurofibromatosis Imaging Grant, PET, MR Tumor Volume
  - MGH, Germany collaboration, DoD
- Harvard Catalyst, CTSC, Imaging Subcommittee
- CAD grants, CT Colonography (Hiro Yoshida and team)
Goals of 3D Clinical Service

• Integrate Computer Aided Diagnosis (visualization, quantitative analysis) into routine clinical workflow

• Bridge research and clinical applications to migrate new technologies into clinical practice
3D Imaging

Axial images are ‘stacked’ into a three-dimensional volume
Information Transmission

Courtesy of Matthew A. Barish, M.D.
Information Transmission

CSF Leak

Courtesy of Matthew A. Barish, M.D.
Image Processing Techniques

- Multi Planar Reconstruction (MPR / MPVR)
- Oblique and Curved Reformat
- MIP (Maximum Intensity Projection)
- Shaded Surface Display
- Volume Rendering
- Endoluminal Views (Virtual Colon, Bronch, Vessels)
- Functional Imaging
- CADx: Segmentation, Quantitation
MIP Rendering

• Maximum Intensity Projection
• Displays the pixels of highest intensity along a ray
• Useful for vascular anatomy
Orthopaedics: Volume Rendering (VR)
Vascular Imaging: VR Curved
CT Bronchography: Endoluminal See-Through
Neurovascular CTA/MRA: VR MIP
Cardiac CTA:
Normal
3˚CABG
Functional CT Perfusion

CBV  CBF  MTT
Functional MRI (fMRI)
Computer-Aided Segmentation
Virtual Hepatectomy

Semiautomated segmentation

Total Volume = 1551.8 cc’s
Virtual Hepatectomy

Transplant segment

- Define surgical plane
- Sufficient volume for regeneration

Left Lobe segment 316.91 cc’s
CAD: Automated Segmentation:
VR
MIP
CAD:
Brain Tumor Volume
Clinical Benefits of 3D Radiology

- More comprehensive and realistic views of patient
- Faster, more confident diagnoses and treatment planning decisions
- Reduced need for exploratory surgery
- Minimize surgical invasiveness and operating room time; reduced damage to healthy tissue
3D Imaging Service at MGH

- Clinical computer visualization for routine clinical use; 3D on request.
- Fast turnaround, full-time technologists
- Full integration with hospital PACS and information, billing systems
- Currently, over 2000 cases processed per month
MGH 3D IMAGING SERVICE: DAILY AVERAGE VOLUME BY YEAR
3D Imaging Service Hardware and Software at MGH

- 5 GE Advantage Workstations
- 5 Vital Images Vitrea Workstations
- Tera Recon Aquarius Workstation and NetServer
- 2 Voxar Workstations
- 2 LINUX Computers with MedX/VolumePro for fMRI
- Mirada Fusion7D Workstation for image registration
- 3 GE LogiqWorks for 3D Reconstruction of US
- AGFA PACS Service Station, and RadWorks PACS
- Materialize SimPlant/Master for Dental Implant Planning
- MMS Preview LINUX Server
- LINUX DICOM Server, 7 PCs, 2 Macs
Tele3D Service

• Many facilities do not possess the resources or expertise to manage or maintain a 3D Imaging Service

• At low volume, it is not cost-effective to maintain the staff, training, infrastructure

• We developed the Tele3D Service to provide access to the resources of the MGH 3D Imaging Service to outside hospitals and imaging centers
2. Clinical Benefits: Workflow and Productivity

Typical 3D Workflow

Scan Patient ➔ QA Exam ➔ Store on RIS / PACS ➔ 3D Workstation ➔ File Report ➔ Read Exam
Tele3D Workflow

2. Clinical Benefits: Workflow and Productivity
2. Clinical Benefits: Workflow and Productivity

Tele3D’s Workflow Benefits

Radiologists

• Radiologists are able to focus on patient care, teaching, and research rather than generating 3D images

Technologists

• Technologists are free to focus on efficiently scanning patients to increase throughput
1. Tele3D Overview

Complete Range of 3D Protocols

**Vascular Radiology**
- CTA/MRA for AAA
- CTA / MRA for TAA
- CTA / MRA for aortic dissection
- Abdominal MRA for mesenteric ischemia
- Abdominal / pelvis MRA / MRV for portal & deep vein thrombosis
- MRI Upper Extremity Runoff
- CTA Runoff
- MRA Chest
- MRI Vascular Run-off
- Renal MRA for Stenosis

**Bone & Joint Radiology**
- Skeletal fractures (Spine, Face, Temporal and Joints)

**Neuroradiology**
- Head CTA / MRA
- Neck CTA / MRA
- Head CT / MR Venography
- Head CT / MR Perfusion
- Facial Bones
- Mandible CT for inferior alveolar nerve
- Pediatric CT for craniosynostosis

**Cardiac Radiology**
- Cardiac CTA
- Chest CT for pulmonary vein evaluation prior to ablation
- Chest CT for Pulmonary Arteries
- Chest MR for pulmonary vein evaluation prior to ablation
- Cardiac calcium scoring

**Chest Radiology**
- Chest CT for any tracheal lesion (Virtual Broncoscopy)
- Chest CT for Video Assisted Thoracotomy (VAT) planning

**Abdominal Radiology**
- Liver Resection / Liver Donor
- CT Liver Volumes
- CT Urography / Hematuria
- CT Renal Donor
- MRCP
- Pancreas CTA
- MRI Liver and Spleen volumes for Gauchers Disease
3D Imaging Research and Computer Aided Detection (CAD)

- MGH 3D Imaging Research and CAD team includes 5 Faculty PhD/MD staff plus fellows
- Funding primarily through research grants
- Focus on developing clinical image-processing applications
Liver Segmentation (transplant)
Liver-Tumor Segmentation

0 months  
2.3 months  
5.7 months  
13.8 months  
18.6 months  
19.6 months
In-Vivo Segmentation

- In-vivo segmentation by CAV (DT level set)
Renal Stone Segmentation

Right Volume = 2.455 CC

Left volume = 4.442 CC
NF-Tumor Burden

Number of Tumors (Total: 63)

Volume of Tumors (CC) (Total: 2495)
An example of the CAV scheme for the quantification of pneumothorax on a 12-year-old/male patient with metastatic angiosarcomas, who had pneumothorax after pleural biopsy.
Sarcoma Viable Tissue Quantification

Using Dynamic Contrast MRI sequence
Estimate the tumor viable tissue by using the early enhancing portion.

T2 Fat Sat Sequence
Early Enhancing

15 Sec
25 Sec
70 Sec
180 Sec
Meniscus Tear
Meniscus

Superior View

Inferior View
Electronic Cleansing (EC)

- “Virtually” cleanse the colon in CTC images
Mosaic Decomposition Example

Fecal-tagging image

Tile decomposition

Tile classification

Cleansed image
Detection of Polyp Candidates

- polyp (cap)
- fold (ridge)
- colonic wall

shape index
Why TIMC?

Current Issues

- Clinical read ≠ Response criteria
- Inconsistent measurements due to different readers across time points
- Time-consuming for trial staff & radiologists
- No image-based longitudinal record
- Image data not available for audit

TIMC Solution

- Standardized measurements
- Centralized image analysis to increase reliability
- Online data entry & review system to increase efficiency
- Web-based secure results reporting
- Centralized database and archive
TIMC Experience

- Service BWH, DFCI, MGH, BIDMC and CHB
- >300 active trials
- >17,000 scans analyzed
- Proficient in various assessment criteria
- Most new trials now budget for TIMC services

Assessment Criteria Breakdown

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Percentage</th>
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<tr>
<td>RECIST 1.0</td>
<td>72%</td>
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<tr>
<td>RECIST 1.1</td>
<td>7%</td>
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<tr>
<td>Cheson/IWRC</td>
<td>10%</td>
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<td>PET SUV</td>
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<td>WHO</td>
<td>3%</td>
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<tr>
<td>Choi</td>
<td>1%</td>
</tr>
<tr>
<td>Brain Volumetrics</td>
<td>1%</td>
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</tbody>
</table>
TIMC Exam Volume
Usage by Disease Group
Usage by Institution

- MGH, 35.6%
- DFCI, 31.3%
- BWH, 23.3%
- BIDMC, 8.3%
- CHMC, 0.3%
TIMC Services

Protocol Consultation
• Consultative services for imaging components in trials

Image Capture & Analysis
• DICOM transfer from DF/HCC institutions’ PACS
• Import of outside scans via secure internet or CD
• MRI, CT, PET & multi-modality scans
• Standardized linear, volumetric, SUV and density measurements

Web-based Services
• Online Order-Entry for authorized users
• Results viewable by study staff on a secure website
• Centralized database for internal/external auditing
TIMC Staff

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Impact of New Technologies on Radiology

- 3D Visualization enables faster, more confident diagnoses and treatment decisions
- Quantitative analysis and CAD can provide more accurate, reliable treatment planning, staging, and assessment
- Improved patient care, increased clinical confidence, reduced time, cost, and invasiveness
Thank you!!!

Any Questions?