Multiparametric MRI for Precision Oncology and Radiation Oncology: A Physician’s Perspective

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AAPM Annual Meeting, July 12, 2020
The role of Multiparametric MRI is growing rapidly.

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The role of Multiparametric MRI is growing rapidly.
Multiparametric MRI in **precision oncology**
- Precision screening, diagnosis, staging, treatment response and recurrent assessment

Multiparametric MRI in **precision RT**
- Precision simulation, target delineation and RT plan
- Precision treatment delivery
- Precision treatment response prediction
- Precision detection of tumor recurrence

**Multiparametric MRI future potential**
What is Multiparametric Magnetic Resonance Imaging (mpMRI)?
What Is MpMRI?

“A multiparametric MRI (mpMRI) is a combination of two or more sequences, and/or including other specialized MRI configurations such as spectroscopy”


No definition from official organizations like AAPM, ACR, RSNA....
Anatomic T1 weighted, T2 weighted sequences

Additional MRI sequences:

- Diffusion-Weighted Images (DWI)
- Dynamic Contrast Images (DCI)
- Proton Density Images (PDI)
- Flow sensitive images like MR angiography, MR venography, CSF flow study
- Cholangiopancreatography (MRCP), MR Spectroscopy, MR perfusion, functional MRI...

In general, MRI sequences vary with diseases and anatomic sites. Selection of MRI Sequence shall be individualized to the site and function.

https://radiopaedia.org/articles/mri-sequences-overview
“Combining multiple imaging contrasts that reflect different aspects of pathophysiological processes ...”

ADC=Apparent diffusion coefficient

ISODATA=Iterative Self-Organizing Data Analysis Technique

Wu et al, 2010 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3319343/
Relative Cerebral Blood Volume (rCBV)

Fluid-Attenuated Inversion Recovery Images (FLAIR)

Post-contrast T1WI

Pre-STD rCBV maps

post-STD rCBV maps

MpMRI of breast, can be done by different field strengths (1.5-7 T), include DWI, MRS, with Novel MRI parameters (sodium imaging, chemical exchange saturation transfer imaging, blood oxygen level-dependent), and hybrid imaging with PET/MRI and different radiotracers.

MpMRI for Lung

- Conventional T1W,T2W
- T2-weighted fast spin echo (FSE) imaging with and without fat saturation
- Inversion recovery techniques
- T1-spin echo sequence
- Gradient echo sequence (GRE)


T2W FSE-MRI is favorable for the mediastinum. Normal lung tissue can be seen on single-shot sequences (HASTE or TrueFISP). Lung nodules are ideally visualized with a volumetric interpolated 3D-GRE sequence (e.g. VIBE)

~Bierder et al, 2003

A case of Pancreatic adenocarcinoma

Slide courtesy of Allen Li
MpMRI for Prostate

MpMRI of the prostate combines anatomic information from T1-weighted and T2-weighted sequences with functional information from Diffusion-Weighted imaging (DWI) +ADC and dynamic contrast enhancement (DCE), +MRS.

Stabile et al, 2019, https://www.nature.com/articles/s41585-019-0212-4
https://radiopaedia.org/articles/multiparametric-mri-mpmri-of-the-prostate

Bjurlin et al, 2016, DOI: 10.5173/ceju.2016.734
Corpus ID: 17680536
MpMRI for Precision Oncology
MpMRI for Precision Oncology

- Precision cancer screening, diagnosis, and staging
- Precision multidisciplinary treatment decision
- Precision treatment response prediction
- Precision post-treatment response assessment
- Precision detection of recurrent diseases

MRI is being used in clinic in almost all solid tumors
DCE-MRI is the most sensitive test for breast cancer detection, with a good specificity.

DWI, sometimes MRS and higher field strengths (≥3T), has demonstrated improved sensitivity and specificity of breast cancer detection.

MpMRI can quantify the functional processes of cancer development and progression at multiple levels.

MpMRI of the breast improves diagnostic accuracy in breast cancer and obviates unnecessary breast biopsies.

MpMRI of the breast enables an improved assessment and prediction of response to neo-adjuvant therapy.

MpMRI for Breast Cancer Diagnosis

Pinker et al, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5605035/
Low apparent diffusion coefficient values suggest breast cancer

Multiparametric MRI in Prostate Cancer

- Frequently studied and almost routinely used during daily practice
- Has advantage over conventional CT,
  - Screening
  - Surveillance
  - Lesion localization for biopsy
  - Cancer extent assessment (staging)
  - Treatment response assessment
MpMRI Can Accurately Detect Prostate Cancer Nodules

mpMRI to detect prostate cancer nodules, useful for diagnosis, accurate surveillance, post-treatment recurrence

Demirel and Davis, 2018

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5832385/
“prebiopsy mpMRI followed by a targeted biopsy into a PCa detection pathway may lead to the performance of fewer biopsies than a pathway using systematic biopsy alone. Such an approach may increase the likelihood of detecting csPCa, while reducing the detection of low-risk tumors.”

Elwenspoek et al, 2019
https://jamanetwork.com/journals/jamanetworkopen/fullarticle/2747475
# Multiparametric MRI in Prostate Cancer

<table>
<thead>
<tr>
<th>Method</th>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>MpMRI</td>
<td>91.3%</td>
<td>66.7%</td>
</tr>
<tr>
<td>Ratio between lesions:</td>
<td>84.8%</td>
<td>66.6%</td>
</tr>
<tr>
<td>Strain ration (SR):</td>
<td>78.3%</td>
<td>61.1%</td>
</tr>
<tr>
<td>Enhanced Ultrosound:</td>
<td>40.0%</td>
<td>97.2%</td>
</tr>
</tbody>
</table>

From 82 patients with persistently high prostate specific antigen (PSA) levels after medical therapy

MpMRI in Lung Cancer

- MRI is not commonly used in lung cancer
- MRI is particularly good for pediatric patients or pregnant women and others have contra-indication for X-ray exposure.
- MRI provides more contrast than CT for lung nodule detection
- MRI is good for vessel invasion and lung cancer staging
- MRI provides lung function image in perfusion
- MRI provides functional assessment of heart that CT cannot.

### Indications covered by MRI

<table>
<thead>
<tr>
<th>Indication</th>
<th>MRI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complicated thoracic mass (mediastinum and chest wall invasion)</td>
<td>Optional</td>
</tr>
<tr>
<td>Differentiation of atelectasis and pulmonary mass</td>
<td>Optional</td>
</tr>
<tr>
<td>Differentiation of mediastinal masses</td>
<td></td>
</tr>
<tr>
<td>Evaluation of respiratory mechanics</td>
<td></td>
</tr>
<tr>
<td>Diagnosis of pulmonary perfusion deficits (embolism)</td>
<td></td>
</tr>
<tr>
<td>Cystic fibrosis (with perfusion study)</td>
<td></td>
</tr>
<tr>
<td>Pneumonia</td>
<td></td>
</tr>
<tr>
<td>Atelectasis</td>
<td></td>
</tr>
<tr>
<td>Cystic fibrosis (without perfusion study)</td>
<td></td>
</tr>
<tr>
<td>Tuberculosis</td>
<td></td>
</tr>
<tr>
<td>Pulmonary nodules (&gt; 3 mm)</td>
<td></td>
</tr>
<tr>
<td>Sarcoidosis</td>
<td></td>
</tr>
<tr>
<td>Acute and chronic pulmonary embolism</td>
<td></td>
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<tr>
<td>Abnormalities of pulmonary venous drainage</td>
<td></td>
</tr>
<tr>
<td>Pulmonary arterial aneurysm</td>
<td></td>
</tr>
<tr>
<td>Lung sequestration</td>
<td></td>
</tr>
<tr>
<td>AV malformation (M. Osler)</td>
<td></td>
</tr>
<tr>
<td>Staging of lung cancer</td>
<td></td>
</tr>
<tr>
<td>Vasculitis (e.g. Wegener’s)</td>
<td></td>
</tr>
<tr>
<td>Pleural effusion of unclear origin</td>
<td></td>
</tr>
<tr>
<td>Mesothelioma</td>
<td></td>
</tr>
</tbody>
</table>

MpMRI can definitely provide functional information and better evaluation for vessels/heart that CT can not.

Pediatric pregnant or radiation contraindicated patients warrant to have MRI.

MpMRI to Diagnosis Pediatric Tumors

6 year-old with osteosarcoma

The steady state free precession study

The respiration triggered (navigator triggered) series

MpMRI Detects Small Lung Nodule

May be even faster and more efficient to read lung MRI for pulmonary nodules—bright signal against the dark background of the healthy lung tissue.

Calcified nodules tend to disappear in the lung background of T1W, as they have no inherent signal.

The sensitivity of MRI for lung nodules larger than 4 mm ranges between 80 and 90% and reaches 100% for lesions larger than 8 mm.

MpMRI for Non-Cancer Differentiations

- Pleural effusion
- Pneumonia
- Abscess

Planar x-ray images showing:
- Pneumonia

MRI images with annotations:
- No Contrast CT
- SSFP
- T2

Images labeled:
- Fat-Sat T2 FSE
- T1 3D GRE
- Planar x-ray
Clinical Trials in mpMRI for Cancer Diagnosis and Staging

5 studies listed in Clinicaltrials.org through searching by “MultiParametric MRI” and “Cancer Diagnosis and Staging”

100 studies for “MRI” and “Cancer Diagnosis and Staging”, mostly from Europe, followed by US, 4/100 from China;

3 studies for PET-MRI
Multiparametric MRI for Precision Oncology and Radiation Oncology: A Physician’s View

- Multiparametric MRI in precision oncology overview
  - Screening, diagnosis, staging, treatment response and recurrent assessment

- Multiparametric MRI in precision RT
  - Precision simulation, target delineation and RT plan
  - Precision treatment delivery
  - Precision treatment response prediction
  - Precision detection of tumor recurrence

- Multiparametric MRI future potential
MpMRI for Simulation/ target delineation/RT plan
### MRI Simulation for RT

<table>
<thead>
<tr>
<th>Anatomical site</th>
<th>Acquisition sequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brain</td>
<td>T1 3D gradient echo</td>
</tr>
<tr>
<td></td>
<td>Post Gd-T1 standard spin-echo</td>
</tr>
<tr>
<td></td>
<td>Proton density fluid-attenuated inversion recovery (FLAIR)</td>
</tr>
<tr>
<td></td>
<td>T2 FLAIR</td>
</tr>
<tr>
<td>Head and Neck</td>
<td>Post Gd-T1 Standard Spin-Echo</td>
</tr>
<tr>
<td></td>
<td>T2-weighted sequence with fat saturation</td>
</tr>
<tr>
<td></td>
<td>T1 3D gradient echo (pre- and postcontrast)</td>
</tr>
<tr>
<td>Breast</td>
<td>T1 inversion recovery (STIR) sequence</td>
</tr>
<tr>
<td></td>
<td>T2-weighted 3D fast spin echo (XETA)</td>
</tr>
<tr>
<td></td>
<td>T1-weighted turbo spin echo</td>
</tr>
<tr>
<td></td>
<td>T1 3D gradient echo</td>
</tr>
<tr>
<td>GYN</td>
<td>Turbo spin echo T2 (TSE T2)</td>
</tr>
<tr>
<td></td>
<td>T2-weighted fast spin echo (FSE)</td>
</tr>
<tr>
<td></td>
<td>T1 3D gradient echo</td>
</tr>
<tr>
<td>Prostate</td>
<td>T2-weighted fast spin echo (FSE)</td>
</tr>
<tr>
<td></td>
<td>T1 3D gradient echo</td>
</tr>
<tr>
<td>Rectum</td>
<td>T2-weighted fast spin echo (FSE)</td>
</tr>
<tr>
<td></td>
<td>T1 and T2 short tau inversion recovery (STIR)</td>
</tr>
<tr>
<td></td>
<td>T1 3D gradient echo</td>
</tr>
</tbody>
</table>

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Dacic, Med. Phys. 39 (11), November 2012
Multi-parametric MRI for Synthetic CT

Slide Courtesy of Jing Cai
MRI Target Delineation

MRI Target Delineation in comparison to CT

- Nice soft tissue contrasts
- Rich presentation in detailed tissue structure
- Contains metabolic and functional information

- Routinely used in RT target delineation for CNS, head/neck NPC, liver, pancreatic, cervical, prostate …and rectal cancers.
MRI and Tumor Target

- Glioblastoma multiforme in a 49-year-old man
- Metastatic melanoma in an 18-year-old man
- Cerebral toxoplasmosis in a 54-year-old woman (Infection)

Floriano et al https://www.researchgate.net/publication/259269120
rCBV Map for Target Volume in GBM

Picture from C Tsien
4D-MRI May Be Superior than 4D-CT in Liver

4D-MRI of Liver Cancer

Compared to 4D-CT, 4D-MRI improves tumor contrast and tumor motion measurement for abdominal cancers.

Slide courtesy of Jing Cai
MRI Target Delineation for BrachyTherapy in Cervical Cancer

CT: Target, red or blue?
MRI: Target, clearly red!

Picture provided by Zhiyuan Xu from HKU SZH
MRI Target Delineation in Gyn Tumors

MRI/IGRT Consensus Guidelines

Tumor GTV, parametria

Lim K et al.  IJROBP 2010; 79:348-355
http://www.rtog.org/CoreLab/ContouringAtlases/GYN.aspx

Slide Courtesy of Nina Mayr
Use of MRI Simulator Consensus Opinion

➢ To determine the levels at which consensus … regarding general and site-specific principles of MRI simulation for offline MRI-aided EBRT.
➢ A process inspired by the Delphi method to determine levels of consensus using a series of questionnaires interspersed with controlled opinion feedback.

Full consensus was reached regarding general principles of MRI simulation.

However, the level of consensus decreased when site-specific principles of MRI simulation were considered.

https://www.thegreenjournal.com/article/S0167-8140(16)34368-7/fulltext
Use of MRI Simulator
Clinical and Cost Effectiveness

- No tumor control outcome studies
- No cost effectiveness study
- Only one relevant clinical study MRI-CT simulation may reduce acute GU toxicity without reducing GI toxicity compared with CT simulation only.
- Recommend more research

CADTH SUMMARY WITH CRITICAL APPRAISAL
Magnetic Resonance Imaging Simulators for Simulation and Treatment for Patients Requiring Radiation Therapy

By Chantelle Lachance and Suzanne McCormack
Clinical Trials in mpMRI for Target Delineation

1 study listed in Clinicaltrials.org through searching by “MultiParametric MRI” and “target delineation”

26 studies for “MRI” and “Target delineation”, mostly from Europe, followed by US, 0/26 from China;
0 studies for PET-MRI
Clinical Trials in mpMRI for RT Plan

9 study listed in Clinicaltrials.org through searching by “MultiParametric MRI” and “RT Plan”

149 studies for “MRI” and “RT plan”, mostly from Europe, followed by US, 1 study for PET-MRI in recurrent GBM
MpMRI for precision RT treatment delivery
Advantages of MRI Linac is MRIgRT-1

No Radiation vs. MRI Interference
Even when Beam-On

- No Radiation
- Better Quality
- Real time beam-on monitoring

Picture Courtesy of Jihong Wang
Advantages of MRI Linac and MRgRT-2

Monitoring Patient Motion During “Beam-on”

Example of real time motion monitoring of multiple OARs

High frame-rate, multi-planar acquisition for motion monitoring

Courtesy of Jihong Wang
MRIgRT Linacs for Treatment Delivery

Does it make a difference for our patents? Evidence?

The CADTH report

MRIgRT Treatment Delivery: A Review of Clinical Effectiveness, Cost-Effectiveness and Guidelines

1. What is the clinical effectiveness?
2. What is the cost-effectiveness?
3. What are the evidence-based guidelines?

1. One study of 8 matched pairs, lung SBRT, MR Linac versus Conventional Linac, no early damage
2. No evidence
3. No relevant evidence-based guidelines

CLachance and McCormack
https://www.ncbi.nlm.nih.gov/books/NBK546999/
MRI Linacs for Radiation Therapy Delivery

Kim et al, 2018 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5880382/

MRI Linacs were not better
Comparing CT density changes in areas above 48 Gy, no significant differences were seen.
Clinical Trials in mpMRI for Radiation Treatment Delivery

3 study listed in Clinicaltrials.org through searching by “MultiParametric MRI” and “radiation treatment delivery”

<table>
<thead>
<tr>
<th>#</th>
<th>Status</th>
<th>Title</th>
<th>Countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Recruiting</td>
<td>Stereotactic MRI-guided On-table Adaptive Radiation Therapy</td>
<td>UCLA (Los Angeles, California, United States)</td>
</tr>
<tr>
<td>2</td>
<td>Recruiting</td>
<td>Pilot Study of Same-session MR-only Simulation and Treatment With Stereotactic MRI-guided Adaptive Radiation Therapy</td>
<td>Multiple institutions (Europe, US)</td>
</tr>
<tr>
<td>3</td>
<td>Completed</td>
<td>HCG Rise</td>
<td>UCLA (Los Angeles, California, United States)</td>
</tr>
<tr>
<td>4</td>
<td>Recruiting</td>
<td>Optimizing Radiation to Oligometastases of the Spine</td>
<td>Multiple institutions (Europe)</td>
</tr>
<tr>
<td>5</td>
<td>Recruiting</td>
<td>Prostate Radiotherapy Integrated With Simultaneous MRI (The PRISM Study)</td>
<td>Multiple institutions (Europe, US)</td>
</tr>
</tbody>
</table>

69 studies for “MRI” and “radiation treatment delivery”, mostly from Europe, followed by US, 1 study for PET-MRI
MpMRI for precision RT treatment response assessment
Blood-Brain/Tumor Barrier Opening During RT

Red: initially enhanced region; Yellow: initially non-enhanced tumor region

MRI Detects Early Changes During-RT: GBM

Cao, Y. et al J Clin Oncol 23: 4127, 2005
rCBV MRI Demonstrates Tx Response

Figure provided by Chenevert T, Ph.D
**Mp MRI to Assess Pharyngeal Constrictor Toxicity After Radiation**

Messer J et al https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4794348/

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**Pre-RT T1w**  
**Follow-up T1w**

**Pre-RT T2w**  
**Follow-up T2w**

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**Pre-RT T1w**  
**3 mo T2w**  
**29 mo T1w**

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**Slide courtesy of Jihong Wang**
51-year-old woman invasive ductal carcinoma (Grade 3, ER+/PR+/HER2+), prior to neoadjuvant therapy

14 days after starting treatment with paclitaxel and trastuzumab

MRI Detects Early Changes During-SBRT: HCC

Pre SBRT
Unresectable

During SBRT
s/p 2/5 Tx

One month
Post-SBRT
Changes of ADC in Pancreatic Cancer during RT

Slide Courtesy of Allen Li
Weekly DWI During Lung Treatment

Picture courtesy of Zhongxing Liao & Jihong Wang
**K-trans MRI Detects Early Changes in Metastatic Melanoma**

*Pre-RT 2 weeks into anti-angiogenic treatment*

1. **T1W with contrast**
   - No changes in size

2. **K-trans color maps**
   - Less K-trans color maps

Clinical Trials in mpMRI for Treatment Response Assessment

<table>
<thead>
<tr>
<th>Row</th>
<th>Saved</th>
<th>Status</th>
<th>Study Title</th>
<th>Conditions</th>
<th>Interventions</th>
<th>Locations</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>□</td>
<td>Uni</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>□</td>
<td>Recruiting</td>
<td>Bladder fiducial markers and multiparametric MRI (mp-MRI)</td>
<td>Bladder cancer</td>
<td>Procedure: fiducial</td>
<td>Cedars-Sinai Medical Center (CSMC)</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>to optimize bladder chemo-radiotherapy</td>
<td></td>
<td>marker placement</td>
<td>shoes, California, United</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>Not yet recruiting</td>
<td>New</td>
<td></td>
<td></td>
<td>University of California San Francisco, California, United</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>Recruiting</td>
<td>Multi-parametric Magnetic Resonance Imaging for Prostate Cancer Patients</td>
<td>Prostate Cancer</td>
<td>Device: Multiparametric MRI</td>
<td>Henry Ford Health System, Detroit, Michigan, United States</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>Unknown</td>
<td>Deformable Registration of Multi-parametric MRI to intra-operative Transrectal Ultrasound for Prostate Brachytherapy</td>
<td>Prostate Cancer</td>
<td>Procedure: Brachytherapy</td>
<td>Sheba Medical Center, Tel Hashomer, Israel</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>Unknown</td>
<td>Multi-Parametric Brain Cancer MRI</td>
<td>Brain Tumors</td>
<td>Other: 3D MRI Scans</td>
<td>Cross Cancer Institute, Edmonton, Alberta, Canada</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td>Recruiting</td>
<td>Pilot study evaluating the role of histopathology correlation</td>
<td>Prostate</td>
<td>Device: Urosvy</td>
<td>Case Comprehensive Cancer</td>
</tr>
</tbody>
</table>

13 studies listed in clinicaltrials.org through searching by “MultiParametric MRI” and “treatment response assessment”

455 studies for “MRI” and “tx response assessment”, mostly from Europe, followed by US, 4 studies for PET-MRI
MpMRI for precision ART treatment
Essential Components for Precision ART

- Modern pretreatment imaging
- Real time imaging to detect the changes
- Evaluation the changes in tumor and OARs
- Precise image registration (deformable)
- Model based segmentation, automatic re-contouring (ideally)
- Accurate dose computation (deformable)
- Rapid automatic treatment planning (ideally)

MRI Linac holds almost all of these essential needs for ART. MRI Can also use function imaging to guide Biology Guided Adaptive Radiation Therapy (BigART).
MRI Can Guide ART, Online or Offline

Online: physicist, therapist, physician
Real time: physicist, therapist, physician
Offline: dosimetrist, physicist and physician

Online: physicist, therapist, physician
Real time: physicist, therapist, physician
Offline: dosimetrist, physicist and physician

Online: inter-fraction physical changes
Offline: suitable for progressive change such as tumor response to RT

Pancreatic SBRT Using Online Daily Adaptive Plans

Baseline Reference plan

1st fraction plan
Online Adaptation: Contour Editing

Motion Averaged 4D

Respiration triggered 3D T2

Slide Courtesy of Allen Li
Online Parallel Contour Editing

**MR Philips control**
- Image Reg
- Contour population
- Contour distribution
- Contour combination

**MIM**

**Online Monaco**

**MD MIM**
- Editing GTV/CTV
- Editing OAR inside ring

**Phys MIM**
- Editing bone
- External contour
- Identifying air
- Checking Syn CT

**RTT MIM**
- Editing OARs

Time reduction >50%


Paulson E, Ahunbay E, Chen X, Erickson B, Hall W, Li XA, presenting at ASTRO 2019.
### Average times for Adapt to Shape

<table>
<thead>
<tr>
<th>Activity</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient setup</td>
<td>5 min</td>
</tr>
<tr>
<td>Pre-beam 4DMRI (acqui + recon + trans)</td>
<td>6 min</td>
</tr>
<tr>
<td>Reg + Contour editing</td>
<td>13 min</td>
</tr>
<tr>
<td>Plan adaptation</td>
<td>11 min</td>
</tr>
<tr>
<td>ArtQA + double checks</td>
<td>1 min</td>
</tr>
<tr>
<td>Beam-on time</td>
<td>10 min</td>
</tr>
<tr>
<td>Post-tx 4DMRI</td>
<td>3 min</td>
</tr>
<tr>
<td>Total on-table time</td>
<td>50 min</td>
</tr>
</tbody>
</table>
Baseline mpMRI radiomic can be used for prediction.
Clinical Decision Making of ART at QEH

- Significant increase of high dose area over neck skin (n=4)
- Insufficient dose coverage over neck nodal targets (n=5)
- Increased risk of spinal cord being overdosed (n=2)
- Unfit of thermoplastic casts (uncorrectable) (n=4)

Body weight loss >10% → Adaptive Review (n=39/100)
- Change of neck contour
- Lymph node shrinkage
- Neck tissue loss

Decision Made (n=16/100)
- Part of contoured target volume outside body contour (n=1)
- Increased risk of optic chiasm being overdosed (n=1)

Re-plan (n=16)

Clinical trial ongoing in Hong Kong, Jing Cai et al

Slide Courtesy of Jing Cai
Artificial Intelligence data analysis and modeling are needed. Close collaboration of Physician + Physicist + AI may make this possible.
MpMRI will lift the level of precision oncology and radiation oncology to generate clinical benefit!
Clinical Trials in mpMRI for Adaptive Radiation Therapy

1 study listed in Clinicaltrials.org through searching by “MultiParametric MRI” and “adaptive radiation therapy”

24 studies for “MRI” and “adaptive”, mostly from Europe, followed by US, 0 studies for PET-MRI
Future of MpMRI in Precision Oncology & Radiation Oncology

Stage III NSCLC for example

MRI Precision Oncology to Make the Best Decision

MRI Precision BigART to Optimize Treatment

MRI Precision Adjuvant Therapy and Follow-up to Improve Survival