

## 磁共振造影模擬定位於放射治療的 現況與展望

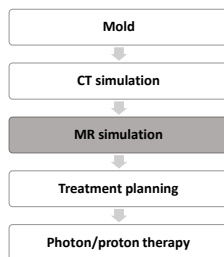
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### MR in RT



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### Radiation therapy workflow



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### Simulation

CT simulation and MR simulation

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### CT Simulation

- Imaging prior to radiation delivery
- A process used by the radiation therapy team to determine the exact location, shape, and size of the tumor to be treated.



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MR simulation?

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## MR simulation

- The **superb soft tissue contrast** of MRI was widely incorporated into radiation therapy treatment planning systems through the process of image co-registration.
- The soft-tissue data from the MRI provides target outline guidance and the CT provides a solid **geometric** and **electron density** map for accurate dose calculation on the TPS computer.

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## MR simulation

- **Patient setup**
  - Patient positioning and immobilization
  - MR compatibility
  - Carbon fiber material should be avoid or tested for the possibility of RF heating
- **RF coil**
  - To cater for immobilization and replicate treatment positioning usually results in some compromise in image quality or coverage

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## MRI simulator in CGMH

- GE Optima 450W, 1.5T, 2016
  - 70 cm big bore
  - Flat couch
  - Specialized RF coil
  - LAP laser



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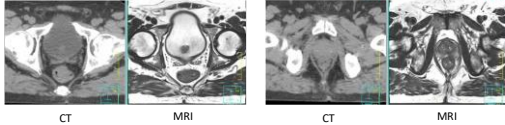
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### CT vs MR

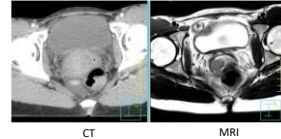
- The apex of the prostate is difficult to see on the CT but better visualized on the T2 TSE MRI.
- The overall anatomy and borders of the prostate are better seen on the MRI than the CT.



MR simulation for radiotherapy planning. Electronic Presentation Online System. DOI: 10.1594/ranac/2014/R-0034

### CT vs MR

- CT and MRI scans of a patient with cervical cancer showing the different bowel and bladder volumes despite following the same protocol. MRI volumes have to be adjusted to the CT dataset for radiotherapy planning.



MR simulation for radiotherapy planning. Electronic Presentation Online System. DOI: 10.1594/ranac/2014/R-0034

### Application and future

### MR in RT symposium

- Pseudo CT generation from MRI
- PET-MR
- Quality assurance
- MRI simulation: practicalities of set-up & coil
- Magnetic Resonance-guided radiotherapy (MRgRT)- MR linac
- MR only treatment planning
- 4D MRI with respiratory motion correction
- Machine learning/ deep learning

### Pseudo CT generation from MRI

- Bulk density assignment

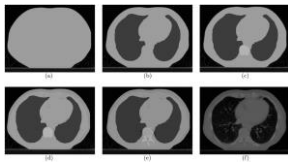
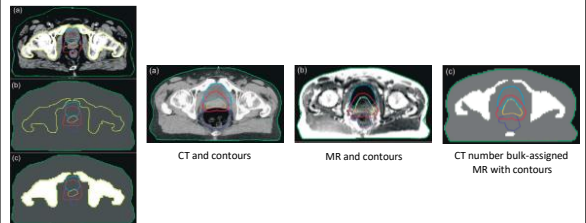


Table 1. Listing of the pseudo-CT's used in this paper. 'Full' indicates that the ED in that structure is acquired from the original CT data.

pCT Name	Hounsfield Units			
	Soft tissue	Lung	Target volume	Fat
Original CT	Full	Full	Full	Full
Water density	0	0	0	0
Lung density	0	-700	0	0
Bone density	0	-700	200	0
Fat density	0	-700	200	-100
Heterogeneous bone density	0	-700	Full	-100

Figure 1. Overview of all the pseudo-CT's used in this study. The bulk ED used for each structure per pCT is listed in table 1. (a) Water density, (b) lung density, (c) bone density, (d) fat density, (e) HBB, (f) original CT.

### Pseudo CT generation from MRI



CT and contours MR and contours CT number bulk-assigned MR with contours

## Pseudo CT generation from MRI

- Philips commercial software, MRCAT (MR for calculating attenuation)

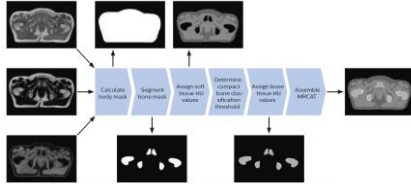


Figure 9. Algorithm flowchart showing the calculation flow from MRI to pseudo-CT images with the calculation MRCAT images as the end result.

## MR only treatment planning

CT-MR registration workflow



MR-only simulation workflow



## Conclusions

- MRI simulator allows improved patient access for radiotherapy planning.
- There is a learning curve to develop the best MRI sequences for definition of tumor/ normal anatomy/ fiducials for different tumor sites.
- Differences in organ position occur despite standard bladder filling/ empty rectum protocols.
- A fine balance between acquiring adequate images vs length of scan (patient tolerability & motion).
- Some loss of resolution from MRI acquisition to viewing in RTP system.
- Close collaboration is required between radiation oncologists, radiation therapists, physicists, MRI radiographers, and radiologists for successful implementation of MRI simulation.

## Conclusions

- The field strength should be no less than **1.5 T** and no greater than **3.0 T**.
- The magnet should be a **closed-tunnel** configuration, preferably with a **wide bore**.
- A flat bed or tabletop insert should be used.
- Appropriate RF coils should be used that cater to immobilization devices.
- Geometric distortion should be verified in all 3 directions, and this will inform the useable FOV (in plane) and slice coverage (through plane).
- Spin-echo**-based sequences (ie, fast or turbo spin-echo) should be used in preference to gradient-echo for the gold-standard anatomical image.
- Slice thickness should match the planning CT acquisition where possible.
- QA** of the optimum patient setup and imaging protocol

Thank you