ADVANCED HEART TISSUE PHANTOM AS A REFERENCE FOR MRI SEQUENCE EVALUATION

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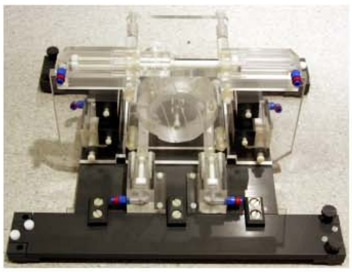
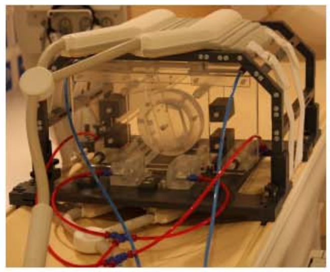
Introduction

For investigating dynamic MR imaging methods as Tagging or tissue phase mapping (TPM) a reliable dynamic reference object is mandatory. To satisfy these demands for cardiac studies a pneumatically driven polyvinyl alcohol (PVA) based tissue model of a enlarged left ventricle is used.[1] The aim of this work was to improve the previously presented cardiac phantom.[2] The task was a full redesign of the setting to enable usage dedicated receive coils and the optimization of the user interface and handling of the phantom.


(1.1) MR compatible frame without tissue phantom

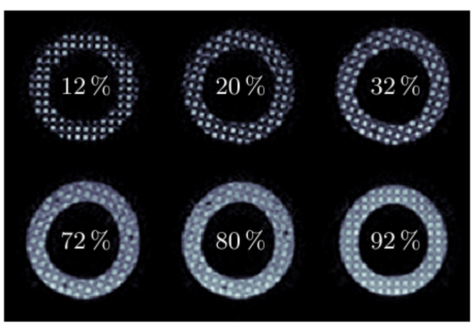

(1.2) fully assembled heart phantom


(1.3) cardiac trigger signal is fed directly into the MRI system

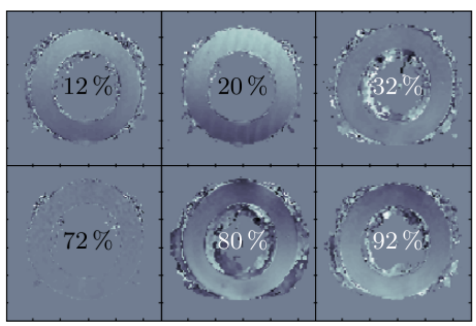

(1.4) control terminal

Components and Modes of Operation

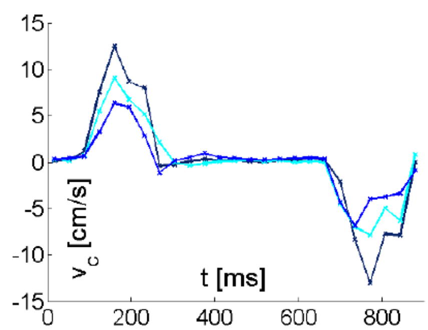
The advanced phantom, as shown in figure 1.1, can simulate heartbeat and breathing motion. Both in combination or separately. The breathing motion is implemented along one linear axis. This allowed the integration of a carrier superstructure for dedicated receive coils. While the movement is not physiologically correct it results in sufficient change in image information to test self gated imaging sequences and motion introduced artefacts. A further advantage of the limitation to one axis is that the complexity in data analysis can be reduced for rapid evaluation of new algorithms. The fully assembled phantom is shown in figure 1.2. Special care was taken to allow easy integration of the phantom device into a clinical environment with limited resources and regulatory restrictions. The phantom requires only a single external mains adapter and access to a compressed air supply system to operate. For evaluation of triggered cardiac sequences a simulated ecg signal can be fed into the MRI system by using the standard physiology input, as shown in figure 1.3. Therefore sequences / protocols evaluated in the phantom can be directly transferred to clinical examinations. To improve handling the valve control and user interface, as shown in figure 1.4, have been separated. Reducing it to a small terminal that easily fits into the control workstation environment of the MRI system. For simulation the user can adjust parameters like pulse or respiratory rate and trajectory parameters like duration of systole/diastole, inhale/exhale or tissue speed. The control interface is equipped with a isolated USB connection. This option allows fully automated testing for sequences when synchronized with the MRI system.



(2.1) subset of Tagged MR images given in percent of heart cycle



(2.2) TPM MR images (RL encoded) given in percent of heart cycle



(2.3) TPM based circuferential tissue speed for three slices showing full heart cycle

Conclusion

The presented phantom provides reliable motion characteristics for two different motion types simulating a contractional cardiac motion and a translational respiratory motion. The easy-to-use user interface and the simple set-up makes it a valuable tool for rapid testing of new sequences and protocols. Example data showing tagged MRI (fig.2.1), tissue phase mapping (fig. 2.2), and resulting circumferential tissue velocities (fig.2.3) are shown in figure 2. For further examples see Tobon-Gomez et al.[3]

References

[1] Lutz, A., et al. *Tissue Phantoms: Optimization of PVA-Gel Additives for Tissue Adapted T2-Relaxation Times at* 1.5 *and* 3*T*, ISMRM, 2011.
[2] Manzke, R., et al. *A new PVA-based dynamic cardiac phantom for evaluation of functional MR imaging methods at* 3*T*, ISMRM, 2010.
[3] Tobon-Gomez, C., et al. *Benchmarking framework for myocardial tracking and deformation algorithms: An open access database.* Medical image analysis, 2013.