Functional Chest MRI in Children

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Advantages of Chest MRI

• No ionizing radiation

• Excellent soft tissue contrast

• High temporal resolution

• Easier implementation of dynamic protocols
Limitations of Chest MRI

- Low signal-to-noise ratio (SNR) due to the low proton density of the lung
- **Motion artifacts** from respiration & cardiac pulsation
- Long examination time
- **Susceptibility artifacts** from multiple air-tissue interfaces
Recent Technical Advancements

• Parallel imaging technique to accelerate scan speed

• Multi (e.g. 32)-channel body-array coil to increase SNR

• Better data acquisition (e.g. radial, spiral) & reconstruction schemes
Reduction of Motion Artifacts

- **Respiratory triggering** using a pressure-sensing belt
- **Respiratory gating** using a navigator echo
- **Saturation bands** to suppress artifacts
- **Signal averaging**
- **Motion-insensitive pulse sequences**
- **Vector ECG triggering**
Chest MRI at 3 T

• High SNR

• Greater susceptibility artifacts

• Much more motion sensitive

• Overall, no apparent benefits

• In the future, ...
Lungs & Airways

• Complex functions, including ventilation, perfusion, respiratory motion, gas exchange

• Anatomic chest MRI: difficult

• Functional chest MRI: much more challenging
Functional Chest MRI

• Lung perfusion
• Lung ventilation
• Mass evaluation
• Respiratory mechanics
• Lung stiffness
Lung Perfusion

• Contrast-enhanced time-resolved MRA

Qualitative or quantitative assessment

Correlation analysis: increased SNR

Respiratory registration or motion correction
Lung Perfusion

- Arterial spin labeling (ASL) techniques

  No external contrast agent

  Animal experiments, volunteer studies

  Low SNR, further technical developments

Goo HW (Unpublished data)
Non-contrast Lung Perfusion MRI
Using ECG-triggered TSE Sequence

A. Systole
B. Diastole

B - A
Lung Perfusion

• Phase contrast imaging

Quantitative measurement of pulmonary blood flow

Flow-curve pattern analysis

No direct information on lung tissue perfusion

Normal PA Pattern  PA Hypertension  Proximal PA Stenosis
Lung Ventilation

• Oxygen-enhanced MRI
  Low SNR
  Procedural difficulties in children

• Hyperpolarized gas MRI
  Very restricted availability
  Procedural difficulties in children
Non-contrast Perfusion- & Ventilation-weighted Imaging Using Fourier Decomposition

• Easy & promising
• Free-breathing, untriggered acquisition of balanced SSFP for 4 min
• Good agreement with ventilation & perfusion SPECT
Mass Evaluation

• Dynamic contrast-enhanced (DCE) imaging
  - Tumor vascular density, permeability ($K_{\text{trans}}$)
  - Tumor grade, treatment responses
  - Respiratory registration or motion correction

• Diffusion-weighted imaging
  - Water diffusivity within tissues
  - Tumor cellularity, treatment responses
  - Degraded image quality by motion artifacts
ADC Map

Qualitative

Benign cyst

Quantitative

Mature cystic teratoma

Lymphoma
Respiratory Mechanics

• **Real-time dynamic MRI (B-SSFP)**

  Motion of lung, airway, chest wall, and diaphragm

  Restricted motion in both tumor infiltration & benign adhesion

  Measured lung volume parameters: a good correlation with pulmonary function test

  Tracheomalacia, diaphragm palsy/paralysis
Real-time Dynamic MRI

Tracheomalacia

Right Diaphragm Palsy

Inspiration

Expiration
Lung Stiffness

- MR elastography

Non-invasive measurement of shear stiffness of human lungs in 10 volunteers


Further technical refinement, particularly in children
Functional Chest CT
CONCLUSION

Functional chest MR imaging has potential to detect early or mild change of lung diseases, to quantify altered lung function caused by lung diseases, to give insights into the pathophysiology of lung diseases, and to evaluate the effectiveness of established and new therapies. A majority of these imaging techniques can be applied to pediatric population.
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