DCE–MRI Team
Activity
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QIBA Groundwork – DCE-MRI

Groundwork (“precursor questions”)

Focus: Cancer and imaging biomarkers
Three pre-selected Imaging biomarkers
DCE – MRI was least mature
What is the specific DCE-MRI group Activity?
Where do we stand today?

…Profiling (“profile details”)

Technical Characteristics and Standards
Diagnostic Accuracy and Reproducibility
Clinical Efficacy and Real-world Effectiveness
DCE–MRI: What are its uses?

- DCE–MRI: Quantitative analysis of T1-weighted dynamic contrast enhanced images

Use cases:
- Clinical trial related:
  - UC1: pharmacodynamic investigations (e.g. $K_{\text{trans}}$) in early phase clinical trials
  - UC2: biological effect assessment as predictive biomarker
  - UC3: heterogeneity of disease/response
- Clinical routine use (future):
  - UC4: diagnostic decision making
  - UC5: therapeutic progress assessment in a clinical environment
QIBA Groundwork – DCE-MRI

Groundwork ("precursor questions")…

Focus DCE-MRI group
Phantom definition and improvement
Phantom study ongoing

Profiling activity regarding
technical characteristics and standards
for clinical application

…Profiling
("profile details")…
Phantom study aim

The aim of this study is to compare DCE-MRI images from GE, Philips and Siemens MR scanners based on imaging a specific phantom with a specific imaging protocol. The following questions will be addressed:

• What are the differences in the slope of relationship between the change in signal intensity and the change in R1 across different vendor’s MRI systems?
• How reliable and practical is the phantom study as a tool for image quality assessment prior to and during clinical trials?
• Are surface/body coil ratio images useful for correcting RF receiver sensitivity variations?
• What is the reproducibility of R1, M0, SNR and CNR on each MRI system?

• Phantom study protocol available at QIBA Wiki
Phantom study design

MD Andersen receives phantoms

Parallel Imaging procedure GE (new) scanner

Phantoms are comparable

Ship phantom A to UPENN

Imaging procedure Siemens MR scanners

Ship phantom A to Duke

Imaging procedure Philips (old)

Ship phantom A and B back to MD Anderson

Ship phantom B to U Chicago

Imaging procedure Philips (new) scanner

Ship phantom B To UC Davis

Image procedure GE (old) scanners

RSNA
Radiological Society of North America
Founded in 1915
Phantom Study - phantom

Phantom:
- Phantom design based on ADNI and IRAT experiences
- 2 phantoms purchased by MDACC based on NCI grant
- Phantom provider: The Phantom Laboratory.
- Phantom delivery with 4 months delay
- Phantoms were not identical, needed adjustments that were provided by MDACC
- Special thanks to Edward Jackson for his efforts and dedication
Image analysis / transport

- VirtualScopics provides analysis
- ftp based image transport
- Using NBIA infrastructure supported by NCI (John Freyman)
Phantom development
Test data and SW validation

- The synthetic test data initiative has one primary and two secondary goals.
  - Primary: to verify analysis software to be used in the DCE-MRI clinical study
  - Secondary 1: to evaluate software already available in the field
  - Secondary 2: to aid the development of new software tools

- Technique: synthetic DICOM compliant DCE-MRI images are created using standard vascular input functions and standard pharmacokinetic models.

- Special results presented by Sandeep Gupta
- Daniel P. Barboriak, Duke Univ. leads this initiative
QIBA DCE-MRI Timeline

2008
- Q1: Awareness RSNA2008
- Q2: QIBA workshop
- Q3: May – July: Start phase, Definition phantom and protocol
- Q4: August – December: Exploratory phase, DCE-MRI phantom study definition

2009
- H1: DCE-MRI team call
- H2: Evaluation start phase, Milestone 1
- Q1: December 08 – June 09: DCE – MRI Phantom study
  DCE-MRI clinical test-retest study definition

2010
- Q1
- Q2
- Q3
- Q4
Lessons learned

- DCE-MRI core team drives activities.
- Volunteer activities can focus only on activities with limited scope.
- Clinical test – retest study is not doable as a volunteer activity.
- Phantom study results are very important for next steps.
- Phantom study experiences led to further phantom development.
Lessons learned

- DCE-MRI has today more clinical applications as two years ago.
- DCE-MRI is used in clinical trials in early phases.
- We need to decide on which phantom to use based on QIBA experiences and promote the immediate use in several clinical trials to assess practical use and quality parameters over time – will this become a standard?
- An agreed basic imaging protocol is needed for phantom imaging and for DCE-MRI procedure understanding high spatial and temporal resolution.
- Speed of development is an issue.
May 2010 Workshop

● Objective:
  ● Phantom imaging study update and discussion on next steps
  ● QIBA 2 phantom – first results and next steps
  ● DCE-MRI profile outline; imaging protocol discussion
  ● Roadmap DCE-MRI
Thank you

- Ed Jackson
- Sandeep Gupta
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- Dan Barboriak
- Mitch Schnall
- Mark Rosen
- David Purdy

- Michael Buonocore
- John Freyman
- Larry Clarke
- RSNA staff
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Backup
DCE-MRI Protocol

Current Status:
- Differences across MRI systems, field strengths, software platforms, site practices (e.g. infusion protocols).
- Wide variety of pulse sequences. No standardization of T1 map acquisition.
- Different vendors use different internal system settings that complicate image comparisons.

Challenge: MEDIUM
- Agree on all aspects of a single protocol for DCE-MRI image acquisition.
- Incorporate a method for motion correction that is common to all vendors.

Recommendations:
- Select a single acquisition protocol including T1 mapping based on dynamic contrast-enhanced imaging acquisition. Each vendor defines similar internal system settings to support the protocol (step #1 of QIBA DCE-MRI team).
- Incorporation of motion correction method is longer term issue.
DCE-MRI Phantom

Current Status:
- An accepted systematic phantom calibration method does not exist for DCE-MRI imaging protocols, especially for calibration across different MRI systems.

Challenge: HIGH
- Phantoms will serve as a useful benchmark to test the accuracy and consistency of the acquisition protocols. Several phantoms to be developed, validated and distributed. Constructing phantom with actual inflow and perfusion is challenging.

Recommendations:
- **Priority 1:** Phantoms will focus on image intensity as a function of relaxation rate (R1, determined by contrast agent concentration).
- **Priority 2:** Phantoms will allow R1 and proton density estimation.
- Determination of geometric distortion due to magnetic field changes and true inflow and perfusion will not be focus for first activities.
Biomarker SW validation

Current Status:
- A plethora of software and quantification metrics exist. Many different semi-quantitative and quantitative metrics are commonly calculated and reported. Even for a widely accepted parameter, $K_{\text{trans}}$ for example, many different models exist and they each have limitations and assumptions.

Challenge: HIGH
- Picking the right algorithms for analysis is very important and challenging. It is complicated due to the non-standardization of acquisition protocols, as well as the fact that different body applications have very different acquisition scenarios. Robustness of the algorithm, speed of computation, ease of use are vital. Accurate image registration prior to analysis and some form of automated segmentation and analysis of disease after analysis are key challenges. No real ground truth without simulation no gold standard.

Recommendation:
- Simulated and real data are needed for reference purposes. It need to be used to assess algorithm implementation and development.
- Demonstration of comparability of algorithm implementations and development. Mainly task for research/academic community.
Reference Clinical Data

Current Status:
- No organized collection of reference data currently available for specific application areas.

Challenge: MEDIUM
- Large volume of clinical data can be obtained from multi-center trials that can serve as use-cases for evaluation of software tools and acquisition robustness. It must be ensured that the data is of high quality and adheres to the requirements of the analysis software. Various groups of datasets for each body application area and targeted types of cancer will have to formed. See validation for challenges - no easy way to build the data base; work with DICOM WG 18 regarding necessary meta data as part of the DICOM header plus SR data

Recommendation:
- Ensure that appropriate DICOM SR is used to make a complete record of input and results obtained (this DICOM SR is likely to support other biomarkers e.g. lesion segmentation, ROI definition).
- Start awareness campaign to ensure acquisition standardization becomes widely used in order to enable future population data based build up.