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The Promise of Quantitative Imaging

- Patient stratification in order to decide on alternative treatments
- Analysis of heterogeneity within and across lesions (can assess varying pharmacokinetics, receptor status, proliferative/apoptotic rates, etc.)
- Early prediction of treatment response
- Basis for modifying therapy
- Monitoring for Treatment Efficacy
- Longitudinal monitoring and evaluation (can be done before, during, after treatment, substituting for longitudinal tissue biopsy)


Modality-Independent Issues

General quantitative imaging challenges
- Lack of detailed assessments of sources of bias and precision
- Lack of standards (acquisition, analysis, and reporting)
  - Varying measurement results across vendors and centers
- Little support from imaging equipment vendors
  - No apparent competitive advantage (reimbursement) or regulatory requirements
    - Varying measurement results across vendors
    - Varying measurement results across time for any particular vendor
- Highly variable quality control procedures
  - QC programs, if in place, are typically not specific for quantitative imaging
    - Varying measurement results across centers
Modality-Independent Issues

General quantitative imaging challenges (continued)
- Cost of QIB studies (comparative effectiveness)
- Radiologist acceptance
  - QIBs are not a part of radiologist education & training.
  - The software and workstations needed to produce and interpret QIB results are typically not integrated into the radiologists' workflow.
  - Clinical demand on radiologists is high — “time is money”.
  - There are few guidelines for QIB reporting.
- Resource availability
  - Technologists trained in advanced, quantitative, protocols
  - Physicians and/or imaging scientists, data processing capabilities, etc.

Single-vendor, single-site studies:

Key Challenges
- Acquisition protocol optimization
  - Scan mode and acquisition parameter optimization for:
    - contrast response and CNR
    - temporal resolution (for dynamic imaging)
    - spatial resolution
    - anatomic coverage
  - Application specific phantoms needed for initial validation scans and ongoing quality control
    - phantom acquisition and data analysis protocols
    - established frequency of assessment and data reporting
- Mechanism for detecting and addressing changes in measured response due to system upgrades (Quality Control)
  - Vendors focused on competitive advantage in radiology, not on quantitative imaging applications and maintaining signal response characteristics over time

Single-to multi-vendor studies:

Key Challenges
- Acquisition protocol harmonization
  - Scan mode and acquisition parameter selection for matched:
    - contrast response and CNR
    - temporal resolution (for dynamic imaging)
    - spatial resolution
    - anatomic coverage
  - Application specific phantoms needed for initial validation scans and ongoing quality control
    - phantom acquisition and data analysis protocols
    - established frequency of assessment and data reporting
- Can be achieved, but requires substantial effort at start up
- Mechanism for detecting and addressing changes in measured response due to system upgrades (Quality Control)
  - Vendors focused on competitive advantage in radiology, not on quantitative imaging applications and maintaining signal response characteristics over time
Single- to multi-center studies: **Key Challenges**

- Acquisition protocol
  - Harmonization across centers and vendors
  - Distribution and activation of protocols
    - Distribute/load electronically
    - Provide expert training and initial protocol load/test
    - Develop / utilize local expertise
  - Compliance with protocol
    - Local radiologists, technologists

- Widely varying quality control
  - Ranging from specific for a given imaging biomarker, to ACR accreditation, to none
  - Even if QC program is in place, it may not test parameters relevant to the study

- “Scanner upgrade dilemma”
- Data management and reporting

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Data Analysis: **Key Challenges**

- Data analysis implementation strategies are often as variable as acquisition strategies
- Choice of model must match data acquisition strategy, *e.g.*, temporal resolution of the acquired data
- Analysis parameters must be standardized, *e.g.*, choice of model, ROI definition, *etc.*

To facilitate testing/validation of various analysis packages, readily available, standardized test data and analysis results are needed:

- Digital reference objects
- Physical phantoms and standardized acquisition protocols and data analysis software
- Publicly available test/retest human subject data and associated metadata

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**ADNI**

- Multicenter, multivendor study
- Optimized pulse sequence / acquisition parameters for each platform
- MagPhan/ADNI phantom scan at each measurement point
- Access to vendor gradient correction parameters
- With corrections for gradient nonlinearities and optimized acquisition strategies, spatial accuracies of ≤0.3 mm can be obtained over a ~180 mm spherical volume
## Quantitative MR Imaging Initiatives

- Consensus Group Guidelines
- NCI: RIDER and Academic Center Contracts
  - Imaging Response Assessment Team (IRAT)
- RSNA: Quantitative Imaging Biomarkers Alliance (QIBA)
- ISMRM: Ad Hoc Committee on Standards for Quantitative MR
- NCI: U01-Funded Quantitative Imaging Network (QIN)
- ACRIN: NCI Centers of Quantitative Imaging Excellence (CQIE)
- Core Labs