System Variance Model for SPECT Ioflupane

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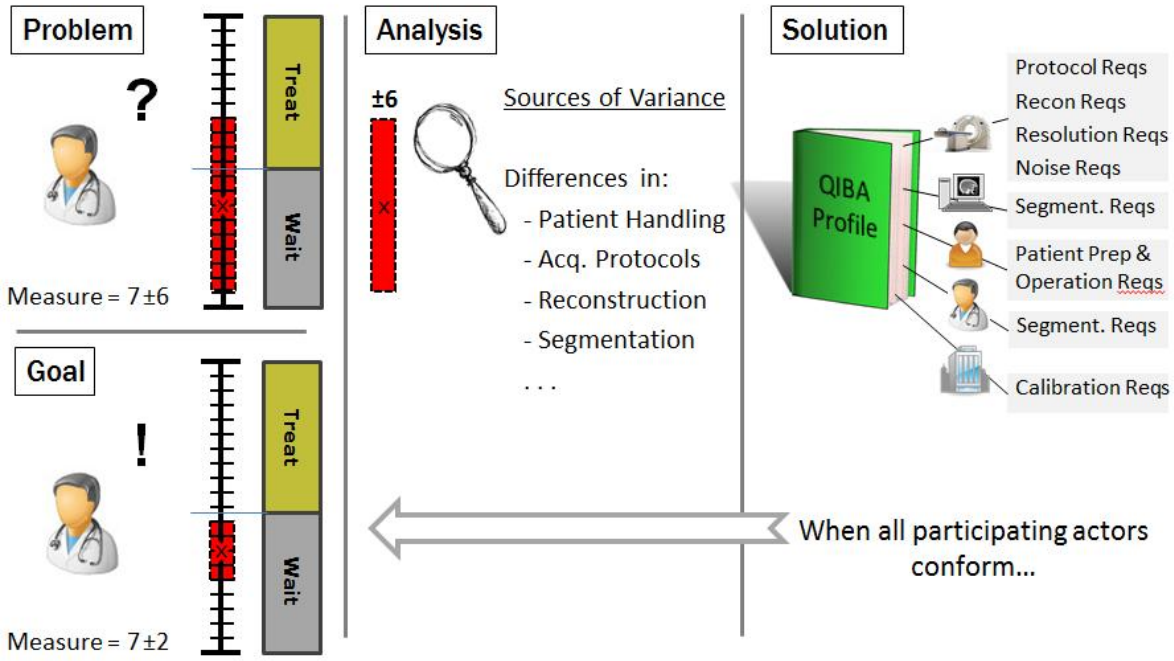
QIBA's Mission



System Variance Sources Model – Ioflupane SPECT

Each source contributes variance to final measureand and ideally should be measured/controlled

Equipment QC

Time synchronization

Dose calibrator

SPECT calibrations & QC

- Uniformity
- Alignment
- Sensitivity

CT calibrations* & QC

- HU accuracy
- Uniformity

Acquisition Protocol

CT acquisition*

Injected dose

Uptake time

Head position

Data statistics

Detector/Collimator response

Data sampling

- Framing
- Time sampling
- Angular sampling

Patient

Size

Motion

Tracer kinetics

Brain condition

- Age
- Atrophy
- Pathology

Image Reconstruction

Attenuation correction

Scatter correction

Gantry response correction

Reconstruction algorithm and settings

Detector/collimator response corrections

Image Analysis

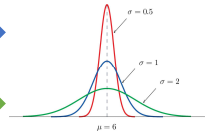
Partial volume correction

Spatial normalization to template

Target VOIs

Reference region

Age correction



*if SPECT/CT or CT image used for attenuation correction

Quantify & Rank the Variance Contribution (example ranking only)

Higher the ranking → more effort needed in Profile to decrease or control ("biggest band for the buck")

Equipment QC

Time synchronization

Dose calibrator

SPECT calibrations & QC

- Uniformity
- Alignment
- Sensitivity

CT calibrations* & QC

- HU accuracy
- Uniformity

Acquisition Protocol

CT acquisition*

Injected dose

Uptake time

Head position

Data statistics

Detector/Collimator response

Data sampling

- Framing
- Time sampling
- Angular sampling

Patient

Size

Motion

Tracer kinetics

Brain condition

- Age
- Atrophy (D%) ❹
- Pathology

Image Reconstruction

Attenuation correction (A%) ❶

Scatter correction

Gantry response correction

Reconstruction algorithm and settings (C%) ❸

Detector/collimator response corrections (E%) ❺

Image Analysis

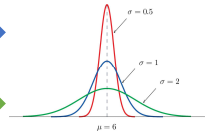
Partial volume correction (B%) ❷

Spatial normalization to template

Target VOIs

Reference region

Age correction



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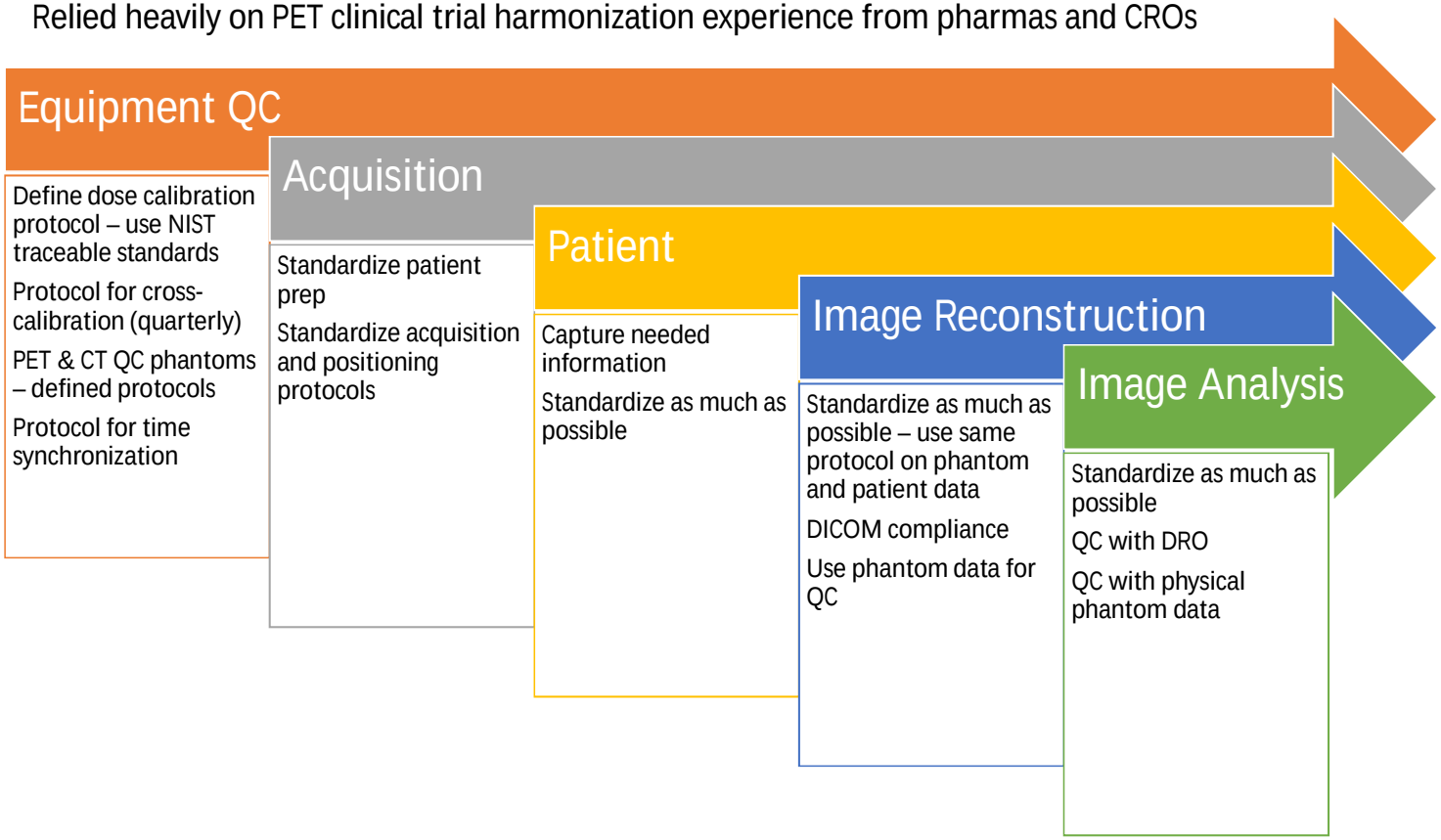
PET FDG Tumor & Amyloid Strategies to Control Variance

Relied heavily on PET clinical trial harmonization experience from pharmas and CROs



Sources of data to determine variance

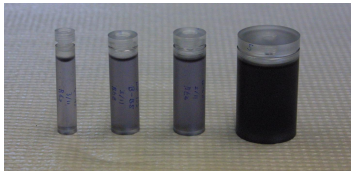
- Scientific literature
  - Analyze data in published studies
  - If possible, acquire the data reported on in the literature
- Phantom studies
  - “Ground truth” is known with certainty
- Pilot studies
  - QIBA has funded several of these
- Manufacturers’ Specifications
  - Accuracy

Excellent Example to Estimate Various Sources of Variance

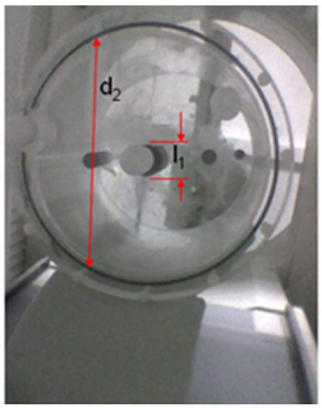
- Following four slides were contributed by Brian Zimmerman from NIST
  - Presented Nov. 17th in the Phantom/DRO Sub-group Netmeeting
- Studies like this can help us quantify and rank our sources of variance
- Note where gaps of data/scientific studies are for quantifying variance contribution
  - Develop projects and request funding (e.g. from QIBA) to fill in gaps

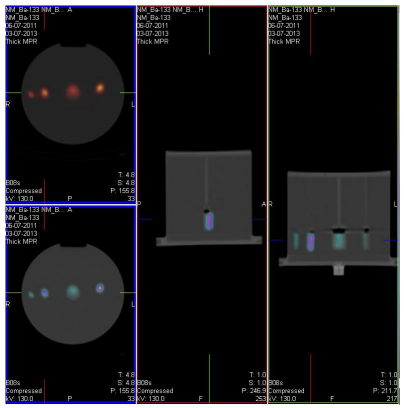
SPECT imaging quantification with surrogates

- Series of ^{133}Ba sources designed and calibrated by NIST (constructed by private company)
- Diameters varied from 0.8 cm to 2.9 cm to test partial volume recovery
- Sources sent to 9 clinics in different countries (usually representing best practice in country); half of participants from developing countries
- Uncertainty on activity calibration < 1 %



Three trials



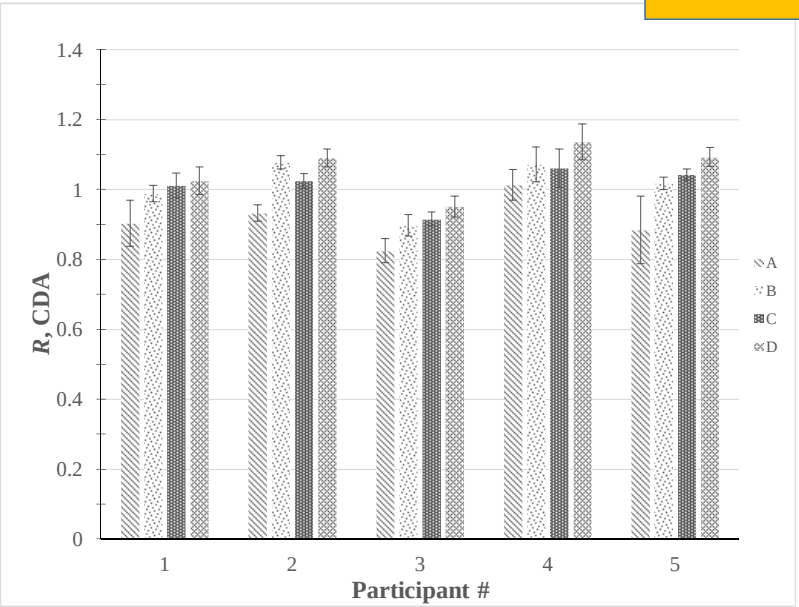


- First: use of “best practice”
- Second: Strict, prescriptive protocol
- Third: Analysis of second trial data by single center
- Study used combination of Planar and SPECT-CT

Best results achieved with prescriptive protocol and centralized data analysis

Justification for our QIBA BC ☺ !

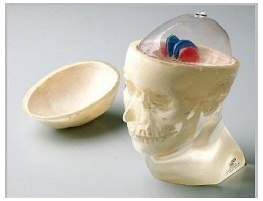
- Average recovery using SPECT-CT improved from +12(6) % in first trial to 0(8) %
- Partial volume corrections of up to 20 % required (not made in comparison)
- Quantification of 5 % should be possible with appropriate corrections and protocol

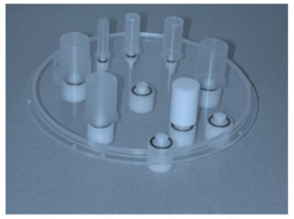


SPECT-CT results: ratio of participants' results to NIST-calibrated activity for each test object

What about this case?

- ^{57}Co as surrogate for ^{123}I?
  - Strongest photons in 123I at 158 keV; doublet in 57 decay at ~125 keV
- With help from source manufacturer, making solid mock sources with any of these configurations should be possible (even with different activity levels)
- Calibrated activity uncertainty should be on order of 1 %





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