Before quantification, must assure proper functioning
Transducer damage/defect is most common

Image Uniformity Test
Level 1 defect
Level 4 defects, replace

Also, should check 3D resolution, contrast resolution and depth of imaging for overall imaging performance
With traditional methods this can lead to a lot of numbers that are difficult to interpret, except in time series, and phantoms are around $3000
A bit harder for slice thickness with depth.
These problems are probably resolved with what is expected to be a much simpler and less expensive phantom.

Visualization of randomly-distributed high-contrast, low-echo spheres
Visually estimate the depth range(s)
Zone 1— the spheres are clearly visible
Zone 2— they are reasonably well delineated, but with very limited contrast.

In Automated analysis Find
• Lesion signal to noise ratio, LSNR, for each detected sphere.
  \[ \text{LSNR} = \frac{\text{mean pixel value in sphere}}{-\text{of background}} \]
• Mean LSNR, LSNR\(_{\text{mean}}\), in overlapping small depth intervals, \(d\)
• Useable range, \(R_1\) to \(R_2\), in which \(|\text{LSNR}_{\text{mean}}|\geq n\, \text{dB} ; n=-3\) for Zone 1
• Mean useable contrast, LSNR\(_{\text{use}}\), in zone \(Z\)
• Clarity Index, CI = \log(|\text{LSNR}_{\text{mean}}|) \times (R_2 - R_1)\)
• Track all 4 relative to original reference values, or just the CI
• The CI for usually only one zone, carries more useable information, related directly to clinical performance than the hard-to-evaluate lateral, elevational and axial 3D plots of the beam profiles of filaments at each depth.

Questions?
**AIUM-QIBA Volume Blood Flow (VBF) Committee Members**

- **J. Brian Fowlkes, PhD, FAIUM** (Co-Chair)
  - University of Michigan
- **Oliver Daniel Kripfgans, PhD, FAIUM** (Co-Chair)
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- **James Jago, PhD** (Co-Chair)
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- **Kazuya Akaki**
  - Canon Medical Systems USA
- **Maryam Alsyedalhashem, PhD**
  - King Fahad Specialist Hospital, Dhahban (Saudi Arabia)
- **Cristel Baiu, MS**
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- **David Dubberstein, PhD**
  - GE Healthcare
- **Todd Nicholas Erpelding, PhD**
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- **Jing Gao, MD, FAIUM**
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- **Timothy J Hall, PhD, FAIUM**
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- **Mark R. Holland, PhD, FAIUM**
  - Indiana University School of Medicine
- **Nicole Lafata, PhD**
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- **Safeer Hyder Laghari, PhD**
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- **Chi-Yin Lee**
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- **Adrian Lim, MD, FRCR**
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  - Fujifilm Healthcare Americas Corporation
- **Andy Milkowski, BSME, MSIE**
  - Siemens
- **Shigeto Ono**
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- **Stephen Z. Pinter, PhD**
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- **Anthony Edward Samir, MD, MPH, FAIUM**
  - Massachusetts General Hospital / Harvard
- **Shriram Sethuraman**
  - Philips
- **Randall Sung, MD**
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- **Rimon Tadross, PhD**
  - GE Healthcare
- **Iman Taghavi, MSc**
  - Technical University of Denmark
- **Kai Erik Thomenius, PhD, FAIUM**
  - Independent Consultant
- **Theresa A. Tuthill, PhD**
  - Pfizer

**Due to:**

- **Dan Sullivan, MD**
  - Duke U. Radiology

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**3D/4D Volume Flow**

Integration of Color Flow Velocity Vector Function Normal to the C-plane Surface Yields Blood Volume Flow

\[ Q = \oint_S \mathbf{v} \cdot dA \]

**Mechanically Swept Probes**

**Fully Electronic (2D array) Probes**

**Complex Flow Phantom**

**Calibrated Volumetric Flow**
Ultrasound Systems in this Study*

- Canon (formerly Toshiba) Aplio 500 with a mechanically swept 9CV2 probe
- GE Logiq LE9 with a mechanically swept RSP6-16 probe
- Philips Epiq 7 with an X6-1 2D matrix array

* Other participating companies have systems in development.

Kripfgans et al. Radiology, 2020

Flow Range Dependence

Kripfgans et al. Radiology, 2020

Ultrasound Volume Blood Flow

- Current status is stage 0 – draft stage, ready for full committee
- A checklist of each actor’s responsibilities is drafted.
- Finalizing section 4 for assurance of conformance and determining the necessary tests for bias and variance.
- Two publications under review:
  - Measurement variation using 2D vs. 3D methodologies for blood flow for improvement / reduction in intra-observer variability
  - Beam spacing and beam width paper
- A currently funded NIH project on umbilical venous flow may provide additional groundwork data.

QIBA CEUS Committee Leadership

- Co-chairs
  - Mike Averkiou, PhD
  - Richard Barr, MD
  - Todd Erpelding, PhD
  - Mike Averkiou, PhD
  - Richard Barr, MD
  - Todd Erpelding, PhD

University of Washington
Northeastern Ohio Medical University
Canon Medical Systems USA

72 members

Why we need CEUS quantification

Extract important physiologic information, related to perfusion, from the time evolution of the tumor image intensity during the bolus transit (wash-in/washout)
Why we need CEUS quantification

Quantification objective: Extract important physiologic information related to perfusion, from the time evolution of the tumor image intensity during the bolus transit (wash-in/washout).

Colorectal metastasis before any chemotherapy

Groundwork—the QIBA CEUS phantom

Use similar for training techs to perform reproducible studies

• Sonovue (0.2 ml) in 19.8 ml saline, inject 2 ml of diluted solution into flow phantom to mimic clinical dose and to be in middle of intensity-concentration linearity range
• Collect 5 TICs per scanner on a single day (4 scanners used)
• Repeat above procedure on 3 different days (total of N=15 per scanner)
• Keep system parameters constant between trials, image tube in same orientation and depth every time

Groundwork Results (sample TIC’s)

• Substantially similar curves are produced from all scanners
• Arbitrary amplitude calibration among vendors produces different intensity scales
• Lognormal distribution produces curves well fitted to the data
• We use fitted curves to extract the important perfusion-related parameters

Results (overall summary)

Averkiou, et al., Invest Radiol. 55, 10 (2020)

RT and MTT: 10-20% variability
PI and AUC: 50% variability

Single scanner; single software
Same scanner; different software
Different scanner; same software