QIBA – Blood Flow Measurement in the Hemodialysis Patient

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Blood Flow Measurement

• Potentially very useful clinical tool
• Available on most US scanners – hand held to high end
• Just push a button and get a number
• Few understand pitfalls or correct way to measure
• How accurate?
End-Stage Renal Disease

- > 300,000 Americans on hemodialysis
- Cost > $1 billion / year for access related procedures and hospitalizations
- Access problems #1 cause of hospitalizations
- Total cost hemodialysis $15 billion / year

2 Types of Permanent HD Access

- Native arteriovenous fistulas (AVF)
  - AVF longevity > 5 yrs.
- Synthetic arteriovenous grafts (graft)
  - Graft longevity ≈ 18 mo. – 2 yrs.
- (Catheter)
Ideal Fistula Features

- Large diameter
- High blood flow
- Superficial
- Adequate useable length for cannulation with two needles

Multicenter Trial AVF Failure Rate

- 60% failure to mature
  - Infection
  - Inadequately sized vessels
  - Inadequate arterial inflow
  - Undetected vein stenosis/ sclerosis
  - Undetected central occlusion

Blood Flow Measurement

• Used to measure graft blood flow in R01
• Assessment of AVF maturity in Radiology 2002 paper
  – Hemodialysis pump: 350 cc/min
  – 100 – 150 cc/min to keep fistula or graft open
  – Need ≈ 500 cc/min AVF blood flow

Robbin et al; Kidney International 2006;69(4):730-735
Robbin et al; Radiology 2002;225(1):59-64.
Blood Flow Measurement Difficulty

- AVF not laminar flow, but turbulent
- ≈ 20% accuracy range?
- 3-D volumetric blood flow calculation not yet available
- Accuracy, precision of measurement depends on machine
- Heavily dependent on technique
- Absolutely need to train sonographers to get meaningful results

Low Resistance Flow in AVF
Low Resistance Blood Flow

Zonare


Low Resistance Blood Flow

Philips iU22

Issue: High Resistance Blood Flow

- Change in blood flow pre to post AVF placement likely important predictor of AVF maturity
- Simulates brachial artery flow prior to AVF placement
- No one has investigated US accuracy of high resistance blood flow measurement
Issue: High Resistance Blood Flow

• High resistance blood flow can have a below the baseline component, different in every subject.

• If there is a significant below the baseline component in the arterial signal, the US scanner calculated blood flow can drop significantly.

• Sometimes calculates very low flow (e.g. 12 cc/min) to forearm/hand, likely not correct.

Issue: High Resistance Blood Flow

• US scanner may automatically measure waveform
  – Above the baseline
  – Above and below baseline

• Different manufacturers’ scanners have different presets, algorithms, calculations.
Issue: High Res. Blood Flow

Settings affect blood flow calculation results

High Resistance Flow 75/25
Blood Flow Measurement

• Time averaged mean velocity \times vessel area

• Framingham heart study measured using time averaged peak velocity \times vessel area

• Hand traced peak velocity curve

• Before automatic scanner velocity measurement

Blood Flow Measurement

• When upgrading Toshiba scanner, it reverted to time averaged peak systolic velocity \times area equation

• If meaningless, why does Toshiba have it as default?
AVF Blood Flow - Summary

• Meets criteria for quantitative imaging biomarker
• Potentially useful discriminator for AVF maturation evaluation
• Need solution to current scanner chaos
• Otherwise the measurement will be useless and discredited

Future Work Needed – Expert Panel

• Develop reproducible methodology for testing US blood flow measurement
• Recommend blood flow equation, get all vendors to adopt
• Suggest ways to improve reproducibility
• Uniform recommendation regarding high resistance waveform blood flow analysis of below the baseline components
Opportunity

• NIH has/is supporting R01s/ U01
• will need future direction to plan for future hemodialysis AVF trial
• Measurement protocol/training materials already complete – 70 trained

Conclusions

• Great opportunity for Radiology to be a key player in noninvasive US hemodialysis patient evaluation
• Bread and butter study, large volume
• If we don’t master blood flow measurement, vascular surgery and nephrology will