



QIBA – Blood Flow Measurement in the Hemodialysis Patient

Michelle L. Robbin, M.D.
University of Alabama at Birmingham
mrobbin@uabmc.edu

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 \approx 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

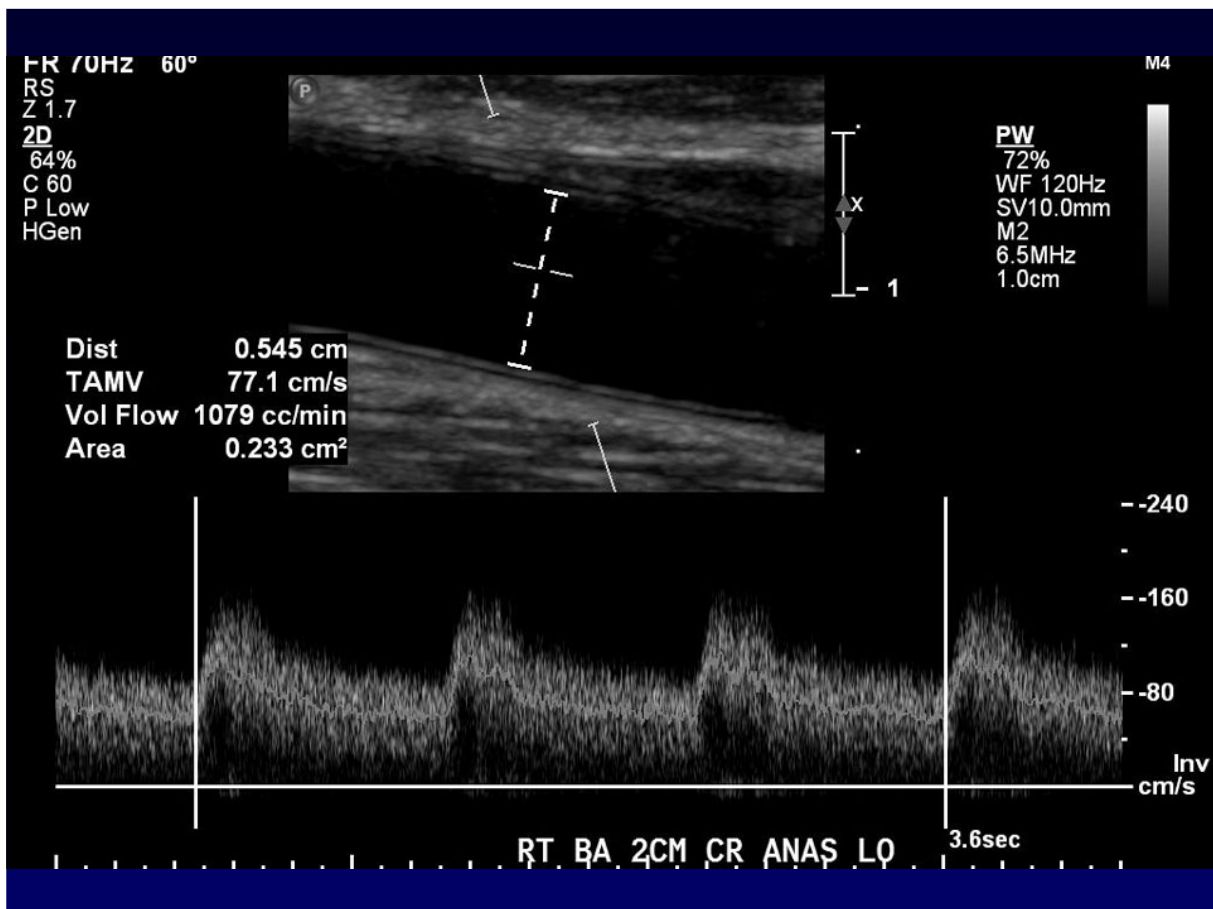
- 60% failure to mature
 - Infection
 - Inadequately sized vessels
 - Inadequate arterial inflow
 - Undetected vein stenosis/ sclerosis
 - Undetected central occlusion

Effect of clopidogrel on early failure of arteriovenous fistulas for hemodialysis. *JAMA* 299:2164-2171, 2008

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 \approx 500 cc/min AVF blood flow

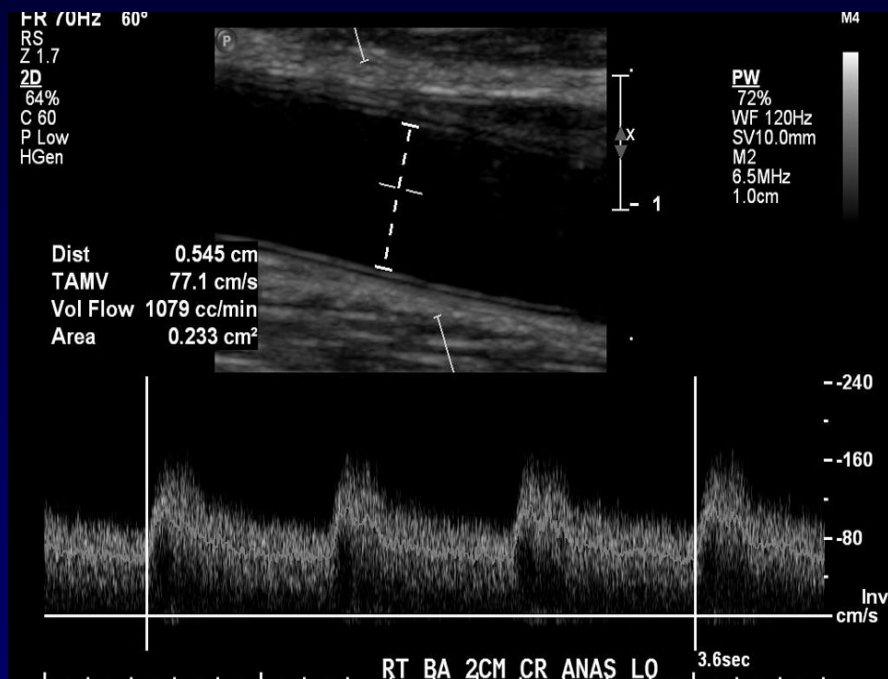
Robbin et al; Kidney International 2006;69(4):730-735
Robbin et al; Radiology 2002;225(1):59-64.



Blood Flow Measurement Difficulty

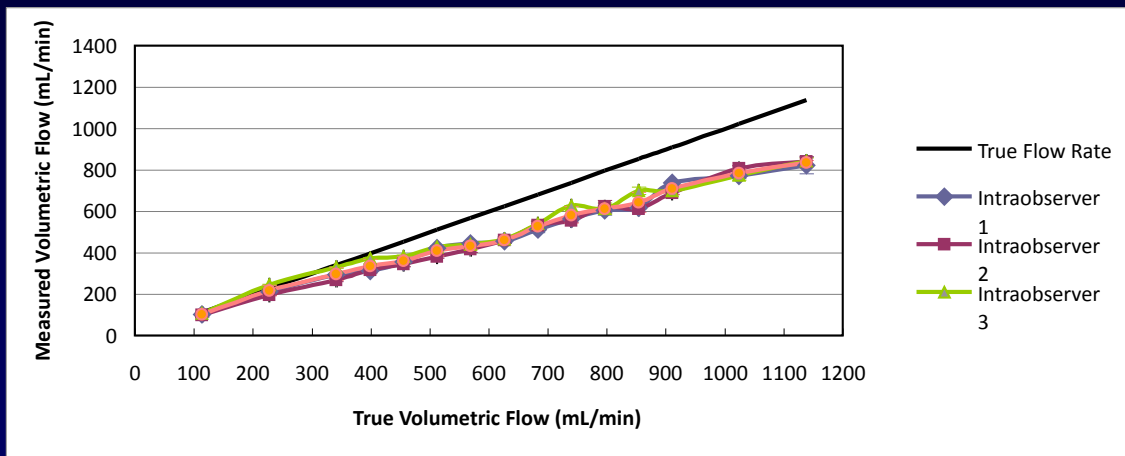
- AVF not laminar flow, but turbulent
- $\approx 20\%$ accuracy range ?
- 3-D volumetric blood flow calculation not yet available
- Accuracy, precision of measurement depends on machine
- Heavily dependent on technique
- Absolutely need to train sonographers to get meaningful results

Low Resistance Flow in AVF



Low Resistance Blood Flow

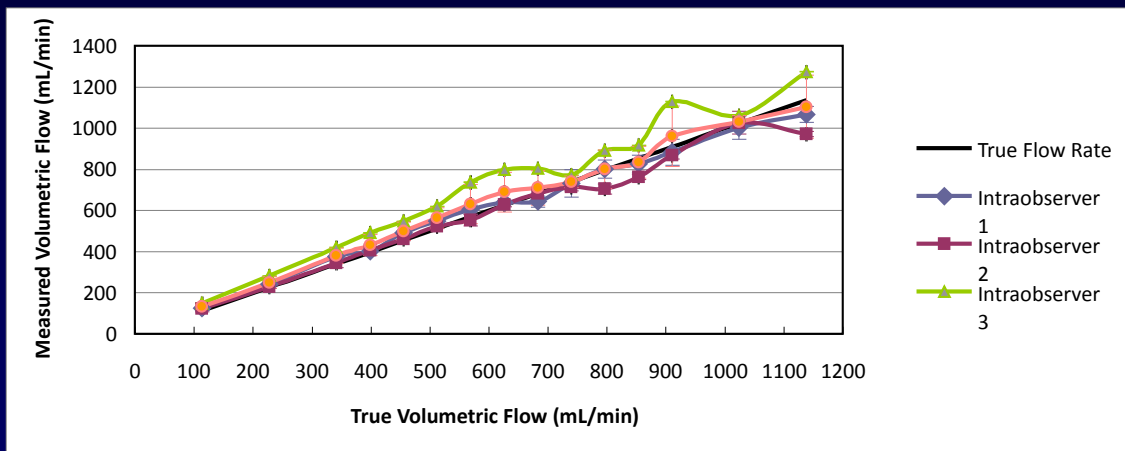
Zonare



Hoyt K; Accuracy of Volumetric Flow Rate Measurements: An In Vitro Study Using Modern Ultrasound Scanners. *J Ultrasound Med* 2009;28:1511-1518.

Low Resistance Blood Flow

Philips iU22

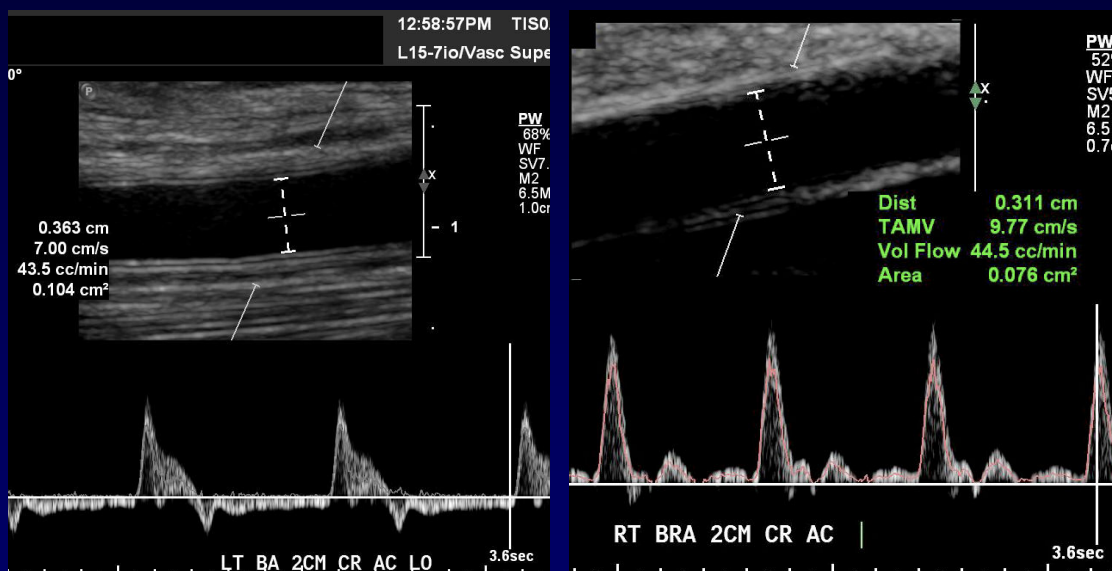


Hoyt K; Accuracy of Volumetric Flow Rate Measurements: An In Vitro Study Using Modern Ultrasound Scanners. *J Ultrasound Med* 2009;28:1511-1518.

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

High Resistance Flow Brachial Art.



Issue: High Resistance Blood Flow

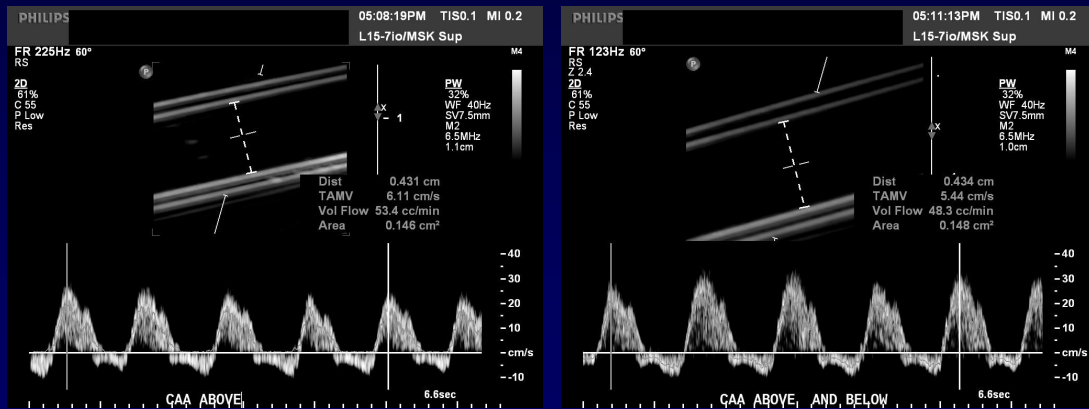
- High resistance blood flow can have a below the baseline component, different in every subject.
- If there is a significant below the baseline component in the arterial signal, the US scanner calculated blood flow can drop significantly
- Sometimes calculates very low flow (e.g. 12 cc/min) to forearm/hand, likely not correct

Issue: High Resistance Blood Flow

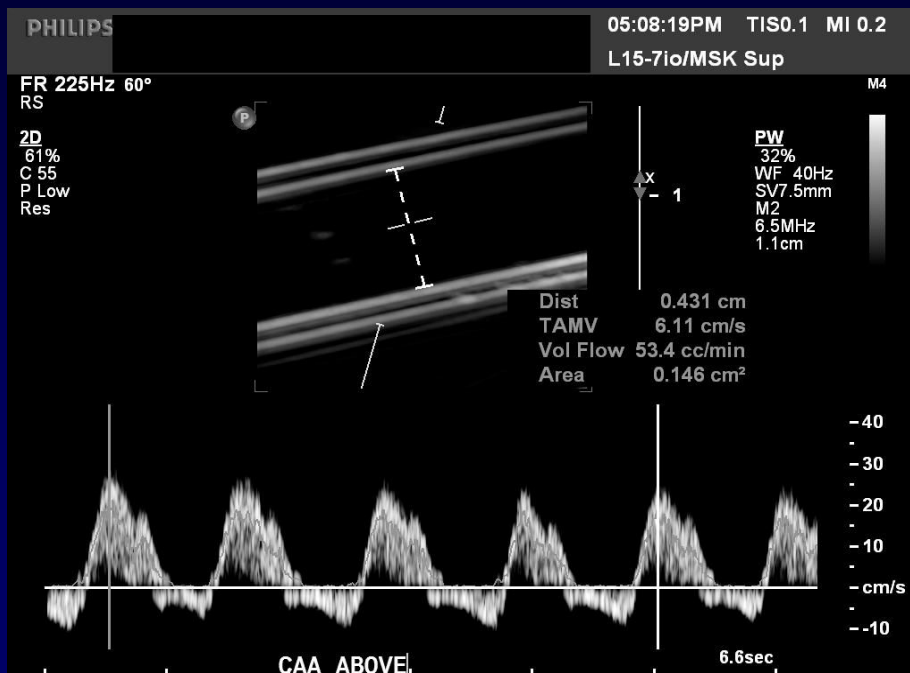
- US scanner may automatically measure waveform
 - Above the baseline
 - Above and below baseline
- Different manufacturers' scanners have different presets, algorithms, calculations

Issue: High Res. Blood Flow

Settings affect blood flow calculation results



High Resistance Flow 75/25



Blood Flow Measurement

- Time averaged mean velocity x vessel area
- Framingham heart study measured using time averaged peak velocity x 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 x 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