

## Dynamic Vascular Assessment (DVA): Premises

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- Vessels autoregulate for adjacent vessel segments and systemic conditions
- DVA measures non-invasively the “state” of autoregulation
- DVA measures “endothelial function” at rest
- DVA explains how vascular disease, in both subtle and severe conditions, causes or is affected by a large number of medical conditions
- DVA may be used to formulate a physiological differential diagnosis that may, in some conditions, be diagnostic

## Dynamic Vascular Assessment: what is it?

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### Consists of:

- 3-parameter nomogram of well-characterized physiological parameters normalized to standard deviation z-scores
- Considers acceleration, time domain (dynamic information) that measures vessel wall properties

### Produces:

- Vascular physiological profiles for segments and systems of segments
- “Bar charts”

### Clinical Value:

- Objective, quantitative, automated TCD data processing
- Physiological DDx that has the potential to be diagnostic

### Compares to:

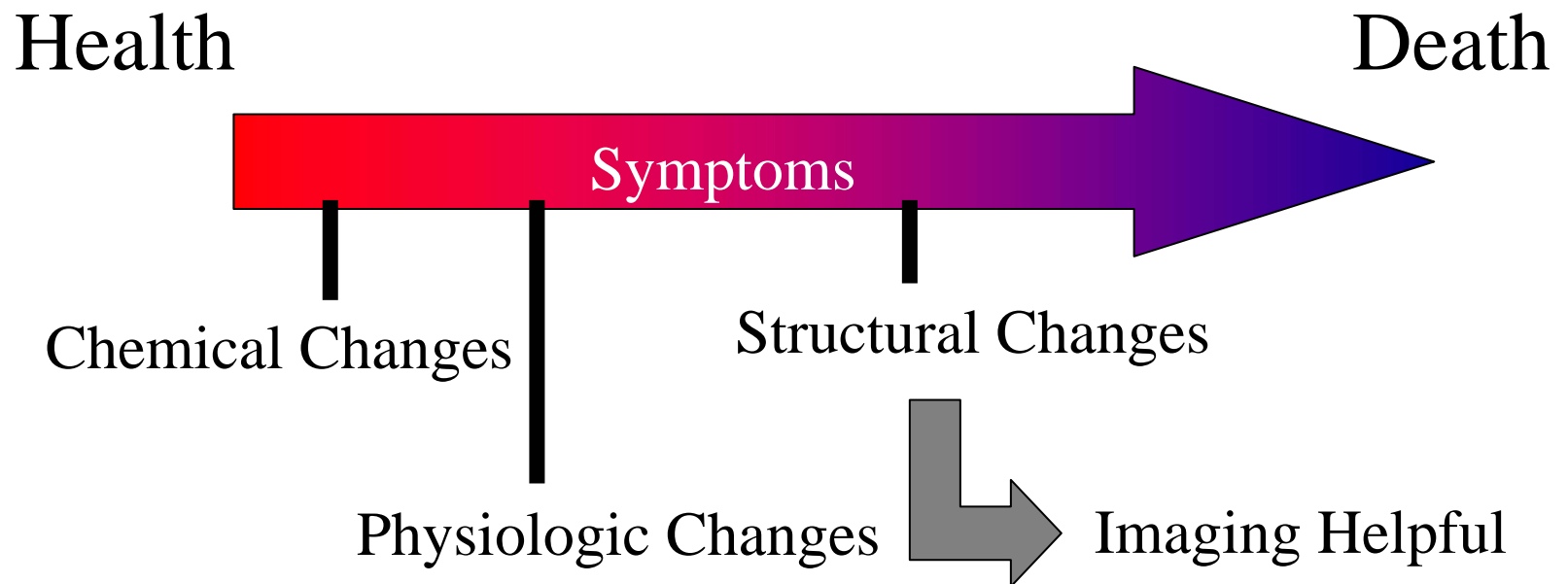
- Good medical lab practice of gathering reference norms
- Physiological (stress) testing

## Flow Paradigms: volumetric (flow rate) vs dynamic (vessel performance)

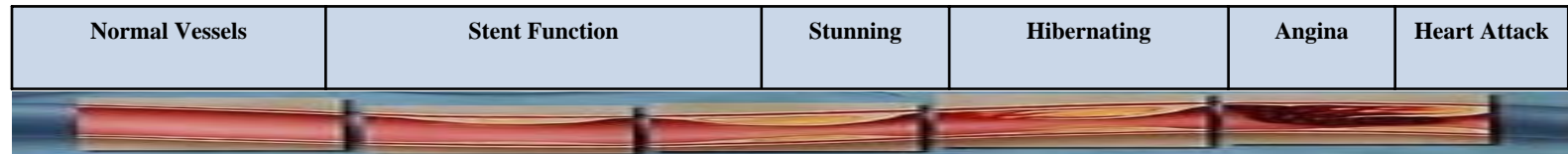
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- Steady
- Volumetric
- First order velocity
- Blood Flow
- Pulsatile
- Dynamic
- Second Order Velocity
- Vessel Function

## Disease Progression








## Cardiovascular Continuum



- There is a continuum of vascular disease associated w a relatively limited set of cardiac symptoms
- Measures along the continuum include:
  - Physiological screening (stress testing)
  - Functional studies (echo, nuclear scan)
  - Anatomical assessments - end-stage, occlusive heart disease

## Cerebrovascular Continuum

Normal	Chronic Degenerative, Depression, Parkinsonism	Cognitive Impairment	TIA	Stroke
				

- DVA measures vascular performance and relates the measurements to a continuum of cerebrovascular disease
- Physiological states reflect directly:
  - vascular disease at the large or small vessel level, or
  - elevation of pressure in the skull
- Carotid artery disease causes many neurological symptoms however, stroke risk is the only current indication for treatment
  - Is the risk-benefit ratio optimal at 70% stenosis – with more sensitive tools, probably not.
- Systemic diseases can have neurovascular effects and primary neurovascular disease can have systemic effects

## DVA Process and NHSi Platform

*Doppler blood flow velocity spectra acquisition*

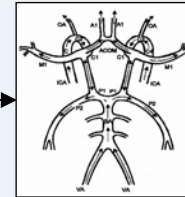
**Target Vascular System**



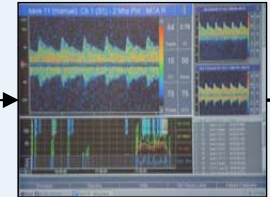
**Doppler ultrasound clinical test with current instrumentation**



**Standard Doppler segmental study**

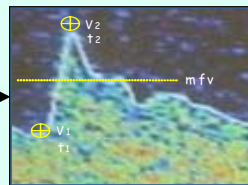


**Segmental spectra saved to instrument file**



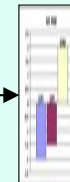
### NHSi DVA PLATFORM

*DVA Analytical Platform*

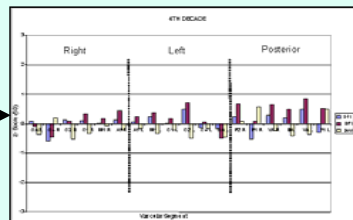


**Spectral Data Analyzed and DVA Variables Extracted**

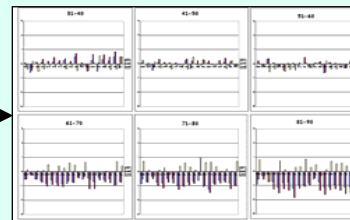
**DVA Indices Calculated and Compared with Reference Databases**



**DVA Indices z-scores generated for each vascular segment**



**All z-scores for all segments compiled as "bar code" profile**

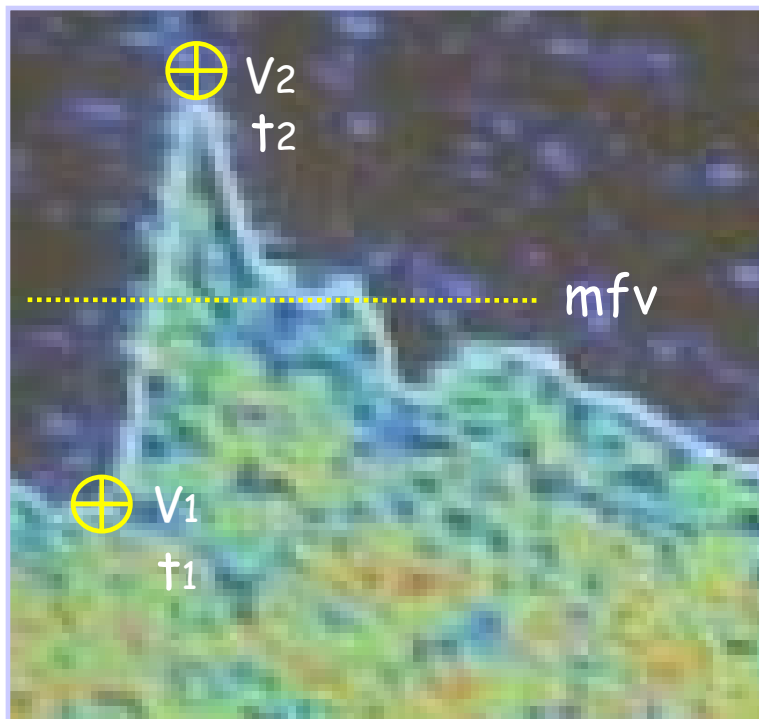


**DVA profile compared against suite of reference and disease specific databases**



**DVA Report: Degree of fit between subject findings and known vascular conditions**

## DVA Makes TCD Readings Quantitative and Objective



Force of Flow:

$$F \propto SA = \Delta V / \Delta t$$

Mean Flow Velocity:

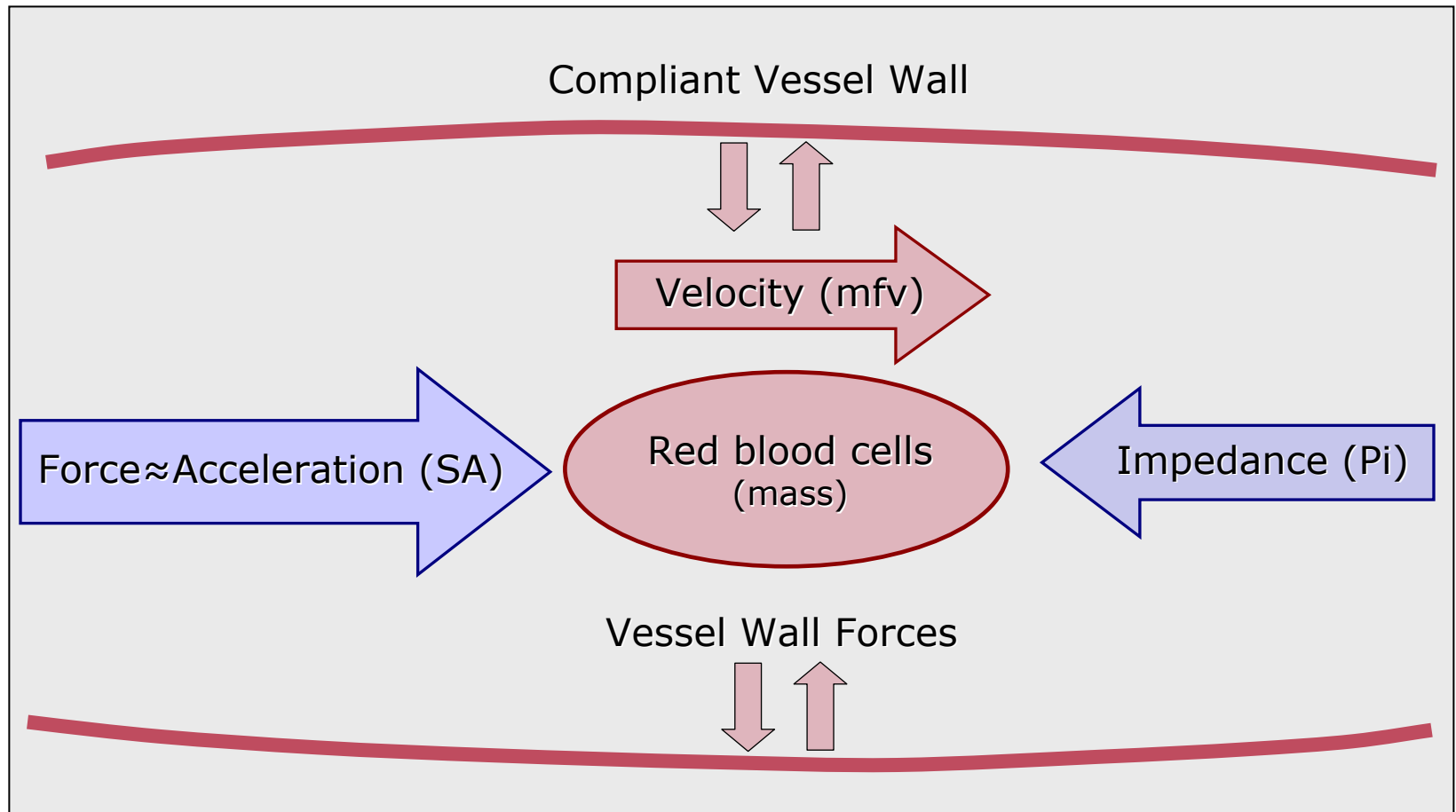
$$mfv = \Delta V / 3 + V_1$$

Impedance to Flow:

$$P_i = \Delta V / mfv$$

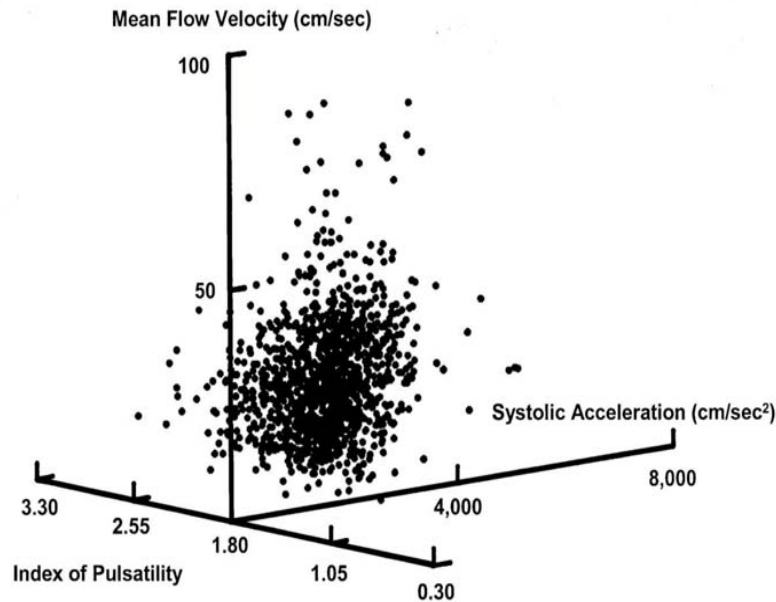
*DVA takes the TCD waveform and systematically measures it to quantify the different components of vascular physiology*

## The DVA Paradigm

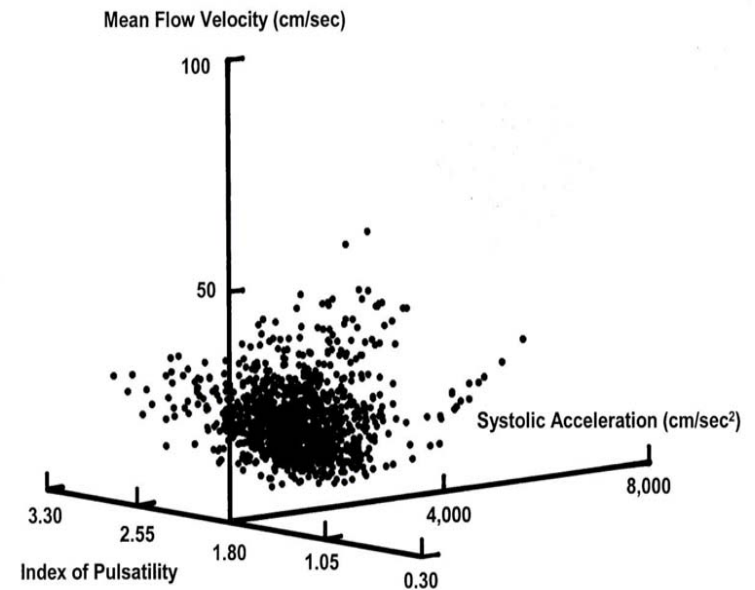


## Different Vessels Have Different DVA Signatures

### Basilar Artery

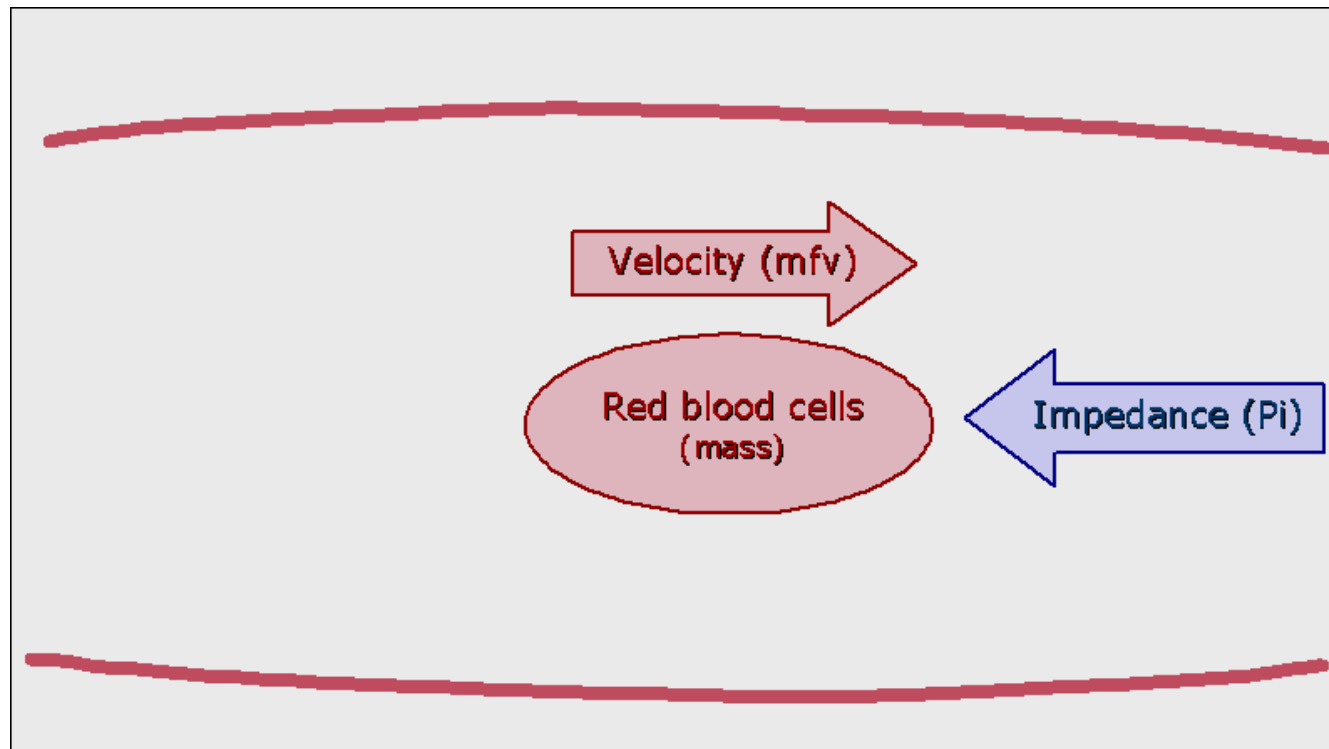


### Ophthalmic Artery



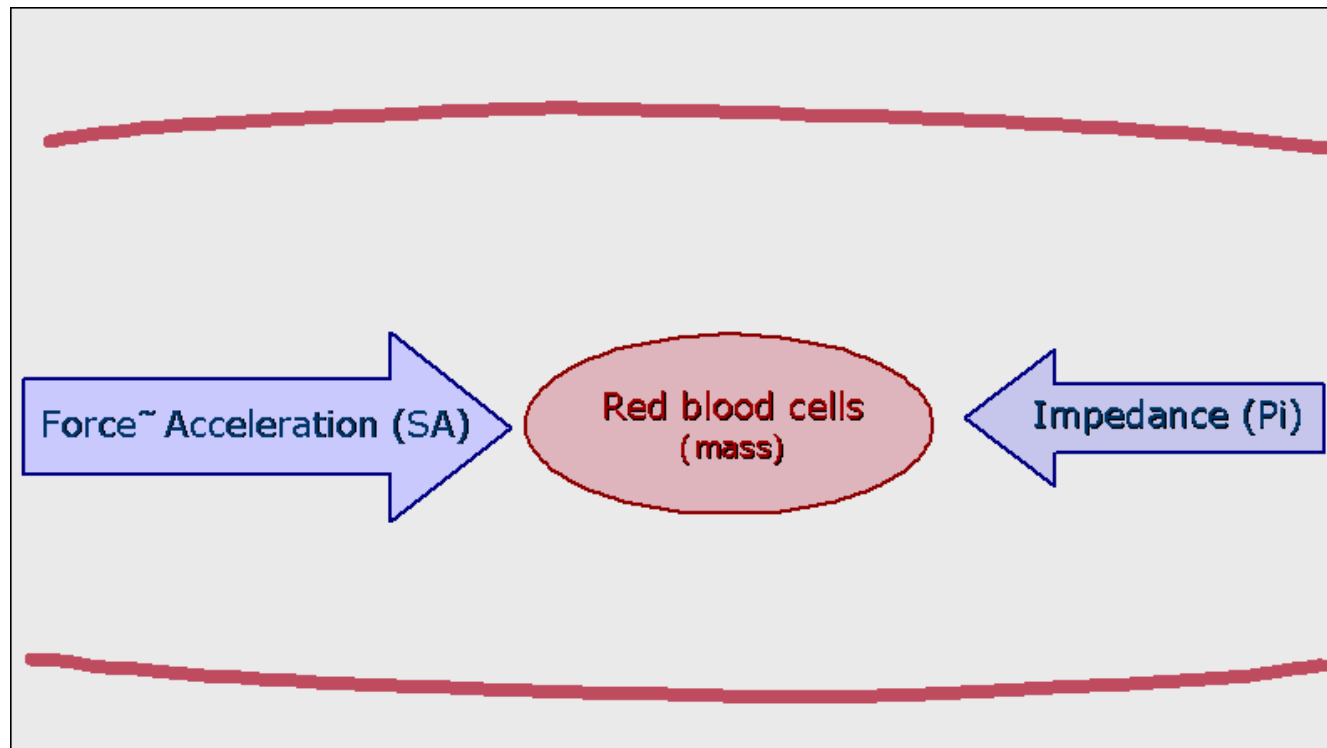
## DVA: Dynamic Flow Index

- $DFI = mfv/Pi$ 
  - Relates Mean Flow Velocity to Impedance (Pi)
  - Capacitance effect on flow through conductance vessels



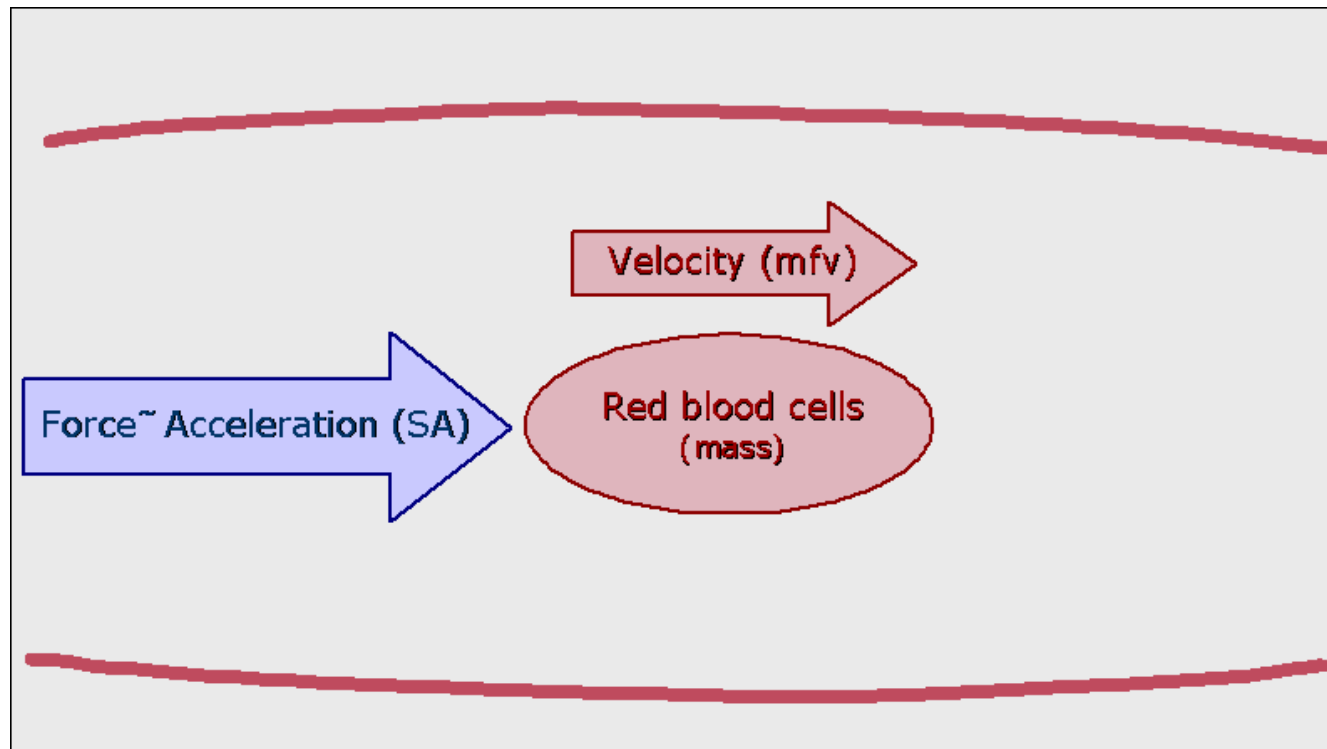
## DVA: Dynamic Perfusion Index

- $DPI = SA/Pi$ 
  - Relates Force of Flow to Impedance
  - Effect of capacitance vessel volume on the force of flow



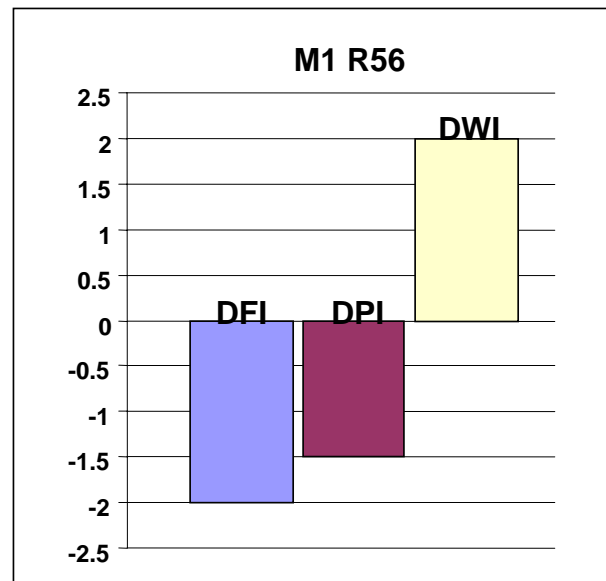
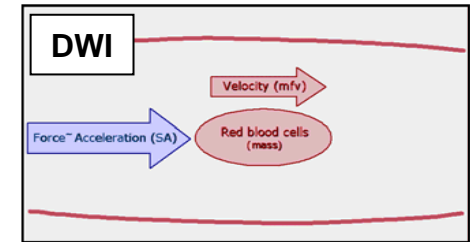
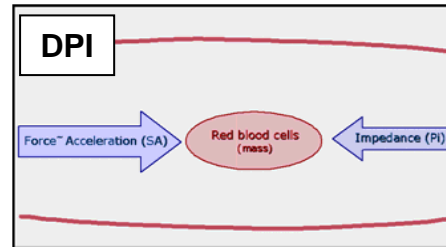
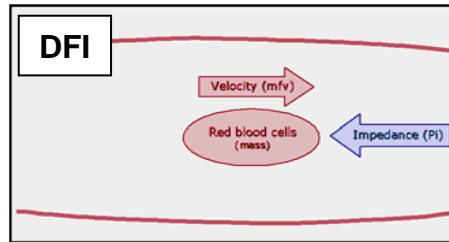
## DVA: Dynamic Work Index

- $DWI = SA/mfv$ 
  - Relates force of flow to mean flow velocity
  - Kinetic efficiency of segment in moving blood forward

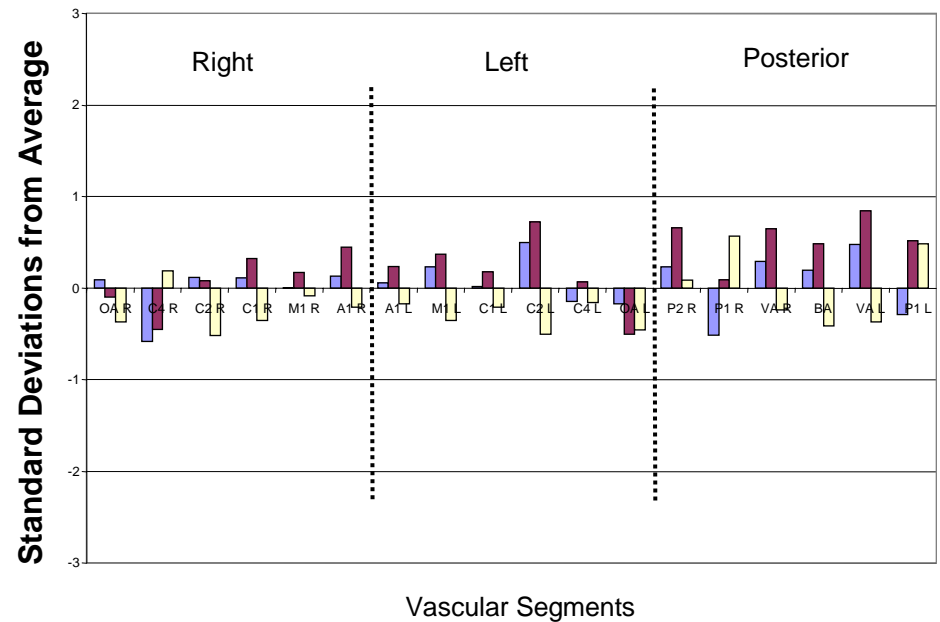
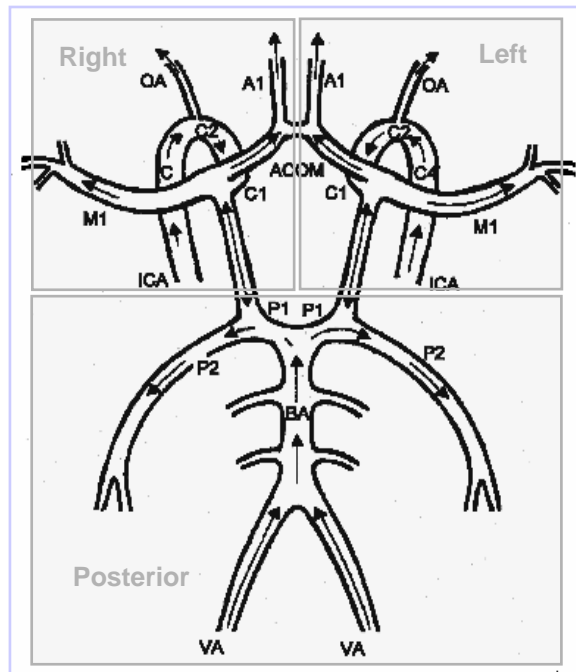


## DVA – Dynamic Indices are Internally Referenced

Expressed as  $\pm$ SD (z-scores) from a reference data set

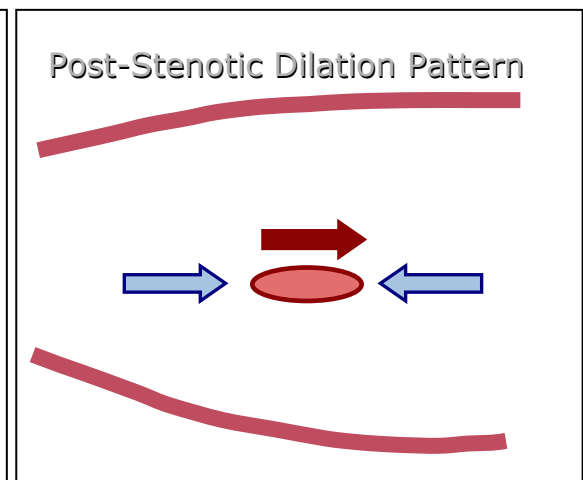
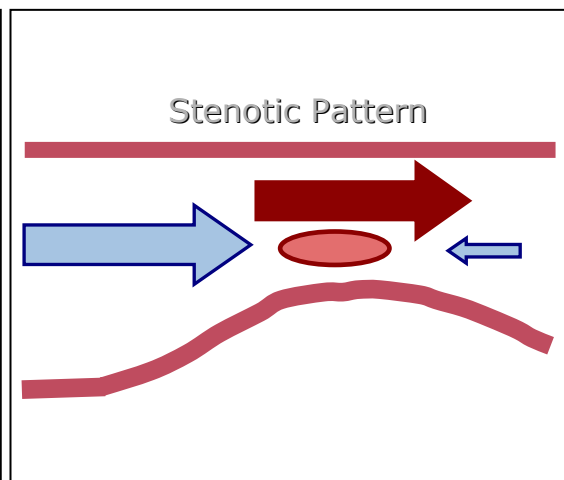
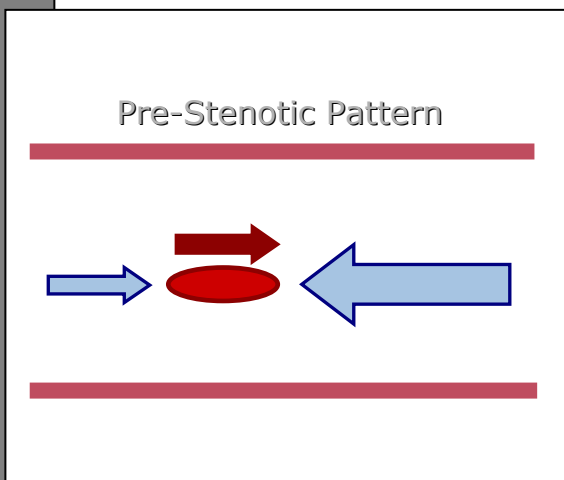
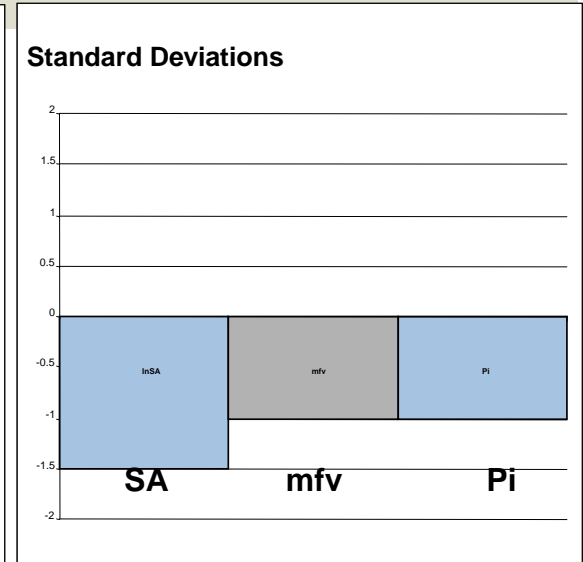
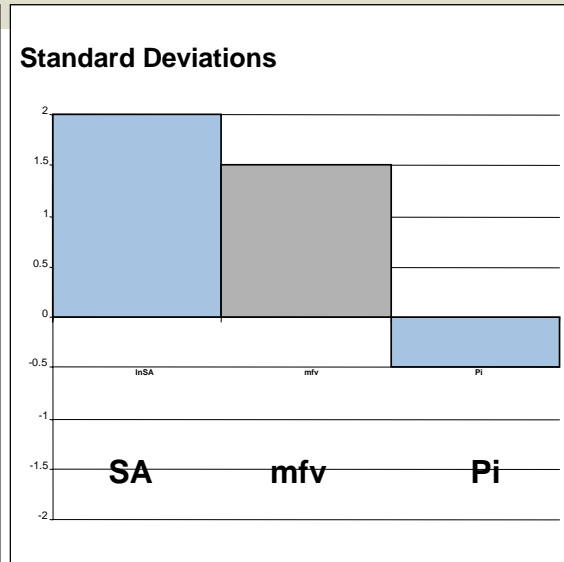
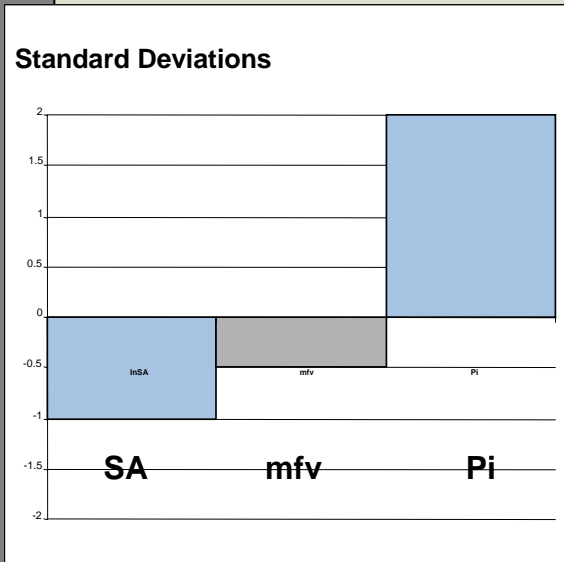


## DVA Creates a Comprehensive Cerebrovascular Footprint

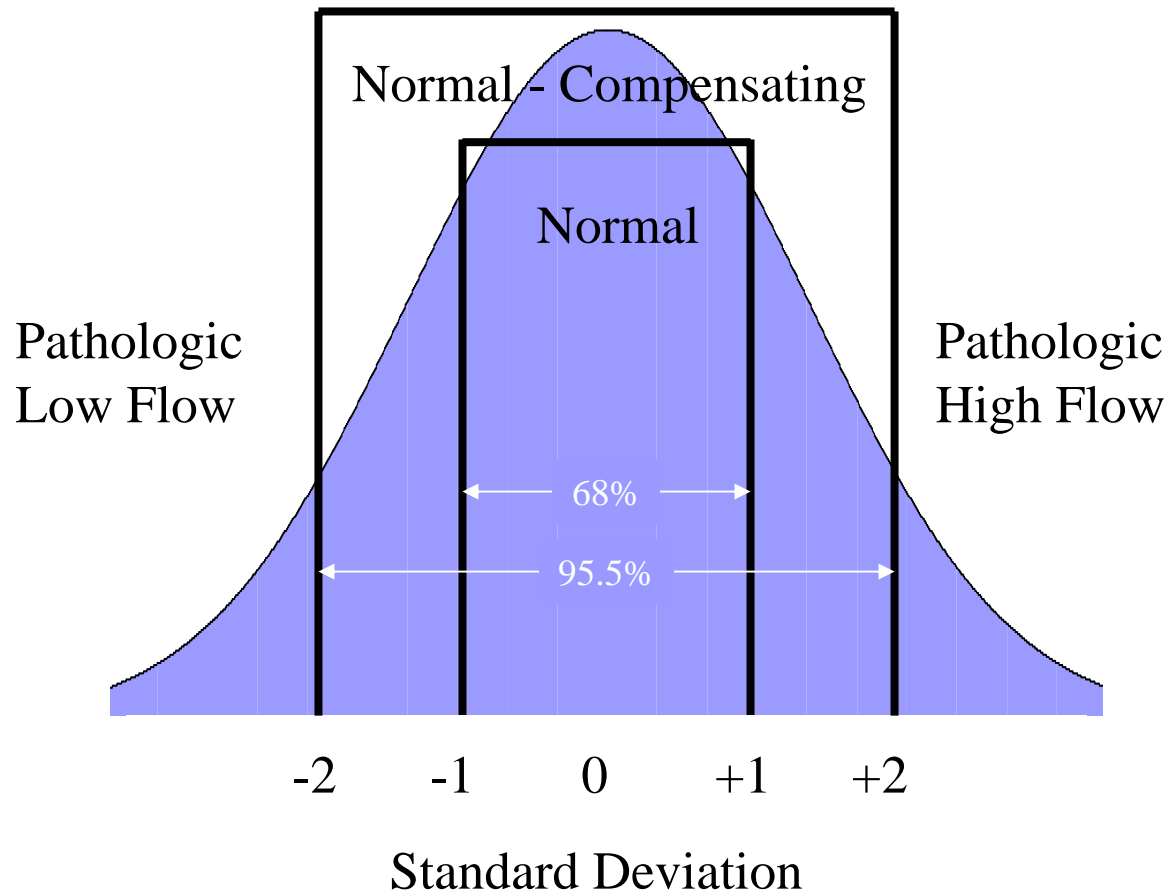


*DVA measures 15+ cerebrovascular segments and compares them to a proprietary reference database creating a meaningful picture of a patient's vascular health. Assigning each measurement a normal, high or low value, there are 300k theoretically possible vascular "signatures".*

# DVA Measures the Physiological Impact of an Angiographically Defined Lesion



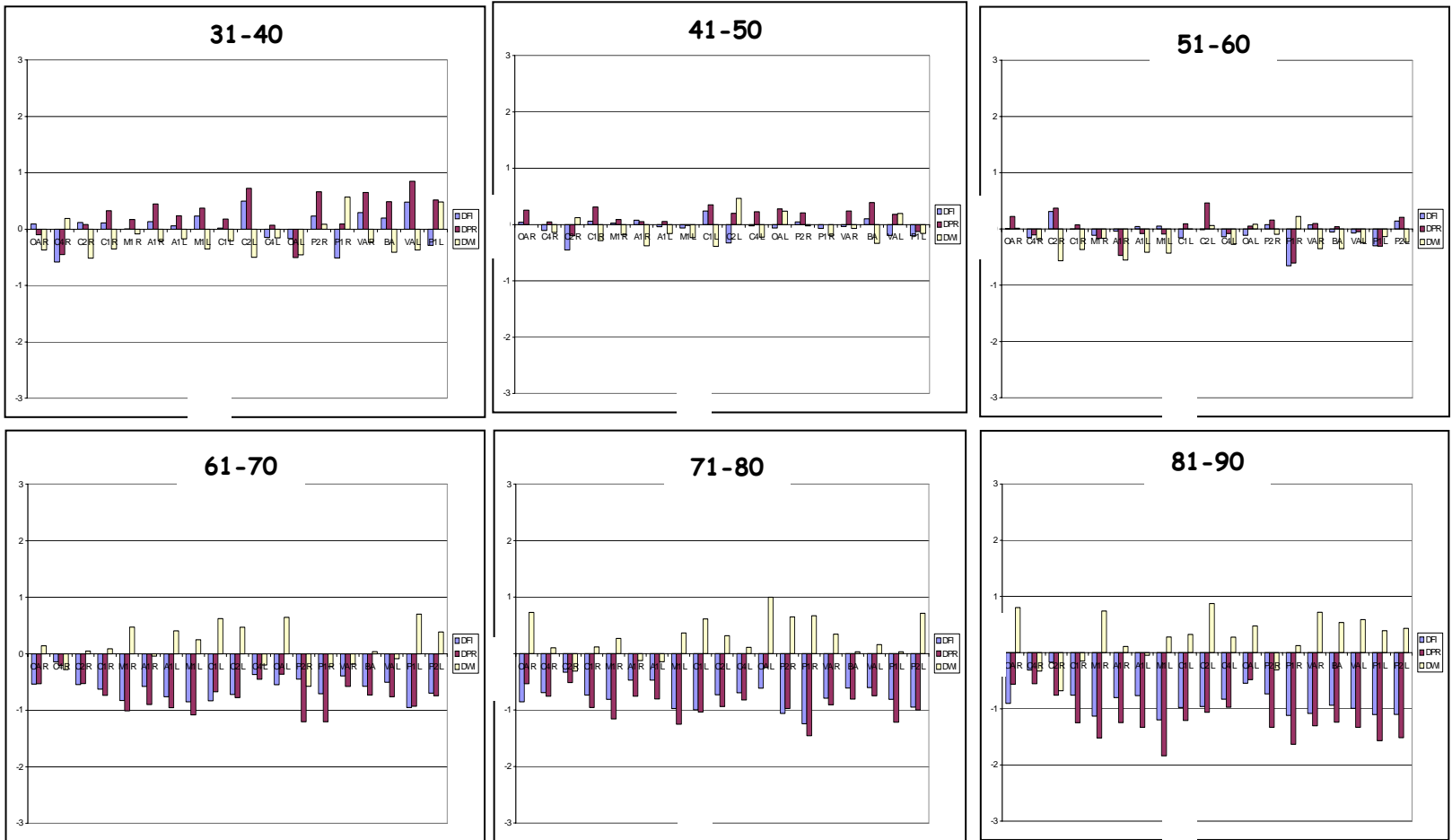
## Regulatory Strategy: physiological claims of vascular states



## DVA-Enabled Differential Diagnosis and Evaluation

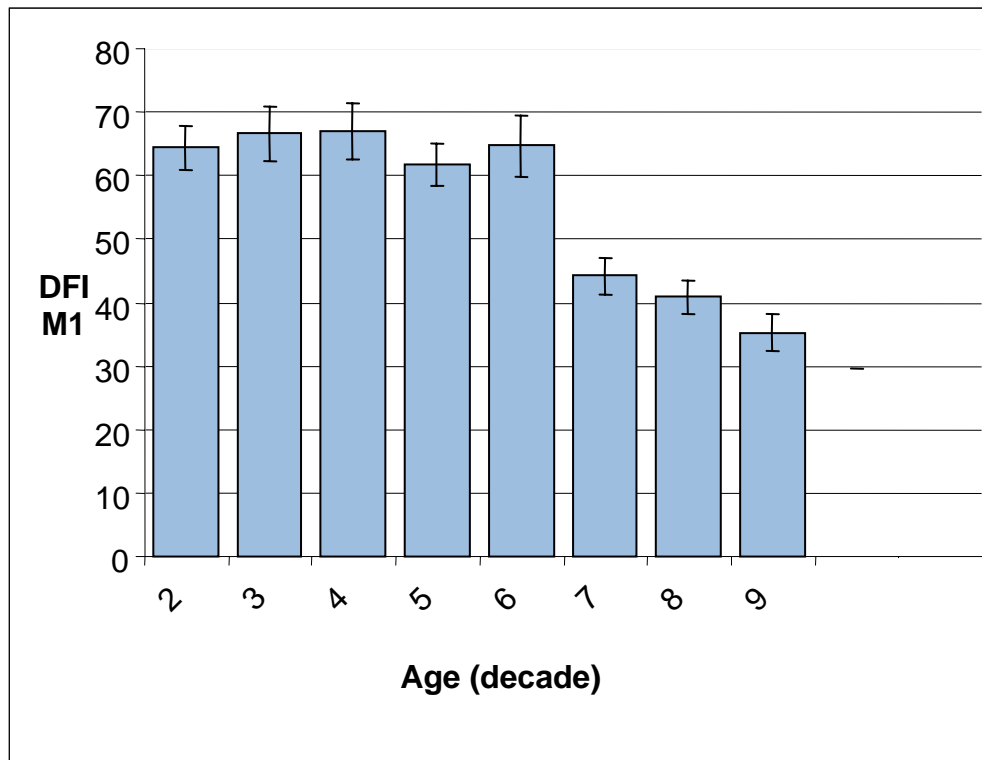
- **Segmental Vasculopathy (diminished compliance, narrowing)**
  - Atheromatous disease-
  - Spasm (hemorrhagic stroke, head trauma)
  - Vasculitis
- **Global Vasodilatation**
  - Metabolic Vasculopathy – diagnostic tests and consultations
    - Sleep Apnea
    - Hypothyroid
    - B-vitamin deficiency
    - Medication effect
  - Low Input
- **Vessel disease vs. intracranial pressure (‘perfusion-impedance mismatch’)**
  - Global
    - Alzheimer’s disease – normal pressure
    - Extensive small vessel disease
    - Hydrocephalus – shunt unresponsive
  - Regional
    - Frontal – shunt responsive
      - Adult hydrocephalus – VP Shunt

# DVA: Cerebral Reference Data by Decade of Life, 147 subjects



## DVA Research: Normal Aging

- Cerebral blood flow dynamics demonstrate how the vascular system ages
- DFI declines after the 6th decade of life

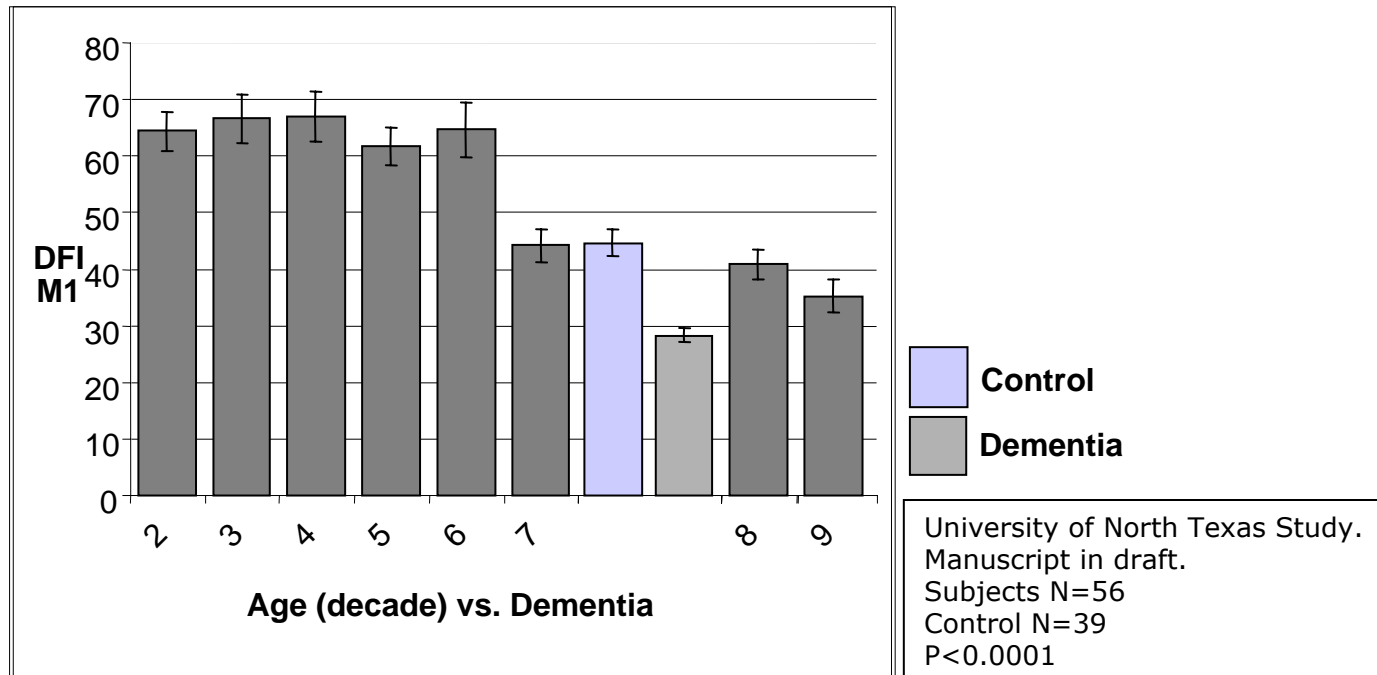


NHSi Internal Study

N=147, 1400 measurements

## DVA Research: Dementia

- Alzheimer's Dementia assisted living facility (Ft. Worth, TX)
- Shows subtypes – sorts among forms of dementia
- Findings consistent with contraction of capacitance vessel volume
  - Amyloid angiopathy in majority
- DVA studies identified patterns associated with vascular dementias





## DVA Summary

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- DVA quantifies TCD waveform morphology
- Defines vascular physiologic states
- Defines ensemble states
- Classifies disease states by vascular physiologic characteristics or signatures

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