Vascular Dynamics Predict Shunt Responsive NPH

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Disclosure

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Introduction

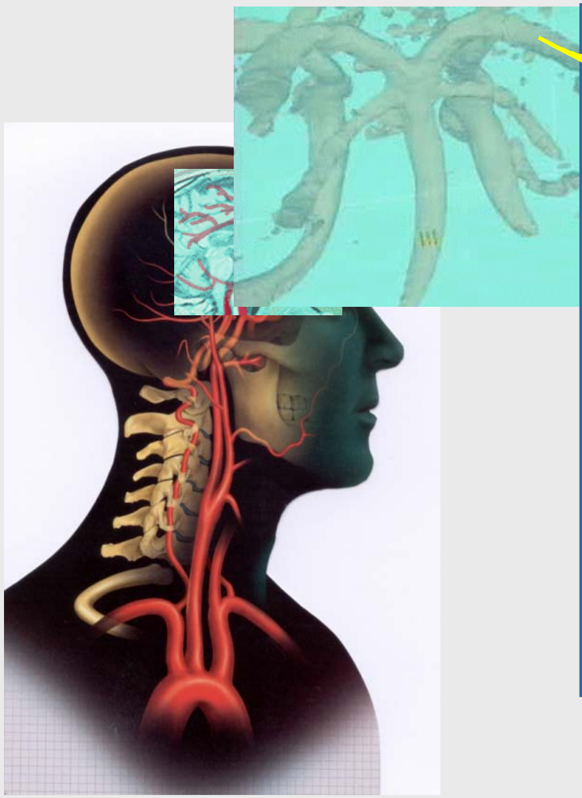
- Currently no single, definitive, non-invasive test for diagnosing or predicting clinically significant shunt responsive normal pressure hydrocephalus (NPH)
- Previous studies showed no changes in global CBF and CBFV patterns
- PET unable to predict VP shunt responsiveness
- Increased CBFV post VP shunt predicts good outcome
- Extensive cerebrovascular disease correlates with poor outcome following VP shunt

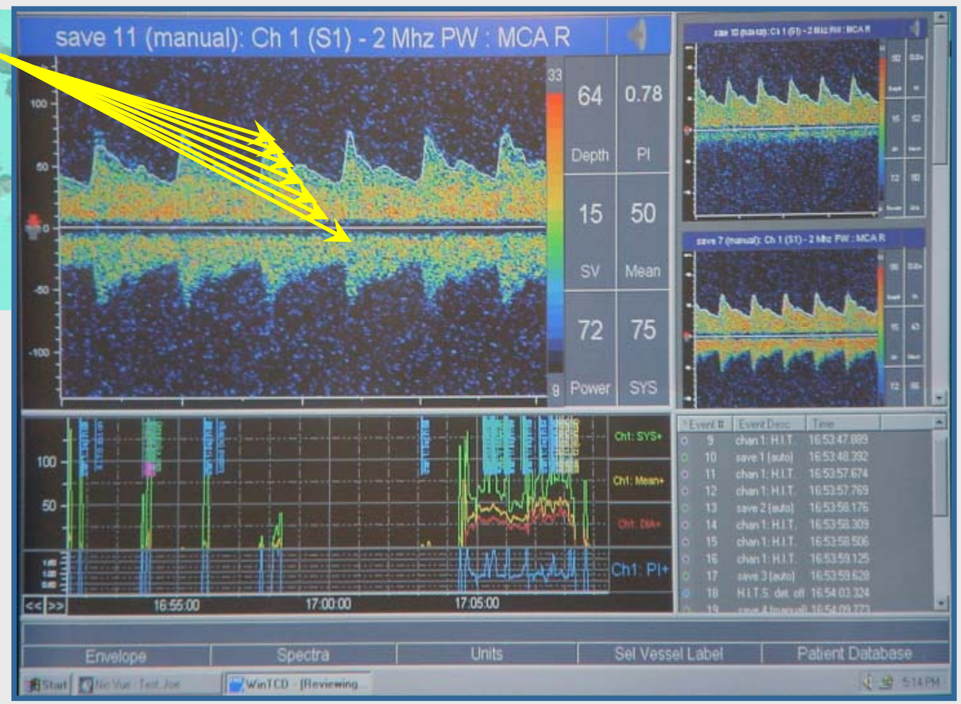
Methods

- Retrospective analysis
- 10 patients with memory disturbance, gait instability, changes in bladder function, and a positive clinical response to CSF removal (NPH)
- 48 symptomatic controls that did not respond to CSF removal
- All patients underwent 20 segment transcranial Doppler (TCD) evaluations prior to CSF removal
- Placed in 15° head-down incline for 2 minutes with continuous insonation of M1 and serial collection of TCD data every 30 seconds
- TCD data analyzed with Dynamic Vascular Analysis (DVA)

DVA Data Source: Doppler ultrasound

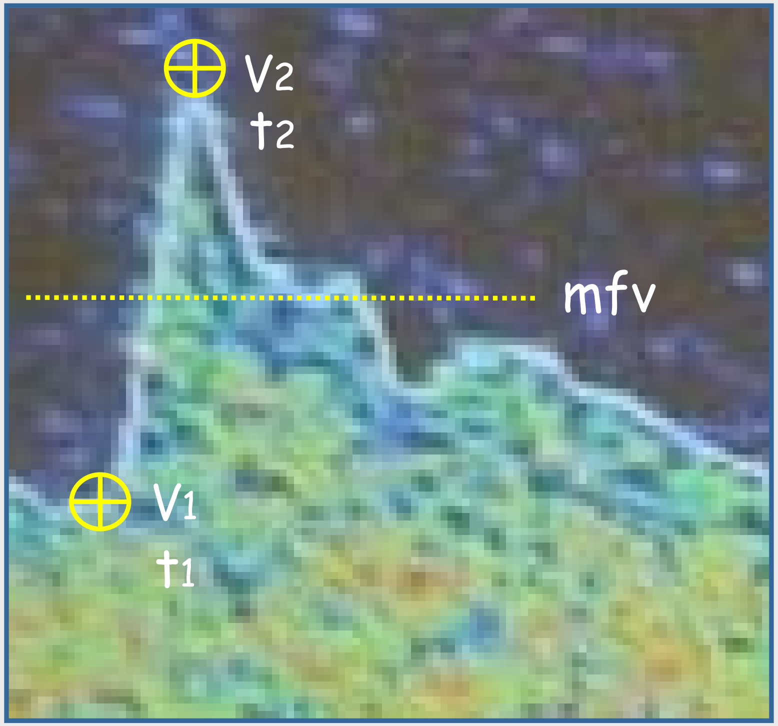
- TCD measured cerebral blood flow velocities
  - Output digitized with FFT
  - Output displayed in familiar pulsatile waveform





DVA

- DVA is a nomogram of three established parameters



Standard Derivations

Force of Flow:

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

Mean Flow Velocity:

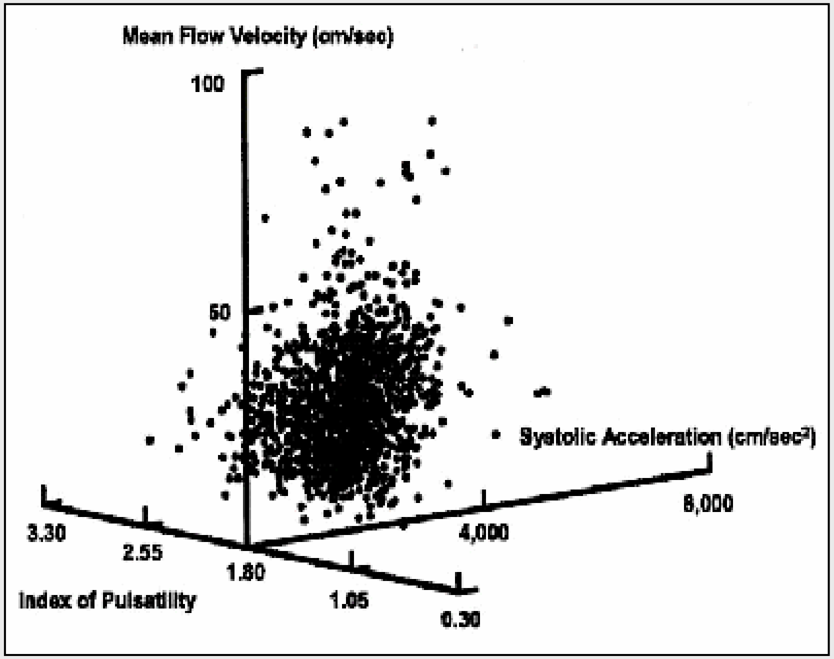
$$mfv = \Delta V/3+V_1$$

Impedance to Flow:

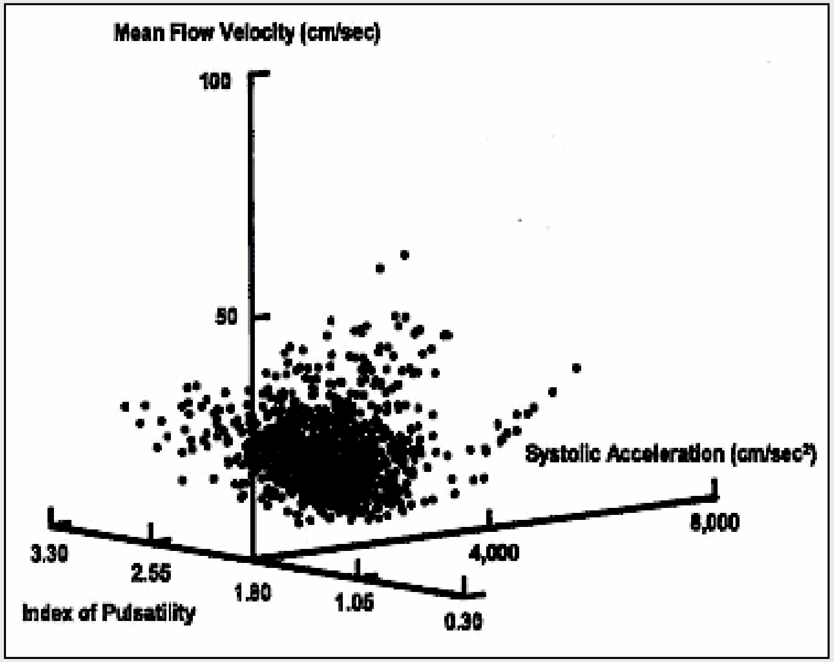
$$P_i = \Delta V/mfv$$

Different Vessels Have Different DVA Signatures

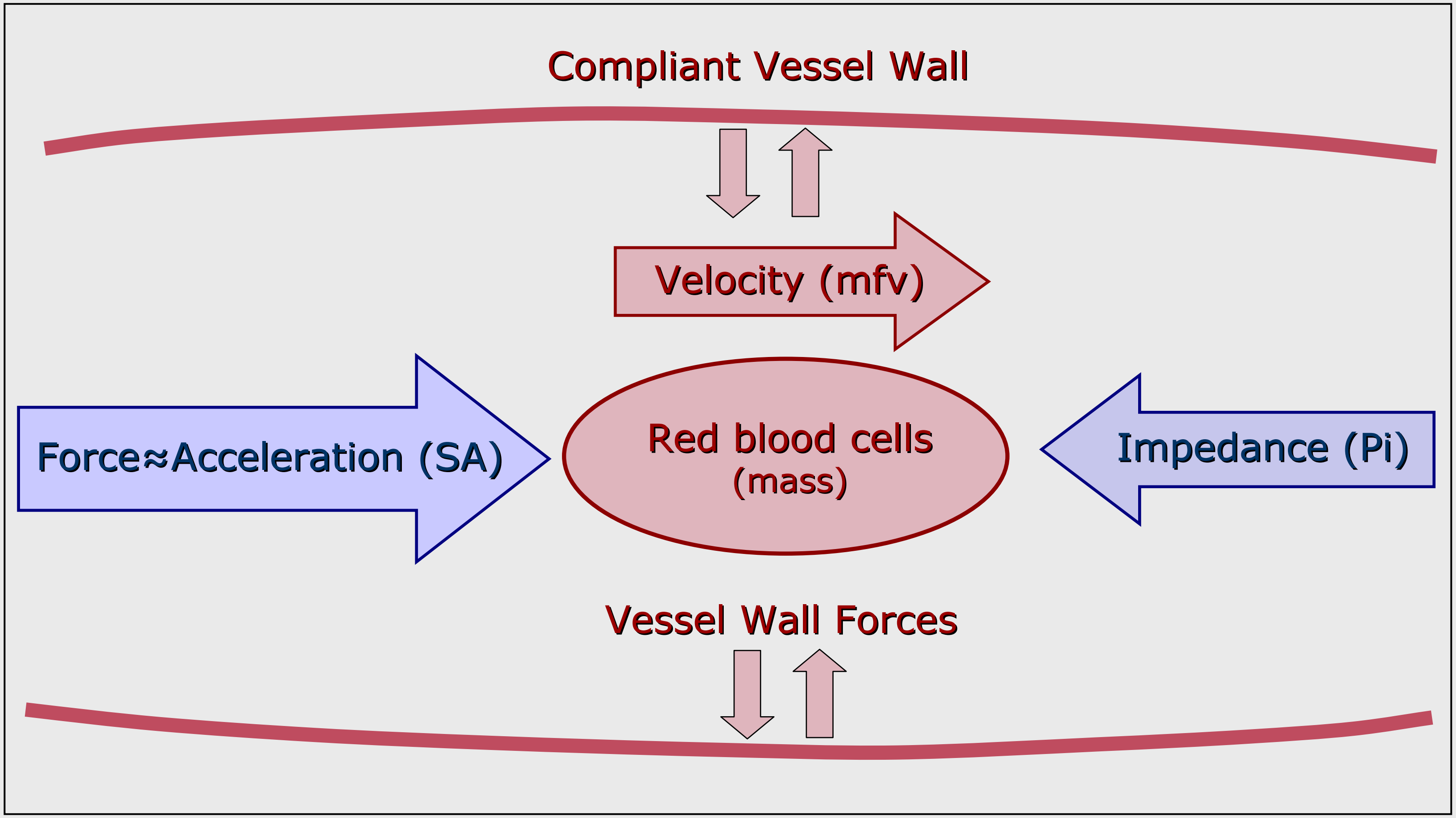
Basilar Artery



Ophthalmic Artery

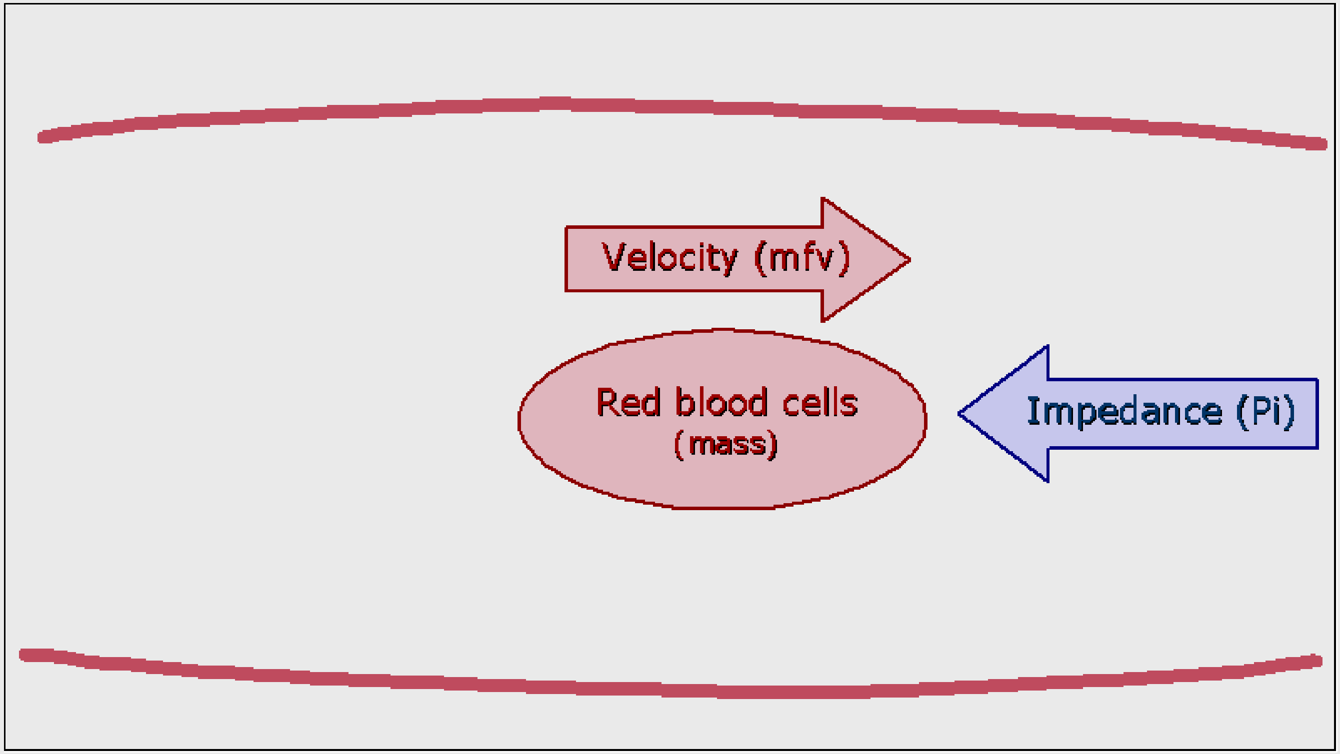


The DVA Paradigm



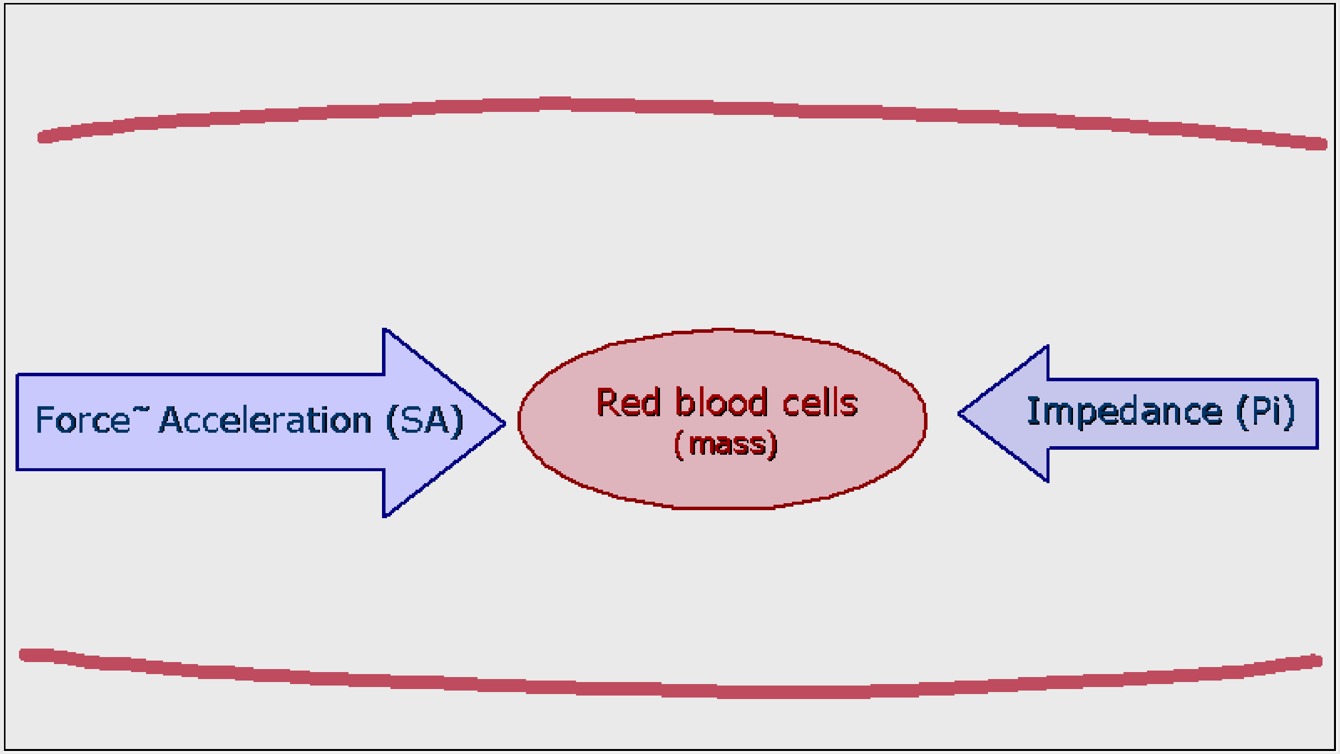
DVA: Dynamic Flow Index

- DFI = mfv/Pi
  - Relates Mean Flow Velocity to Impedance (Pi)
  - Effect of capacitance volume on flow through the conductance vessels



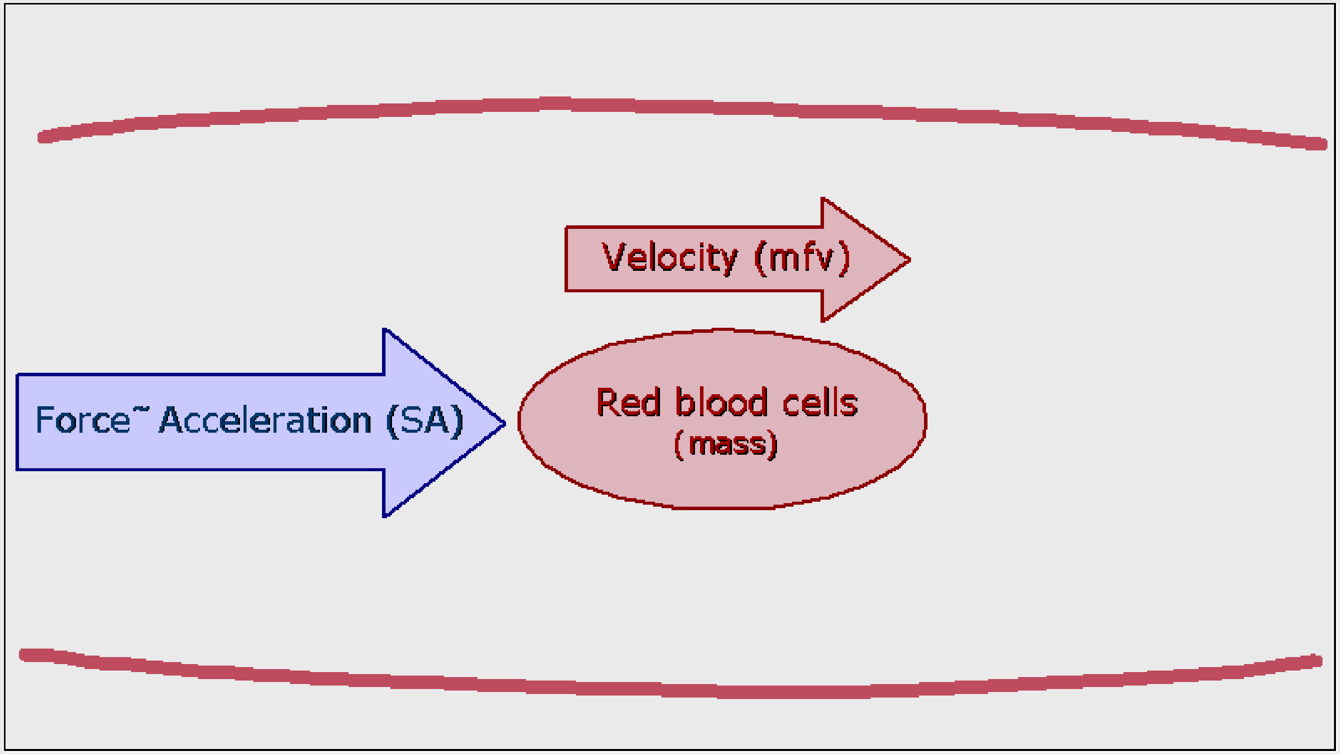
DVA: Dynamic Perfusion Index

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



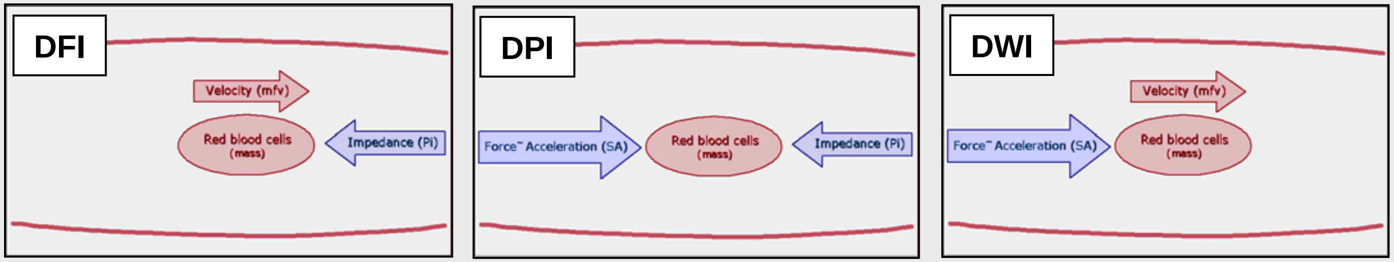
DVA: Dynamic Work Index

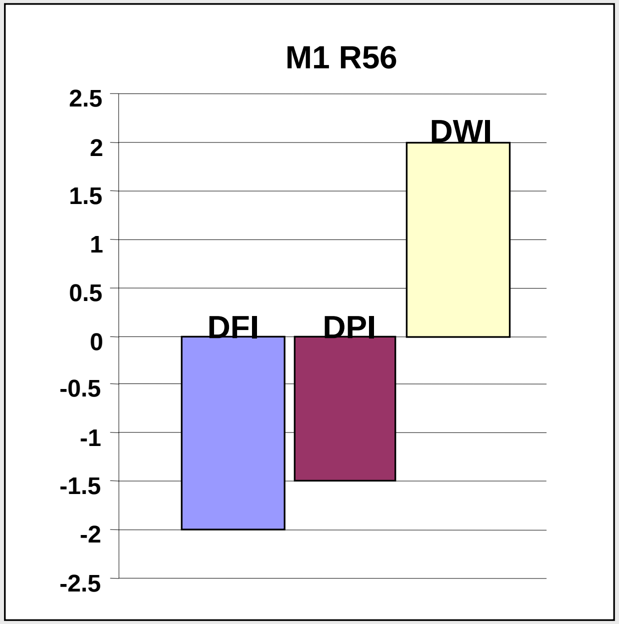
- DWI = SA/mfv
  - Relates force of flow to mean flow velocity
  - Kinetic efficiency of segment in moving blood forward



DVA: Dynamic Indices are Internally Referenced

- Expressed as ±SD from a reference data set

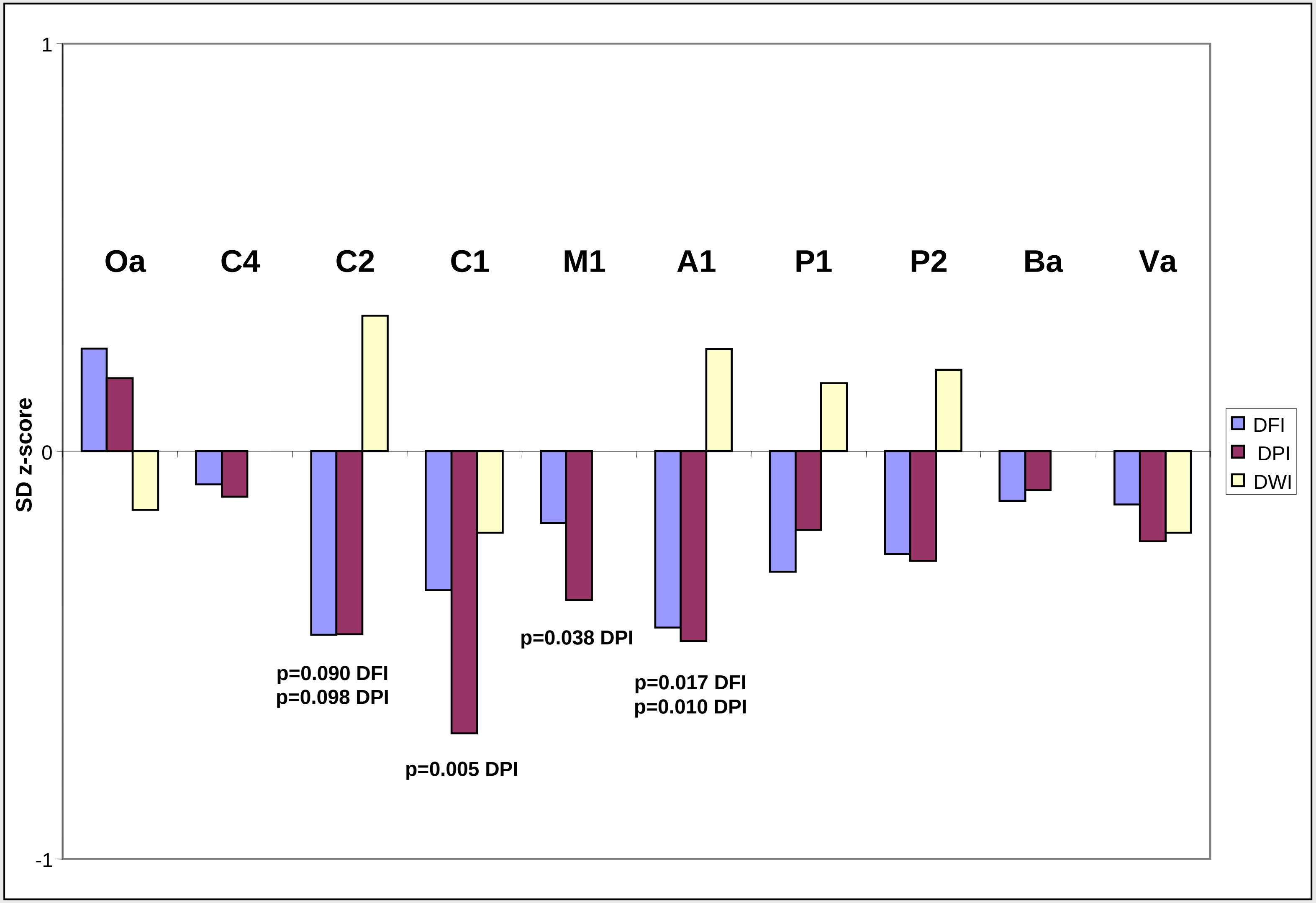




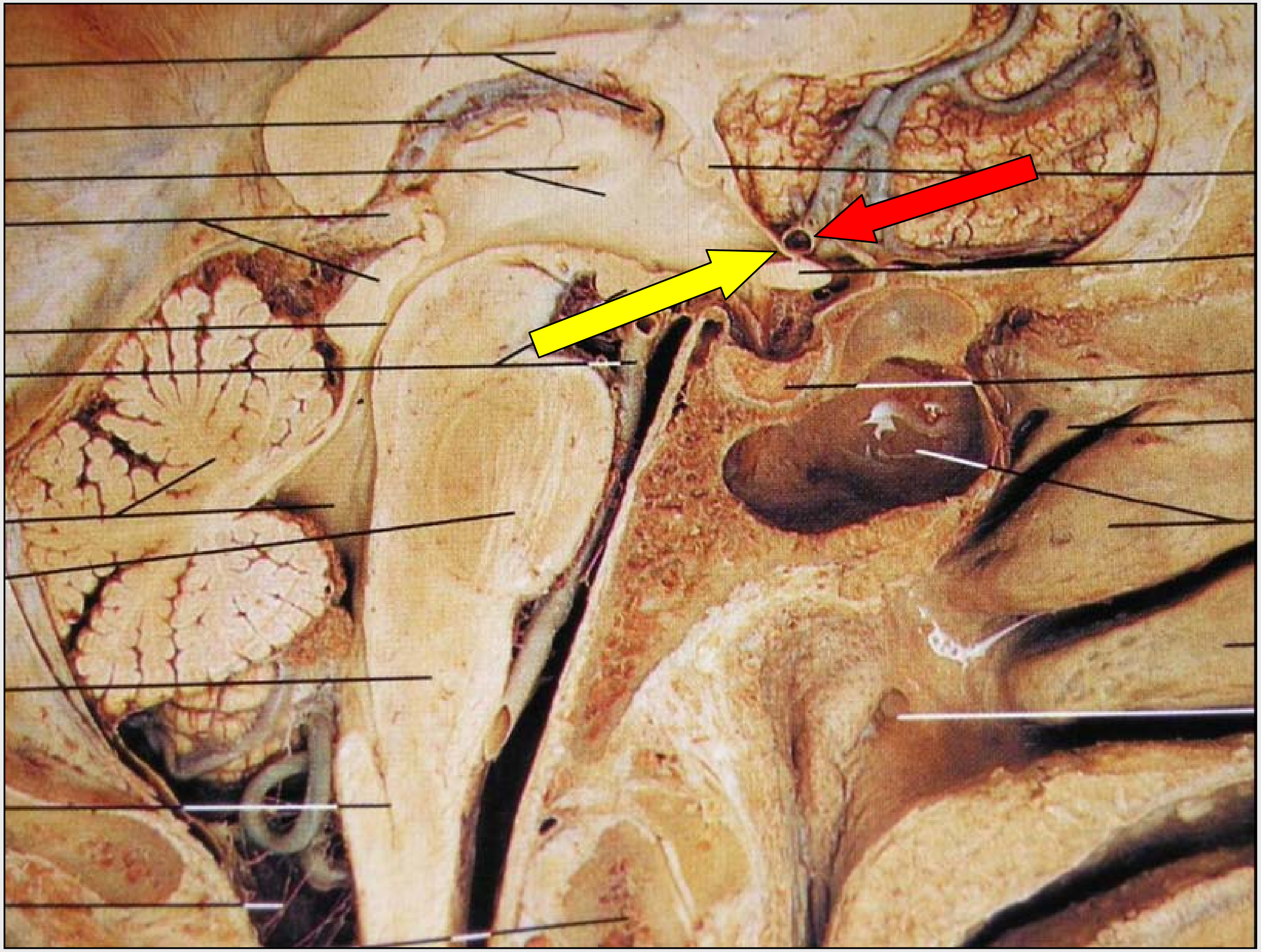
Results

- No significant change was noted following 15° head-down incline
- Baseline systolic upstroke acceleration (SA) differed between the two groups (t=2.177, $p < 0.05$); however, this did not change with head-down tilt
- Index of Pulsatility increased in M1, A1, C1 ($p<0.001$) and in C2 ($p=0.009$)
- SA increased in M1 and C4 ($p<0.005$) and A1 ($p< 0.05$)

DVA: Characteristics of Pressure-Responsive Subjects



ACA and 3rd Ventricle



From Rohen/Yokochi 1983

Conclusions

- Vascular patterns defined by DVA differentiate shunt responsive NPH
- May be used to monitor or adjust VP shunts, obviating the need for more invasive and less clinically predictable tests
- DVA patterns revealed hemodynamic alterations in the A1, M1 and C1 segments, indicating an anterior and midline effect, as would be expected from pressure-expanded third and lateral ventricles
- Future studies needed to expand and calibrate these findings
- Predictive algorithm can be produced from a combination of DVA indices