OMICS International
4th International Conference and Exhibition on
Biosensors & Bioelectronics

Stony Brook Medicine

Spinal Fiber Optic Monitoring

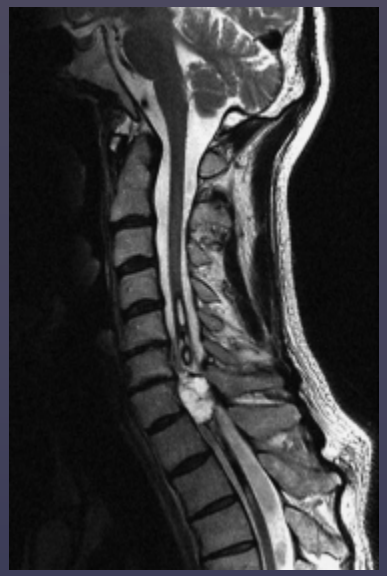
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-Collaborators: D'Souza A, Bilfinger T, Galler R, Mesquita R, and Yodh A.
-Conflicts of Interest-NFOSYS, Inc.







Tumors

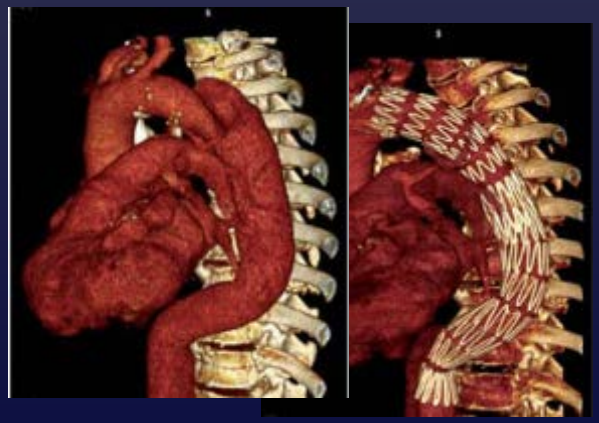
Spinal Cord Monitoring

Trauma

Scoliosis

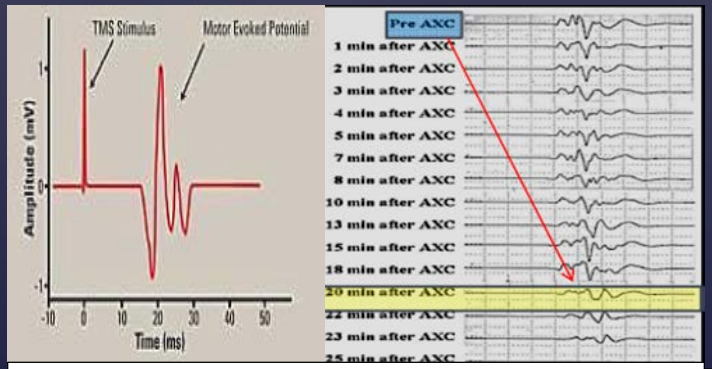


Aortic Disease



Problems ?

- Cumbersome
- Indirect → Event to Alert delay
- High incidence of false alerts
  - Only 16%–40% of the monitored patients with EP changes developed postoperative-onset paraparesis or paraplegia.
- Unsuitable for awake monitoring
- Affected by patient temperature, limb blood flow, and anesthetics



Kakinohana M, et al. J Anesth. 22:304–307, 2008.

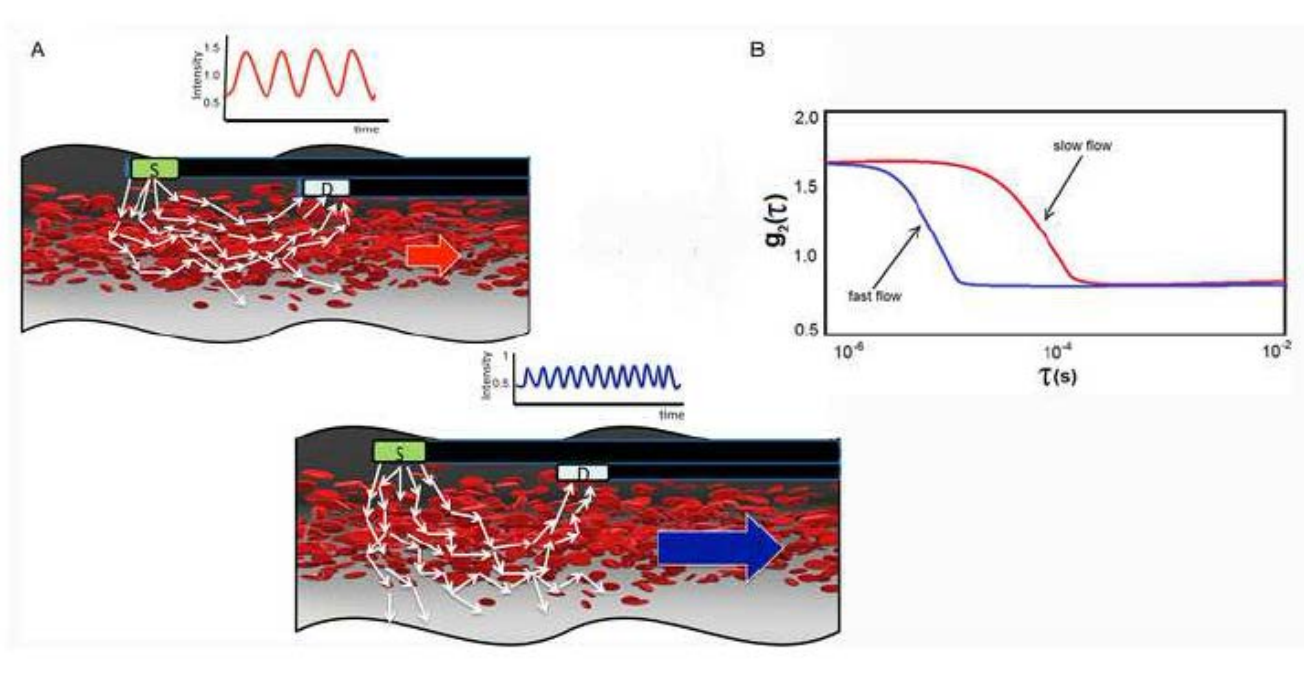
Table 1. The Sensitivity of Neural Tissue to Ischemia

Tissue	Time to Loss of Response With Ischemia*
Cortex	20-30 s (EEG)
Spinal cord sensory white matter	7-18 min (SSEP)
Spinal cord motor white matter	11-17 min (MEP)
Spinal cord gray matter	1-2 min (MEP)
Peripheral nerve	20-30 minutes (SSEP and MEP)

Figure -2b. Sloan T, et al.. **Intraoperative Electrophysiologic Monitoring in Aortic Surgery.** J Cardiothoracic & Vasc Anesth. 27(6): 1364-1373, 2013.

Nuwer MR. et al. ***Evidence-based guideline update: Intraoperative spinal monitoring with somatosensory and transcranial electrical motor evoked potentials***. Report of the Therapeutics and Technology Assessment Subcommittee of the American Academy of Neurology and the American Clinical Neurophysiology Society. Neurology. 78: 585-589, 2012.

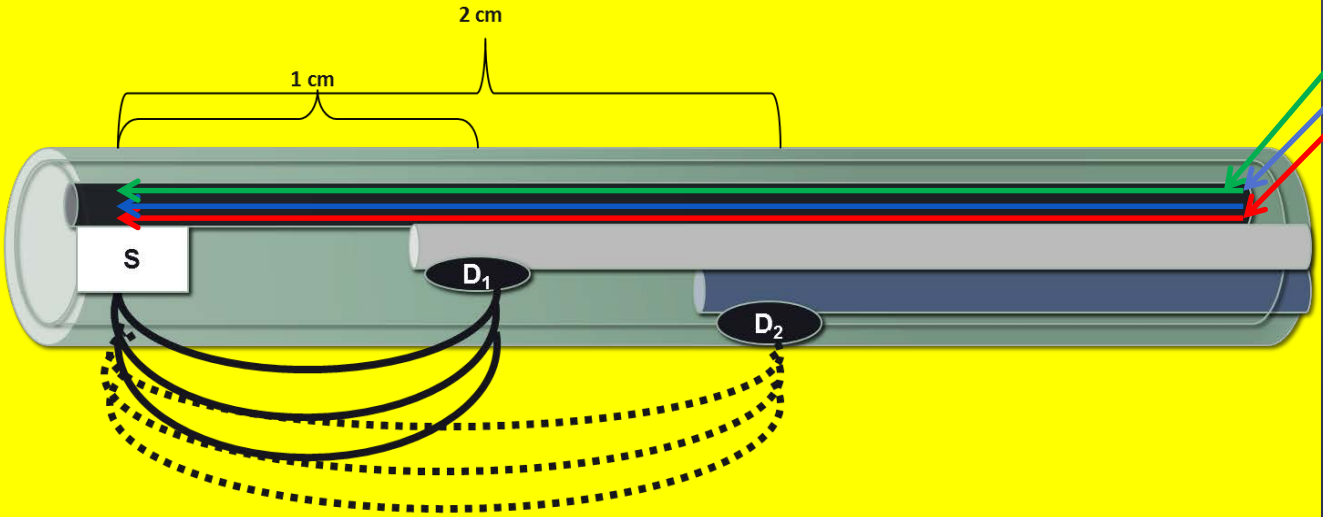
Diffuse Correlation Spectroscopy (DCS)



- **Schematic of the DCS measurement:**
  - The light intensity detected at the output fiber fluctuates in time and is fed to an autocorrelator device that computes the normalized temporal *intensity* autocorrelation function (*g*2(t)) from photon arrival times.
  - Variables, to include: 1) absorbance by chromophores such as hemoglobin, lipid, and water, 2) static scattering by cells or particles, and 3) dynamic scattering by moving fluids such as blood.
  - Dynamic scattering causes fluctuation in the amount of light received at the sensor. DCS uses the dynamic fluctuation in light intensity to monitor changes in flow.

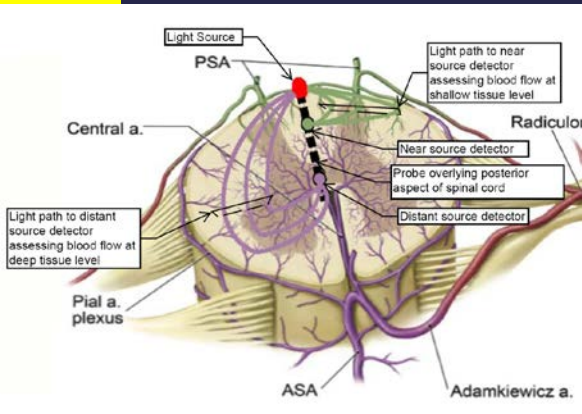
DCS/DOS Probe

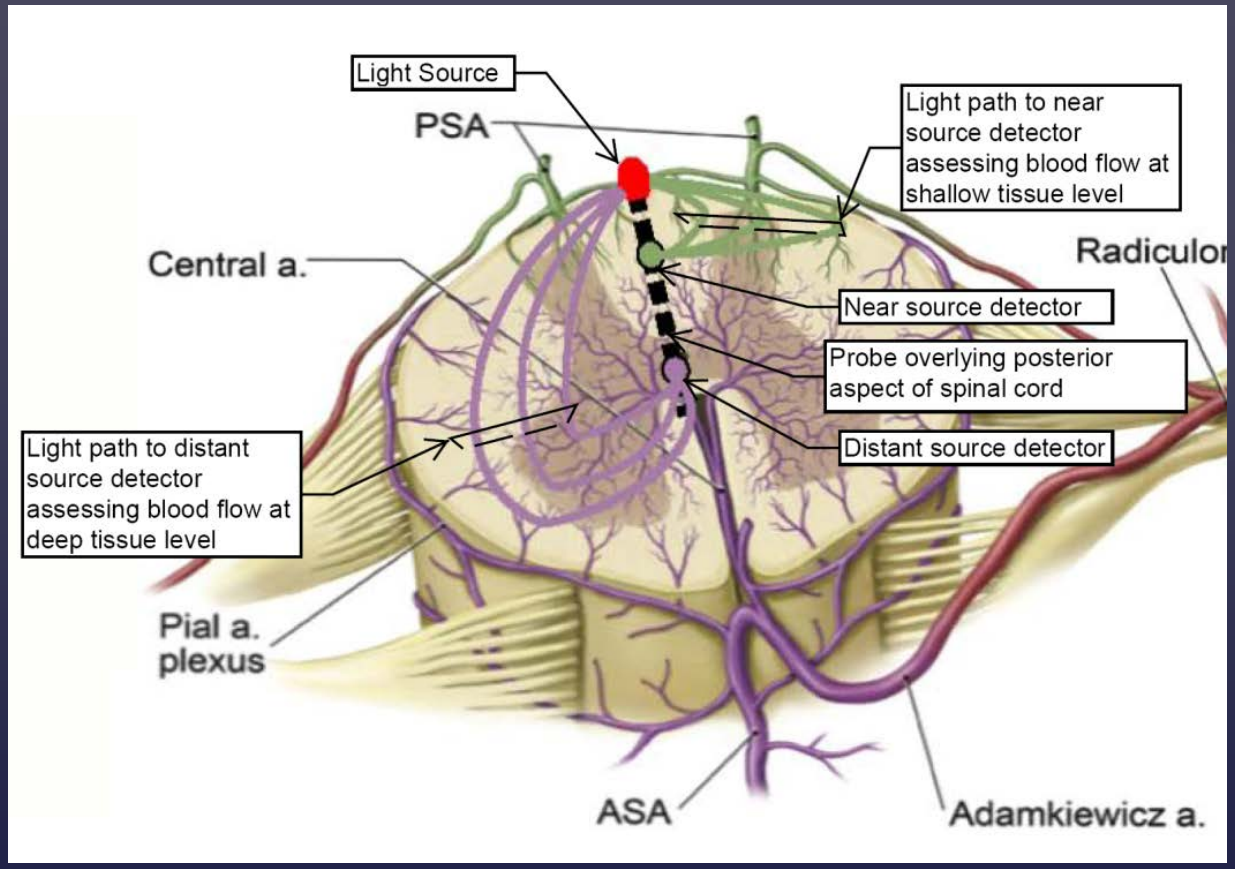
Switchable Laser Source



Linear Arrayed Fiber Optic Spinal Cord Sensor

Figure-1. The probe depicted has one source and two detectors. The source fiber is shared for both DCS and DOS through the optical switch described above. Each detector location has a pair of single mode and multimode fibers. The single mode fibers are used to detect the blood flow, as monitored by DCS, while the multimode fibers detect the blood oxygenation measured using DOS. This probe is very flexible and thin (less than 1 mm thick), and is about 3 m long, which permits flexibility in accommodating the instrument in the operating room. The source-detector separations are 1.0 cm and 2.0 cm, which allows the technique to interrogate to depths of approximately 0.0-0.5 cm, and from 0.0-1.0 cm respectively. Signal sensed from each source-detector pair may be treated separately, averaged, or weighted. The closer the sensor-detector pair yields greater signal. Analysis of differences in flow and oxygen signal patterns from more than one source-detector pair can allow the sensor to offer spatially resolved information.





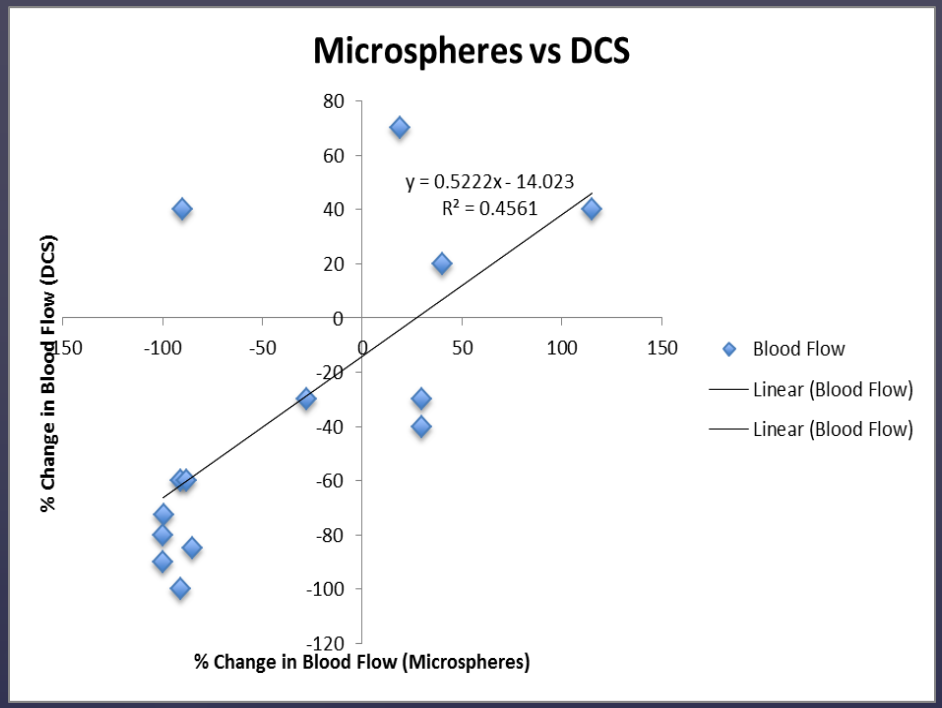
Nicholas Theodore, M.D., *Division of Neurological Surgery, Barrow Neurological Institute, St. Joseph's Hospital and Medical Center, Phoenix, Arizona*

Percutaneous Placement



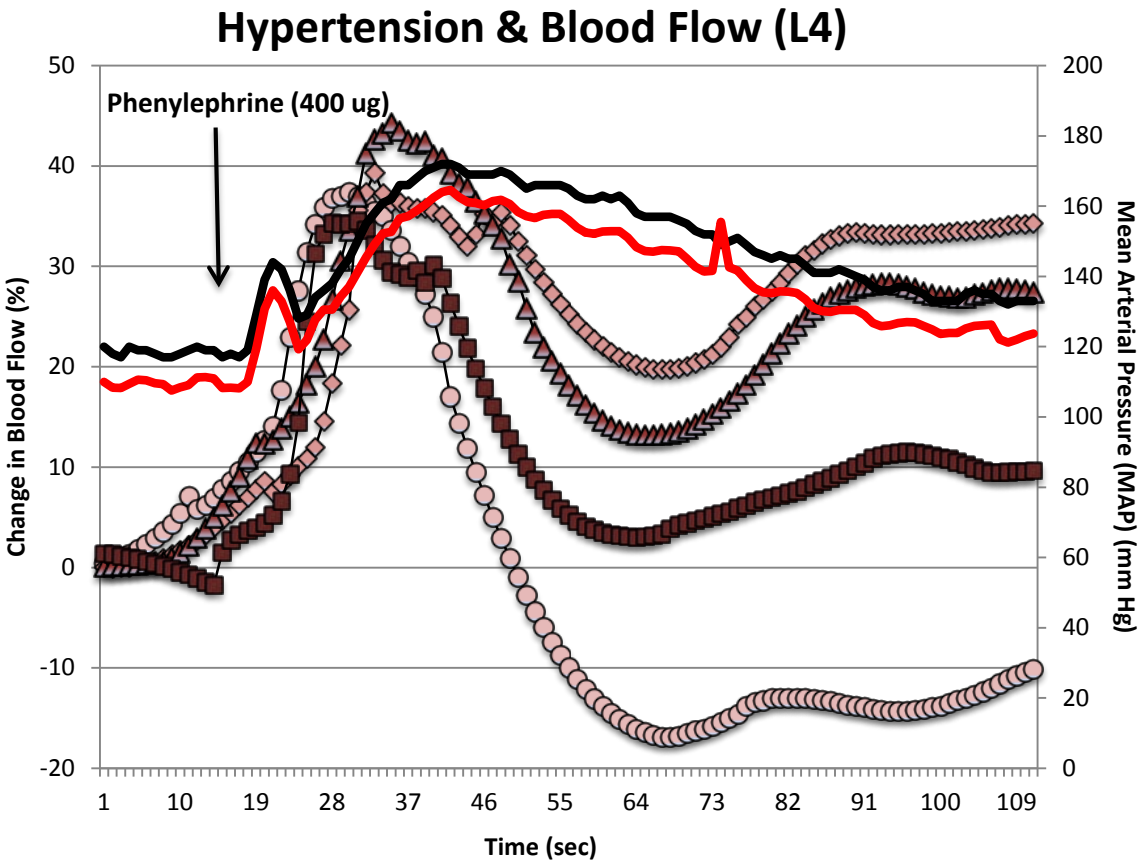
Mesquita RC, D'Souza A, Bilfinger TV, Galler RM, Emanuel A, et al. (2013) Optical Monitoring and Detection of Spinal Cord Ischemia. PLoS ONE 8(12): e83370. doi:10.1371/journal.pone.0083370

Accuracy & Precision

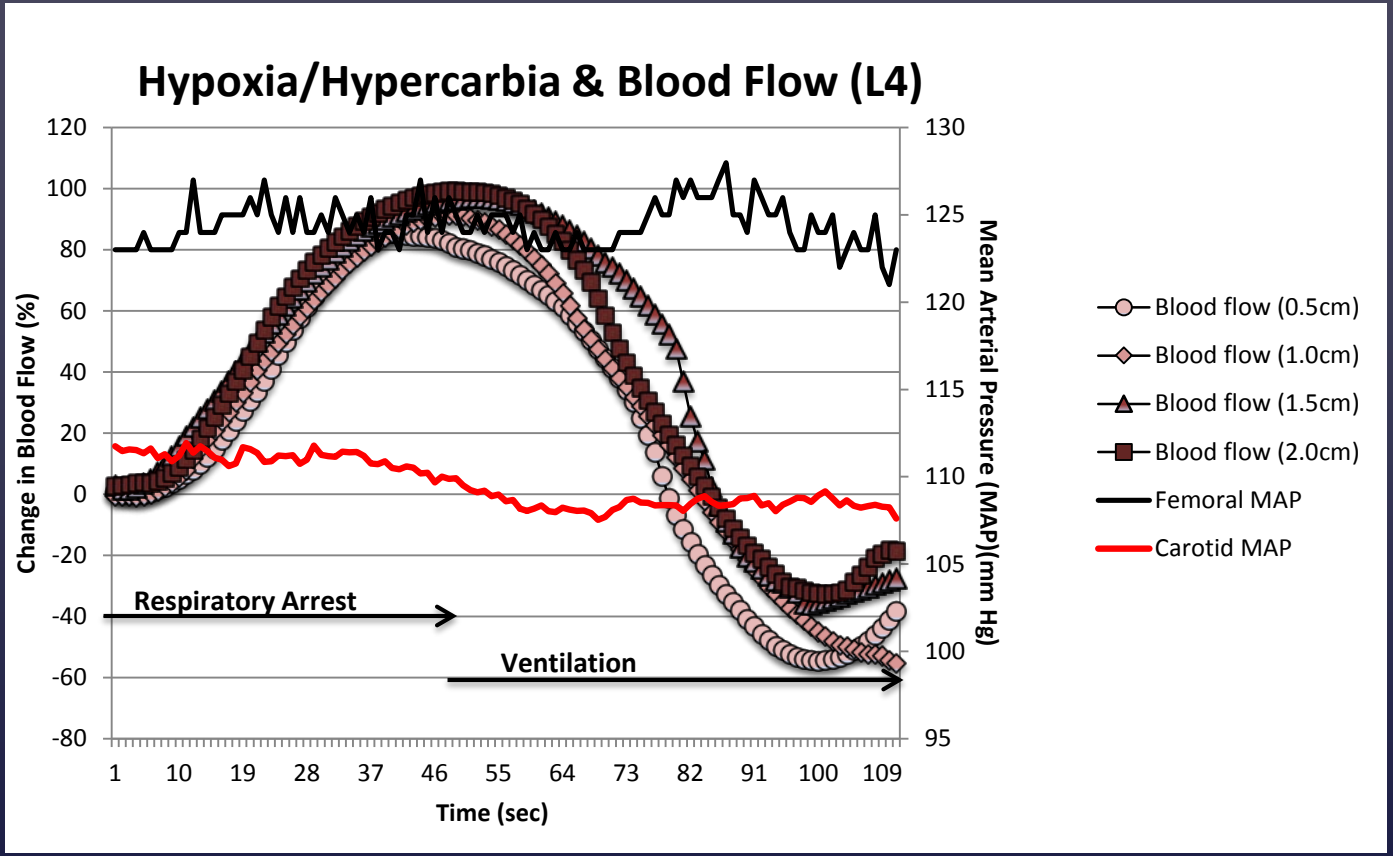


Sheep	10 minutes			
	Mean[1] ± SD[1]	Between-sheep coefficient of variation	Within-sheep coefficient of variation	Repeatability coefficient
1	14.02 ± 1.17	24.60%	9.69%	26.80%
2	8.66 ± 1.08			
3	13.23 ± 1.32			
4	9.09 ± 0.68			

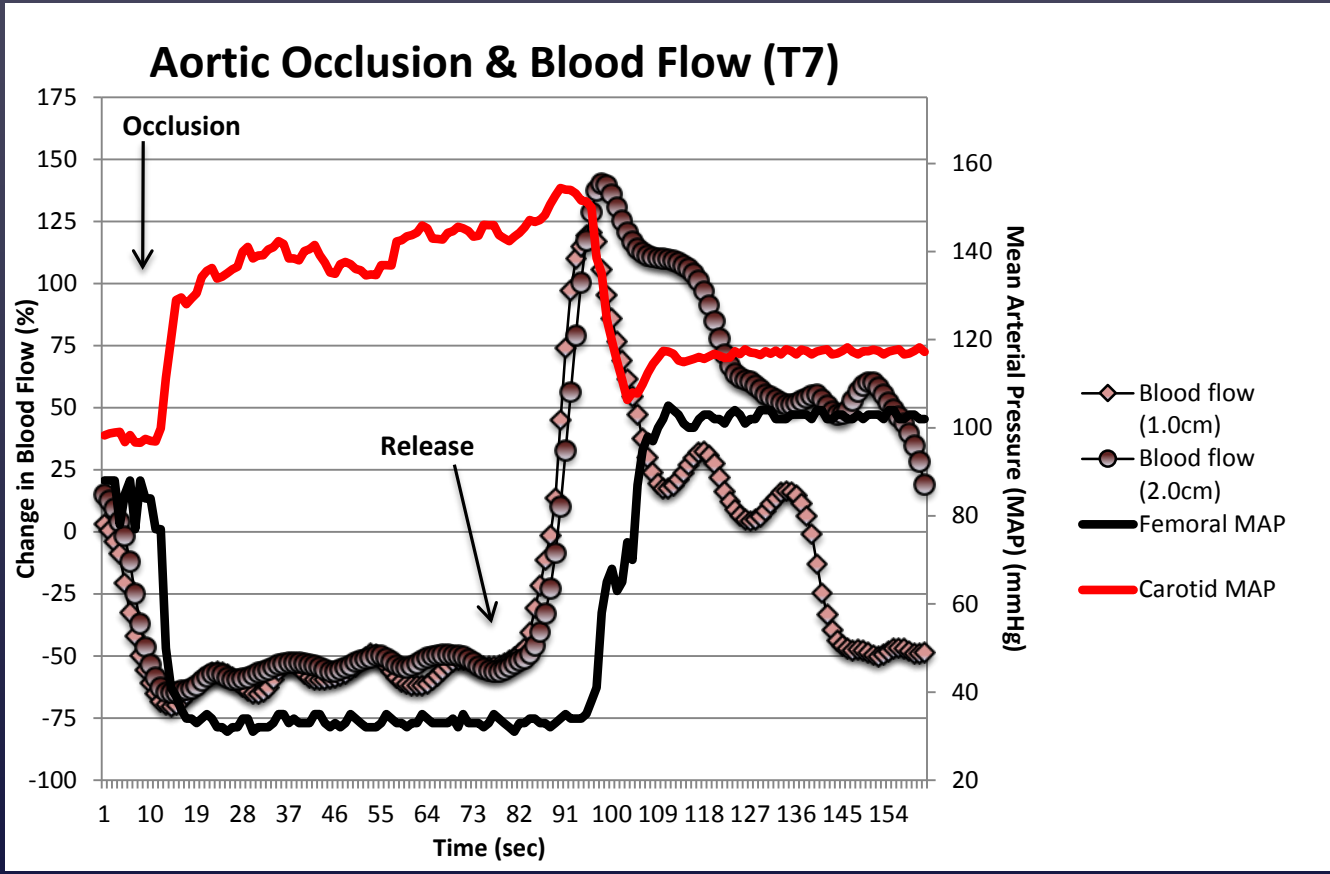
Pharmacological Interventions



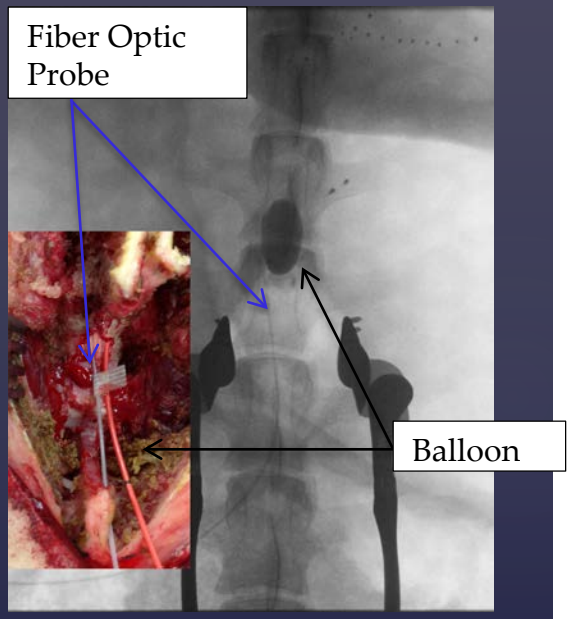
Physiological Interventions

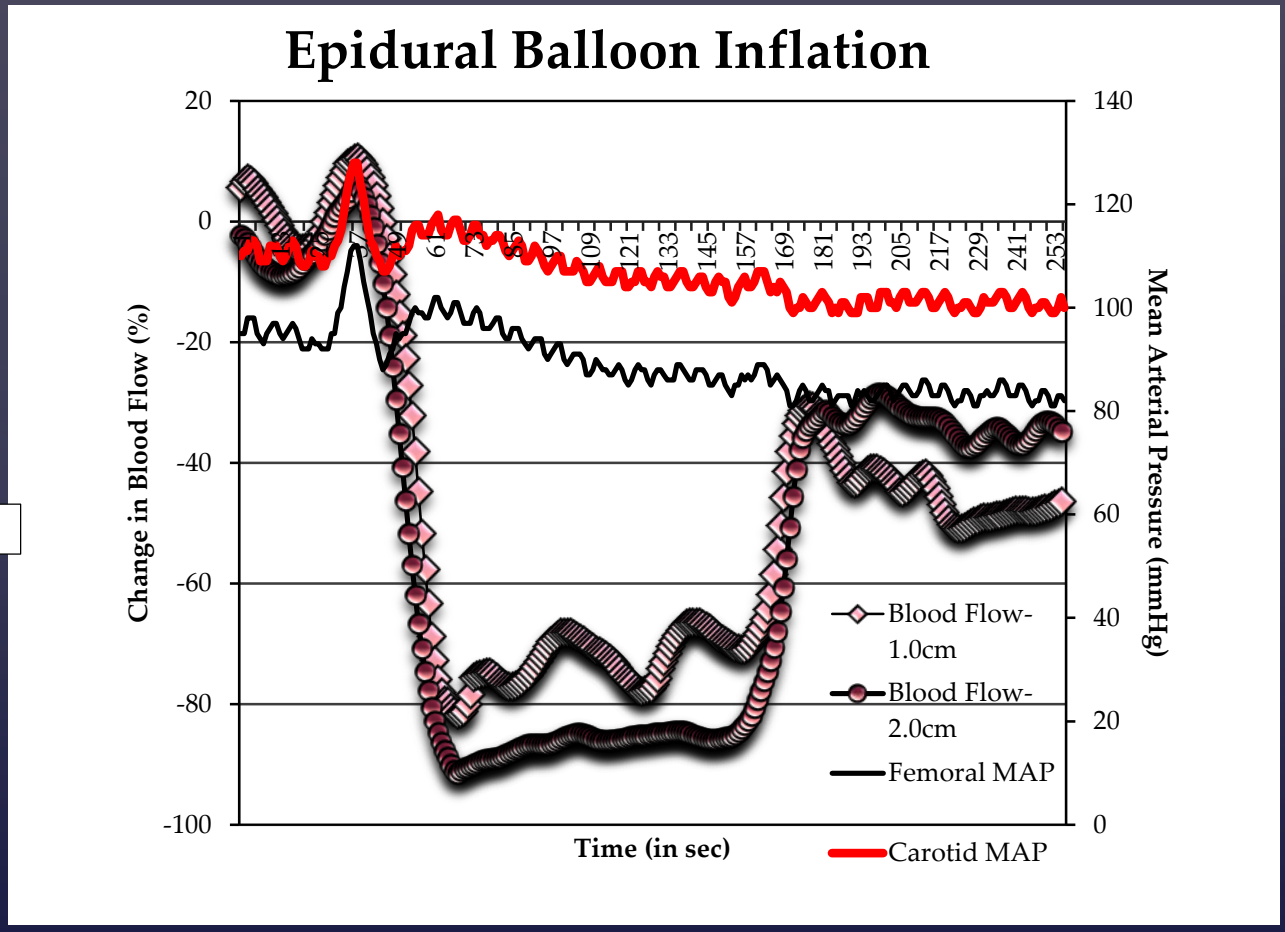


Vascular Intervention

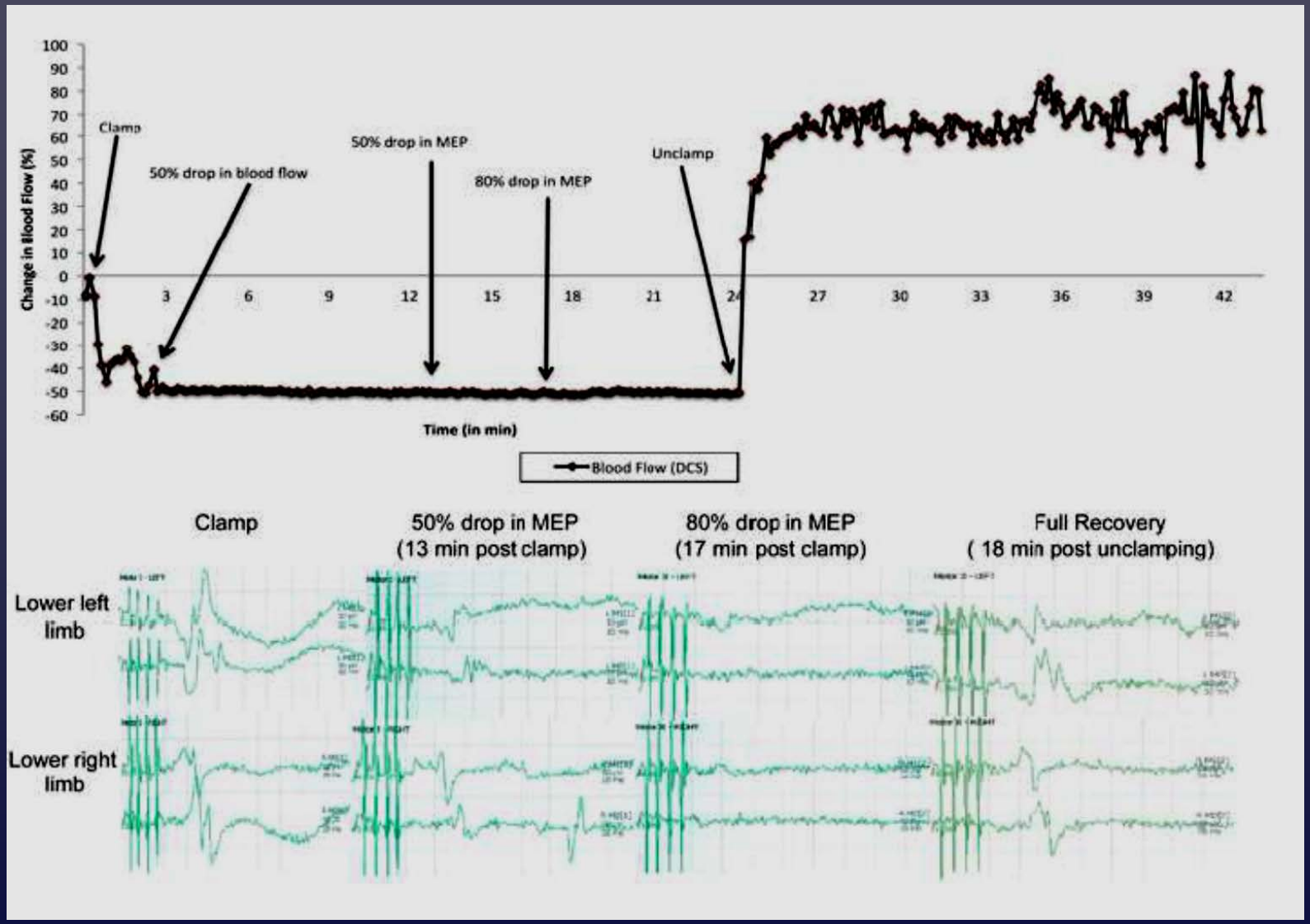


Traumatic Intervention





DCS versus MEP



Summary

- Preclinical Studies
  - Sensitive
  - Accuracy
  - Precision
  - Immediate