



Use of Fiber Optic Spectroscopic Technologies to Monitor Spinal Cord Blood Flow and Oxygenation in Real Time

Asher Emanuel MD, MPH; Robert Michael Galler; Thomas Bilfinger MD, SCD; Angela D'Souza PhD; Rickson Mesquita PhD; Arjun Yodh PhD; Thomas Floyd MD

Introduction

Spinal cord ischemia remains a devastating complication of both surgery and traumatic injury. Often, spinal cord ischemia is amenable to treatment when detected early. Failure to rapidly detect spinal cord ischemia can result in permanent paresis and paraplegia, depending on the severity of the loss of perfusion. Current methods employed to detect spinal cord ischemia are indirect, temporally insensitive, and nonspecific. Our objective was to develop a device to monitor changes in spinal cord blood flow and oxygenation, in real-time.

Methods

A thin fiber optic probe, implementing Diffuse Optical Spectroscopy (DOS) to measure tissue oxygenation and Diffuse Correlation Spectroscopy (DCS) to measure local blood flow, was designed and tested in adult Dahl sheep. The device was tested after placement in the mid-thoracic spinal cord region, after both open (laminectomy) and percutaneous approaches were employed. The device was further tested in intrathecal and epidural locations. Spinal blood flow and oxygenation, along with mean arterial pressure (femoral and carotid) were measured during blood pressure manipulations via sodium nitroprusside, phenylephrine or vasopressin administration, and after intra-aortic balloon inflation in the superior descending thoracic aorta.

Results

Changes in spinal cord blood flow tracked closely changes in mean arterial pressures elicited by all interventions. Patterns of changes in blood flow after interventions were consistent with rapid autoregulation. Significant changes in tissue oxygenation were not elicited. Results were not impacted by positioning in either the epidural or subdural spaces, or by manner of placement.

Conclusions

Our data confirms the novel application of DCS and DOS technologies to appropriately and in real-time monitor changes in blood flow and oxygenation that occur in the spinal cord during various hemodynamic perturbations.

Learning Objectives

By the conclusion of this session, participants should be able to: 1) describe the use of DOS and DCS as an effective monitor of spinal cord oxygenation and blood flow, respectively. 2) discuss the implications of a device that measures spinal cord blood flow and oxygenation in real time on neurosurgical practice in general and spine surgery in particular.

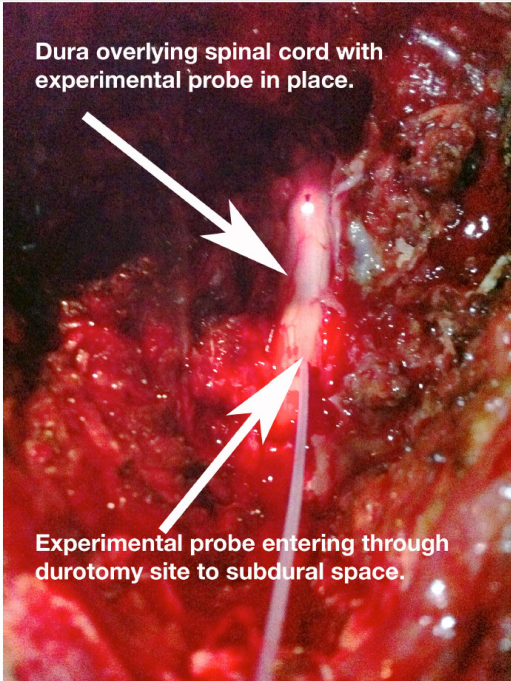
References

Estrera AL, Sheinbaum R, Miller CC, Azizzadeh A, Walkes JC, Lee TY, Kaiser L, Safi HJ: Cerebrospinal fluid drainage during thoracic aortic repair: safety and current management. Ann Thorac Surg 2009; 88: 9-15

Wynn MM, Mell MW, Tefera G, Hoch JR, Acher CW: Complications of spinal fluid drainage in thoracoabdominal aortic aneurysm repair: a report of 486 patients treated from 1987 to 2008. J Vasc Surg 2009; 49: 29-34

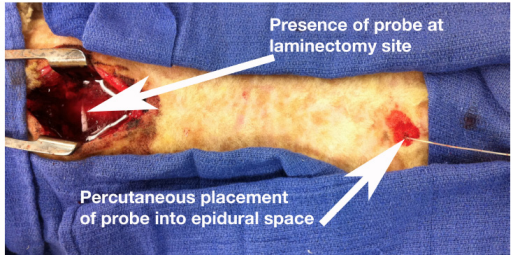
Mesquita RC, Durduran T, Yu G, Buckley EM, Kim MN, Zhou C, Choe R, Sunar U, Yodh AG. Direct measurement of tissue blood flow and metabolism with diffuse optics. Philos Transact A Math Phys Eng Sci. 2011 Nov 28;369(1955):4390-406.

Experimental Probe



Experimental probe in place under dura.

Percutaneous Probe Placement



Probe placed percutaneously into the epidural space and confirmed by presence at laminectomy site.

[DEFAULT POSTER]