Visualizing spinal cord tissue perfusion in real-time

Hofstetter Lab
Neurological Surgery Summer Student Program 2019
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Background

• Traumatic spinal cord injury (tSCI)
  • Motor and sensory deficit caudal to level of injury: bowel, bladder, sexual dysfunction
  • Complete loss of blood flow at injury center
  • Ischemia or hypoperfusion of penumbra $\rightarrow$ secondary cell death

**Problem:** Lack of non-invasive clinical imaging biomarker for injury severity and to identify the penumbra
Novel Technique

**Proposed Solution:**
ultrafast contrast enhanced ultrasound (CEUS) doppler
- Local blood perfusion predicts lesion severity and functional deficits

Validate CEUS doppler with golden standard technique (microsphere deposition)
Experimental Set Up

- Carotid artery catheterization → fluorescent microsphere injection
  - rate: 1 mL for 2 mins
  - red and yellow fluorescent microsphere (15 μm)
- Tail vein catheterization → microbubbles for ultrasound
  - ~ 0.15 mL per injection
- T8-10 laminectomy: 150 kdyn injury at T9

Pre-injury → Injury at T9 → Post-injury
Microsphere Processing

C:

D:

- Distance along cord (mm)
- Microspheres
CEUS Image Processing

Baseline

Injury

Measure signal intensity every 1 mm segment (total of 12 mm)
Pre-injury vs. Post-injury

Microsphere Deposition

Number of Microsphere per Volume of Tissue

Signal Intensity per Volume of Tissue

CEUS

Rostral (R) Caudal (C) R C

Number of Microspheres

Distance (mm) Caudal (C)

Rostral (R) Caudal (C) R C

Signal Intensity

Distance (mm) Caudal (C)
Percent Loss

Microsphere Deposition

CEUS

Microsphere Percent Loss

Signal Intensity Percent Loss
Discussion

Conclusion
• CEUS has better spatial resolution
• Better temporal resolution
  • Real time visualization of hemodynamic changes
• Intravital imaging
• Intraoperative usage

Ongoing and Future Directions
• Include absolute tissue perfusion
• Hemodynamics of chronic injury
• 3D CEUS parametric maps
• Use as clinical tool to evaluate lesion mapping, severity, and rescue-able zone in real-time
Human CEUS: Spine Tumor

Detecting tumor borders to aid during surgery
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And we are fun!

Captain Hofstetter