A Systematic Evaluation of Near-Infrared Imaging Systems in Intracranial Tumors

Steve S. Cho¹,², BS, Love Buch¹, BS, Shayoni Nag¹, BA, Brendan McShane¹, BS, Jun Jeon¹,², BS, Sophie Su¹, MD, Sunil Singhal³, MD, John Y.K. Lee¹, MD, MSCE

1. Department of Neurosurgery, Hospital of the University of Pennsylvania, Philadelphia, PA
2. Perelman School of Medicine at the University of Pennsylvania, Philadelphia, PA
3. Department of Surgery, Hospital of the University of Pennsylvania, Philadelphia, PA

AANS April 28 – May 2 2018
Disclosures

Introduction

- Distinguishing glial tumors from normal brain parenchyma is a critical role for the neurosurgeon during brain tumor surgery.
- Intraoperative near-infrared (NIR) fluorescence imaging using high-dose administration of indocyanine-green (Second-Window ICG; SWIG) offers highly sensitive visualization of intracranial neoplasms.
- Multiple modalities exist for visualizing NIR fluorescence in the operating suite, but can be divided largely into add-on modules to existing surgical microscopes or dedicated NIR scopes.
- A systematic review of seven existing modalities was recently done by DSouza et. al, but did not include neurosurgical microscopes.
- We hypothesized that a dedicated platform would be more sensitive and have a wider dynamic range of NIR detection, offering better NIR imaging for neurosurgery.
Methods

Imaging systems

- **System 1**: Add-on module to existing surgical microscope. Xenon light source and high-sensitivity NIR camera (820-860nm)
- **System 2**: Dedicated platform. 805nm laser source and NIR camera (820-860nm).

**In vitro imaging**

- Twelve serial dilutions (0.47-1007µg/L) of ICG were prepared in 96-well plates and imaged with both modalities

**In vivo imaging**

- Twelve patients undergoing craniotomy for intracranial neoplasms were infused intravenously with 5 mg/kg of ICG approximately 24 hours prior to surgery.
- During the surgery, NIR imaging was performed prior to dura opening, immediately following dura opening, upon tumor exposure, and after excision with both imaging modalities.
Results (1)

Above: Serial dilutions of ICG with corresponding SBR values using each imaging modality.

Left: NIR SBR vs Log(concentration)

Overall, System 2 demonstrates superior NIR sensitivity (SBR 12 vs 3.25 for System 1) and greater detection range *in vitro.*
Comparison of System 1 and System 2 intraoperatively. System 1 detects weak NIR fluorescence upon tumor exposure but not through the dura. In the same patient, System 2 detects strong NIR fluorescence even through the dura and clearly delineates the tumor upon exposure. Background signal is very low comparatively.
Regardless of tumor type or location, System 2 demonstrated higher sensitivity for detecting NIR signal intraoperatively. As expected, the NIR signal increases as the dura is opened and the tumor is exposed.
Conclusion

• SWIG can be safely administered 24 hours prior to surgery to aid in intraoperative visualization of intracranial tumors
• Different NIR imaging modalities offer a wide range of sensitivity and dynamic range for NIR detection
• Dedicated NIR imaging platforms, rather than add-on modules to current microscopes, offer enhanced NIR detection that is capable of localizing and delineating tumors clearly even through the dura
• Future microscopes with improved NIR detection capabilities and enhanced integration into the operating room workflow could greatly aid neurosurgeons in accurately resecting intracranial tumors to improve patient outcome