Evaluating Utility and Efficacy of Laser Speckle Imaging for Visualizing Perfusion During Urologic Surgery

Rai, A; James, J; Richstone, A; Kavoussi, L.

Sophie Davis Biomedical Education Program/CUNY School of Medicine, City College of New York

The Smith Institute of Urology, Northwell Health, New Hyde Park, NY, 11042

Introduction and Objectives:

Medical errors are the third leading cause of death in the United States with 26% attributed to preventable surgical errors. Ensuring tissue perfusion during surgical procedures remains a critical factor in tissue healing, avoiding complications and ensuring good clinical outcome. Currently available additional means of visualizing blood flow intraoperatively are limited to fluoroscopy or dye-augmented near-IR camera systems (i.e. ICG-augmented visualization systems such as Firefly). Unfortunately, most current approaches for visualizing blood flow/perfusion in real-time are suboptimal (lack objectivity), add additional steps into workflow (need for contrast reagent preparation and injection, potential adverse patient allergic reactions), and efficacious utility (need for large capital equipment, cost). Real-time visualization of blood flow and tissue perfusion would potentially have critical impact on clinical outcome and reducing complications. An optical imaging technique based on monochromatic coherent light known as Laser-Speckle-Contrast-Imaging (LSCI) represents a label-free imaging method using coherent monochromatic light where blood flow and tissue perfusion can be detected.

Methods:

ActivSurgical™'s ActivSight, is a laser speckle contrast based endoscopic imaging module that is positioned between the laparoscopic lens and the camera and has the ability to visualize real-time perfusion during laparoscopic procedures. During an initial evaluation of this technology in a live porcine model, several urologic procedures were performed in simulation and the utility of ActivSight was evaluated. Procedures performed included cystoscopy with bladder biopsy, renal hilar dissection and bowel anastomosis.

Results:

During the procedures performed, ActivSight appeared to demonstrate active blood flow to tissue structures that were within 2-3 mm of the surface tissue. Cystoscopically, there appeared to be visualization of submucosal vessels and appropriate lack of signal after tissue cauterization was performed (Figure 1). During renal hilar dissection, superficial and smaller caliber vessels were readily identified however, renal artery and vein were not as obvious. However, during renal artery clamping, there was noted to be immediate, significant loss of signal to renal parenchyma (Figure 2). Upon unclamping the artery, immediate return of signal was noted to the parenchyma. During bowel anastomosis, vessel arcades were dissected and selectively clamped with corresponding loss of signal in associated tissue.

Conclusion:

ActivSight's LSCI module was able to discern superficial changes in blood flow and tissue perfusion. While the product in its existing form factor is not yet available for commercial use, implementation of this new technology may provide us better real-time information in the hopes of decreasing medical errors in the field of urology. While information presented here demonstrates some early potential promise, further research and development will be required to increase visualization depth of perfusion as well as validated perfusion thresholds to increase its clinical utility.

Figure 1: Cystoscopic evaluation of ActivSight technology in a porcine model. Images (a) and (c) are t

traditional white-light cystoscopic visualization whereas images (b) and (d) correspond to ActivSight visualization in the same field of view. Submucosal vasculature on whitelight (a) is visualized readily with ActivSight in image (b) and appears to correspond with vessels noted. Similarly, upon performance of electrocautery under white-light (c), there is loss of laser speckle signal noted (d).

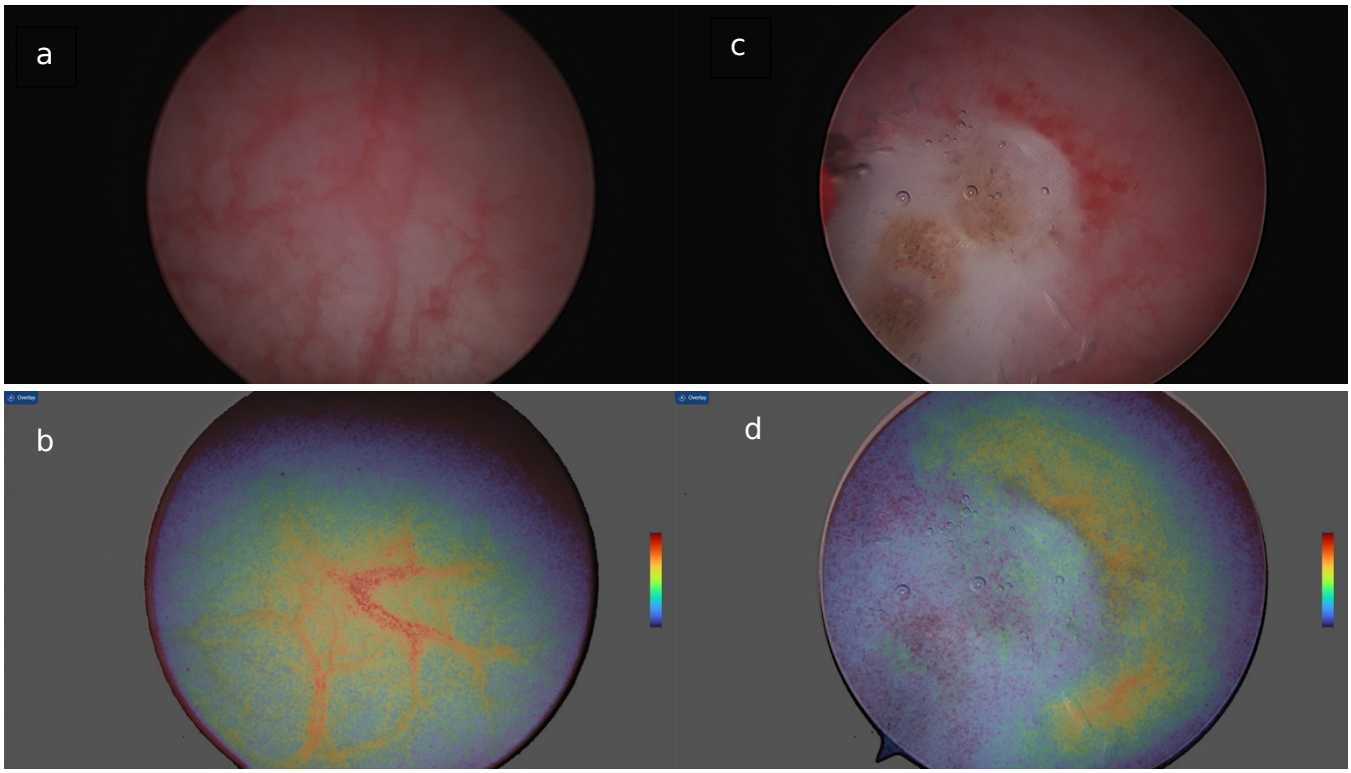

Figure 2: Laparoscopic evaluation of ActivSight in a porcine model. During renal hilar dissection (a), excellent perfusion signal is noted to the kidney during ActivSight (b) and overlay mode (d). During renal artery clamping, absence of signal is noted on ActvSight (c) and overlay mode (e). Not pictured, is the return of signal during release of the arterial clamp.