Turning on the Lights: New Technologies in Optical Diagnostics and Therapeutics

Whether coupling a light source to the first cystoscope or using a laser as a bladeless scalpel, a surgeon’s ability to harness light for surgical guidance and intervention is among the most important modern surgical innovations. In recent years optical diagnostics, particularly fluorescence imaging techniques, have emerged as a potentially important adjunct to standard white light endoscopic and laparoscopic surgery. Similarly laser assisted surgery has been established as an alternative to standard electrosurgical resection during transurethral surgery. In this issue of The Journal 2 studies offer the latest examples of optical technologies used in surgical navigation and extirpative surgery.

Iatrogenic ureteral injury is a rare but serious complication during abdominal and pelvic surgery. To reduce the risk, the urologist is frequently called on to place stents to facilitate intraoperative ureteral identification. While generally straightforward, ureteral stent placement is invasive and associated with potential morbidities. Noninvasive imaging of the ureters offers potential advantages compared to invasive placement of ureteral stents.

In this issue of The Journal Verbeek et al (page 574) report on a feasibility study using near infrared (NIR) imaging for ureteral identification during open surgery. Low dose methylene blue, a drug familiar to urologists that is excreted in urine, served as the NIR dye detectable using a customized fluorescence camera brought in close proximity to the surgical field. Within 10 minutes after intravenous administration NIR fluorescence emanating from the methylene blue excreted in the urine was detectable along the length of the ureter in 10 patients undergoing open gynecologic surgery or radical cystectomy.

This technology is an example of a rapidly emerging field of image guided surgery in which advanced optical imaging modalities are used to highlight and provide contrast between normal and diseased tissue. This application is reminiscent of fluorescence image guided renal surgery using another NIR dye, indocyanine green. The development of clinical imaging systems using previously approved drugs that can serve as contrast agents (eg fluorescein, methylene blue and indocyanine green) decreases the costs and logistics associated with regulatory approval, which are inherently challenging for these drug-device combinations.

Also in this issue Sciarra et al (page 698) report a therapeutic application of light with a thulium based diode laser for nephron sparing surgery. Patients with renal cell carcinoma tend to be older, often have comorbid conditions and may be particularly sensitive to further loss of kidney function after kidney cancer surgery. Thulium lasers, which are currently used for transurethral vaporization of the prostate, emit at infrared range (2,013 nm) with shallow tissue penetration (0.5 mm). Thulium lasers enable precise tissue dissection with concomitant hemostasis and may obviate the need for hilar clamping during nephron sparing surgery. The authors describe successful application of this technology in 10 partial nephrectomy cases (7 open and 3 laparoscopic) with tumors up to 5.5 cm in those with significant medical comorbidities (ie American Society of Anesthesiologists III). After the initial 3 cases with hilar clamping, the remaining 7 were performed without global or regional ischemia. In a similar recent study 15 cases of laparoscopic partial nephrectomy were successfully completed using the thulium laser without hilar clamping.

This description of thulium laser assisted surgery adds to the growing body of literature on nonischemic nephron sparing surgery. This treatment method offers the potential to avoid renal ischemia and could reduce the incidence of surgically induced chronic kidney disease. For select exophytic tumors this approach may obviate the need for any hilar dissection. While ablative therapies rely on renal mass biopsies, thulium laser partial nephrectomy allows for complete histopathological analysis of the excised tumor. It remains to be seen if the thulium laser is superior to other laser sources in kidney cancer surgery (eg holmium, CO2), or if laser assisted partial nephrectomy may be safely performed in other high risk cohorts such as in patients on anticoagulation therapies.
Both of these feasibility reports propose intriguing new applications of light in complex surgical scenarios. Further technical refinements, including improving the penetration depth of NIR fluorescence, applying NIR fluorescence during laparoscopic surgery and controlling the smoke plume generated during thulium laser surgery, will need to be investigated further. Larger multicenter, prospective, surgical cohorts will be required to confirm the benefits and safety of these technologies, as well as comparative studies with current standards. Long-term followup will allow for comparisons of complications and outcomes, as well as comparisons of the cost-effectiveness of these technologies in different patient cohorts in the context of various health care systems.

The costs of new technologies are often significantly higher than those of the current standards, and this will need to be considered when integrating promising new technologies into the operating room. Strategies to reduce cost include sharing the technology platform across different surgical approaches (eg open, laparoscopic) and disciplines (eg urology, general surgery, gynecology). With further validation these innovative optical technologies may continue the tradition of harnessing light to move urological surgery forward.

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REFERENCES


