Editorial

Clinical applications of fluorescence imaging in laparoscopic surgery

The laparoscopic approach has greatly improved patient care throughout various surgical subspecialties. Minimizing surgical trauma has a beneficial effect on patient recovery and decreases complications. Another advantage of laparoscopy is the improved surgical view. Not only due to improved monitors (4K), magnification and 3d view, but more recently also through image guided techniques, such as fluorescent imaging. Using specific (targeted) agents important anatomical structures can be visualized even more precisely. In this series of *Laparoscopic Surgery* we highlight the clinical application of fluorescence imaging throughout various laparoscopic abdominal surgical procedures. Due to the recent standard incorporation of fluorescent imaging capabilities in most mainstream laparoscopic/robotic surgery systems, the majority of laparoscopic surgeons now a days has the ability to use this technique. The principle consists of adding an exogenous fluorophore into the patient, intravenously or directly in tissue of relevance, providing highly sensitive discrimination of a relevant target within the surgical field (1). Most of the fluorescent systems use the near-infrared region (700–900 nm) as it has advantage over visible light in, for example, enhanced debt penetration (5–10 mm, depending on the tissue) and invisibility to the human eye and therefore not changing the surgical field (2). The technique had a relatively fast clinical introduction due to the availability of non-specific fluorophores methylene blue (700 nm) and indocyanine green (ICG, 800 nm) that could be used off-label (3). Although the technique is quite easy to use, in our opinion still a short learning curve must be completed of at least 20 procedures to get familiar with the technique.

A recent PubMed search (*Figure 1*) shows an increasing number of manuscripts that are published yearly about fluorescence and laparoscopic surgery marking its growing relevance in clinical practice. Especially non-specific ICG is frequently used due to its wide availability, good fluorescent properties, low costs and negligible adverse events. Application has been described in various fields such as biliary tract imaging (4,5), donor nephrectomies (4), colorectal surgery (6), liver surgery (7,8), lung surgery (9), gastric surgery (10,11), bowel and esophageal anastomoses (12-14), lymph node mapping (15,16), endocrine surgery (17), evaluation of perfusion of colon (18) and peritoneum (19), ureter imaging (20), tumor-specific imaging (21) and for the identification of occult pulmonary (22) or abdominal lesions (23). Specific tracers are in development that recognize vital structures or tumors and show promising results but are all still in pre-clinical phases or in clinical trials and not freely available (24).

The disadvantage of fluorescence imaging is the relatively low tissue penetration. Therefore, the focus of this technique is on visualizing superficial anatomical structures in addition to intraoperative ultrasound and preoperative imaging techniques rather than a stand-alone application (25). Nevertheless, applications such as lymph node detection, evaluating tissue perfusion and ureter- and biliary tract imaging can benefit from fluorescence alone. We believe that fluorescent imaging is changing intraoperative decision making and will result in more radical surgeries, better recognition of vital structures, better evaluation of tissue quality, less iatrogenic damage and therefore less morbidity and mortality and possibly even increased patient survival. Future developments must focus on enhancing the sensitivity and resolution of the cameras, and developing advanced (targeted) tracers for specific tumor detection integrating the technique with preoperative CT and PET scans and intraoperative ultrasound. Furthermore, research must focus more on the added clinical benefit of the technique, as in changing intraoperative decision making, rather than on its diagnostic performance (26).

This series include a comprehensive overview of fluorescence imaging during robotic surgery and reviews about liver surgery, colorectal liver metastases surgery, lymphadenectomy during colorectal surgery and dyes for real-time ureter imaging. We hope this series will be of interest for all readers providing useful information about the current status of fluorescence guided laparoscopic surgery. We thank *Laparoscopic Surgery* journal for the invitations to be guest editors and all authors for their contribution.

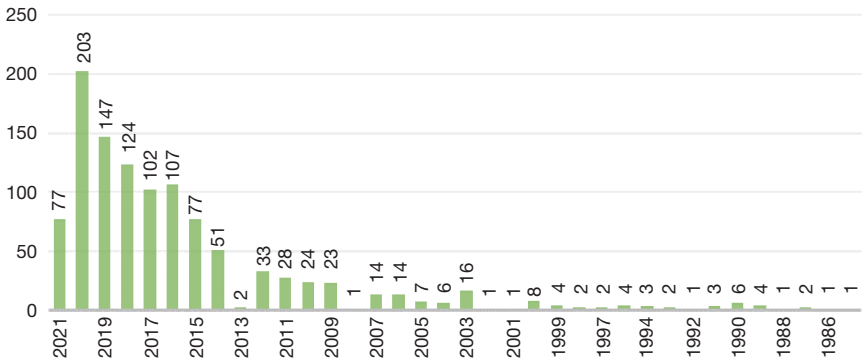

Figure 1 Graph shows the number of published manuscripts between 1985 and April 2021 on pubmed.gov using the following search: "fluorescence AND laparoscopic AND surgery".

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