

Editorial

The Beginning of a New Era of Digestive Surgery Guided by Fluorescence Imaging

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There has been a dramatic increase in the use of fluorescence imaging for visualizing biological structures during surgery; a MEDLINE search with the keywords “fluorescence imaging” and “surgery” yielded year-on-year increases in the number of publications, which reached more than 1,200 articles in 2012 (fig. 1). Use of fluorescence imaging in surgical settings started at the beginning of the 21st century with angiography using indocyanine green (ICG) as a source of fluorescence during coronary artery bypass grafting [1], and this was followed by sentinel node navigation in breast cancer surgery [2] and intraoperative angiography for cerebral aneurysm [3] in the mid 2000s. Since near-infrared imaging systems became commercially available for open surgery in 2005 and for laparoscopic surgery in 2011, the application of fluorescence-guided surgery has further accelerated.

Among the numerous fluorescent probes available for *in vivo* imaging, ICG remains the mainstay in the clinical setting. The safety of ICG has been established over more than 50 years of clinical usage. Its fluorescent properties (excitation 750–810 nm, emission around 830 nm) mean that the signal is not absorbed by hemoglobin or water, which confers advantages in visualizing deep-lying structures. In the field of hepatobiliary surgery, the fact that ICG is excreted in bile is a very useful pharmacological characteristic. For example, ICG-fluorescence imaging enables delineation of the bile ducts following intravenous ICG injection (fluorescence cholangiography) [4–6]. Using ICG, intraoperative identification of both primary and secondary hepatic malignancies is possible through visualization of the biliary excretion disorders that exist in hepatocellular carcinoma tissues and in non-cancerous hepatic parenchyma compressed by metastatic tumors [7–10]; this approach may lead to the development of photodynamic treatment [11]. Currently available techniques can also be used to assess portal uptake in hepatic segments with venous occlusion during liver resec-

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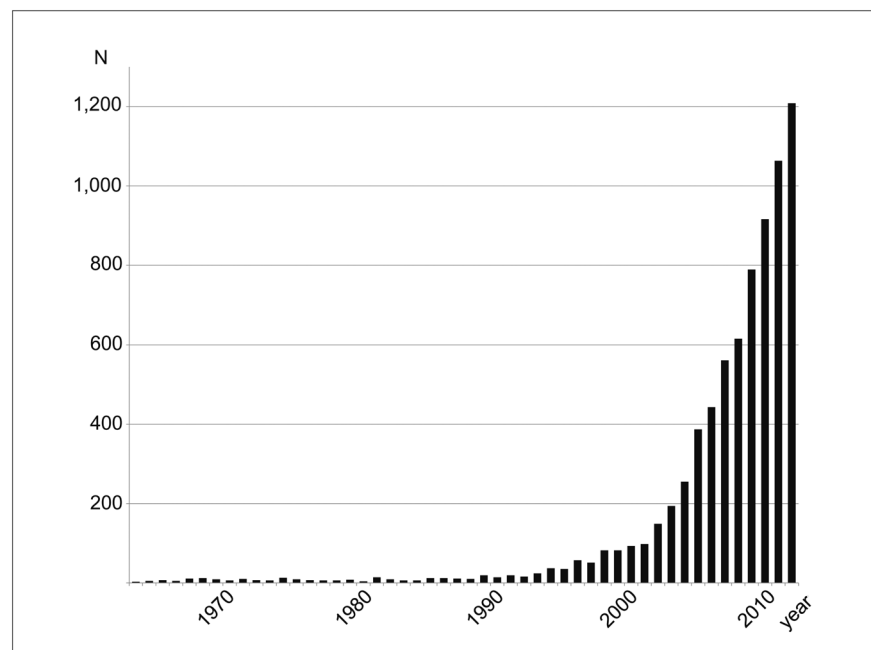


Fig. 1. Annual number of publications (N) on fluorescence imaging in the field of surgical treatment. A MEDLINE search was carried out using the keywords “fluorescence imaging” and “surgery” (accessed on 19 December 2013). The number of publications started to increase dramatically from about 2000.

tion or transplantation [12]. Another clinically available fluorescent probe is 5-aminolevulinic acid; however, its application to digestive surgery has rarely been evaluated.

In basic and preclinical studies, many novel fluorescent probes have been developed to enhance ICG-based fluorescence imaging to delineate biliary and vascular anatomy and to detect cancerous tissues other than hepatocellular carcinoma. Among these techniques, intraoperative fluorescence imaging of pancreatic leaks has the potential to reduce the incidence and severity of postoperative pancreatic fistulas [13]. Novel fluorescence imaging systems are also being actively developed to allow simultaneous identification of two or more structures with different fluorescence probes [14]; furthermore, fluorescence goggle systems worn by the operating surgeon should soon be able to provide real-time visual information on the surgical field [15]. The history and techniques of fluorescence-guided surgery are well-summarized in a recent review article by Vahrmeijer et al. [16] and are also described in detail in the book *Fluorescent Imaging: Treatment of Hepatobiliary and Pancreatic Diseases* [17]. In addition, the first international symposium on fluorescence-guided surgery, held in February 2014, promoted the sharing of cutting-edge knowledge for further development of these exciting new techniques.

Conventionally, intraoperative diagnosis and decision-making have been based on surgeons' visual inspection and palpation, with the aid of ultrasonography and radiation. Fluorescence imaging will open a new era of surgery, in which more detailed information on vascular anatomy and cancer status will be rapidly available for surgeons to view when needed, enhancing the safety and efficacy of digestive surgery.

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