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Fluorescence-Guided Surgery Using Indocyanine Green (ICG): A Game Changer in Modern General Surgery

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Abstract

Fluorescence-guided surgery (FGS) using indocyanine green (ICG) is an emerging technology that enhances intraoperative decision-making by allowing real-time visualization of anatomical and pathological structures. This technique has gained prominence in various domains of general surgery including hepatobiliary, colorectal, and minimally invasive procedures. This article highlights the principles, applications, benefits, and future scope of ICG-based FGS.

Keywords: Indocyanine Green (ICG), Fluorescence-Guided Surgery, Minimally Invasive Surgery, Hepatobiliary Surgery, Colorectal Surgery, Sentinel Node Mapping, Anastomotic Perfusion

Introduction

General surgery has witnessed significant technological evolution over the past two decades, particularly in the integration of imaging techniques into operative practice. Indocyanine green (ICG) fluorescence imaging, initially used in ophthalmology and hepatic function studies, is now widely applied intraoperatively to improve visualization of vasculature, lymphatic drainage, and tissue perfusion.

Mechanism of Action

ICG is a water-soluble, fluorescent dye that binds rapidly to plasma proteins and emits fluorescence when excited by near-infrared light (approximately 800 nm). After intravenous administration, the dye distributes through vascular and lymphatic systems, offering real-time imaging via specially equipped laparoscopic or open surgical cameras.

Applications in General Surgery

1. Hepatobiliary Surgery

Intraoperative identification of biliary anatomy during laparoscopic cholecystectomy reduces bile duct injury risk.

Tumor localization and liver segment demarcation during hepatic resections.

(Ishizawa et al., 2009)

2. Colorectal Surgery

Assessment of anastomotic perfusion helps reduce anastomotic leak rates in colorectal resections.

(Jafari et al., 2015)

3. Breast Surgery

Sentinel lymph node mapping in breast cancer surgeries, offering an alternative to radioisotopes.

(Sugie et al., 2013)

4. Parathyroidectomy

Autofluorescence and ICG-enhanced imaging help localize parathyroid glands and preserve vascularity. (Thomas et al., 2016)

5. Minimally Invasive Surgery

Enhanced visualization in laparoscopic and robotic platforms promotes safer dissections and better outcomes.

Advantages

Real-time, dynamic imaging

Reduces need for intraoperative X-rays

Enhances surgical precision

Minimally invasive and safe with a low adverse reaction rate

Limitations

High cost of equipment

Learning curve for interpretation

Limited tissue penetration depth (~5-10 mm)

Future Directions

Development of targeted fluorescent dyes for tumor-specific imaging

Integration with artificial intelligence for automated interpretation

Expansion into trauma surgery, organ transplantation, and more

Conclusion

ICG-based fluorescence-guided surgery is transforming the field of general surgery by improving surgical accuracy and safety. As equipment becomes more affordable and user-friendly, this technology is poised to become a standard of care across various surgical specialties.

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