Original Article

Study on the application value of fluorescent laparoscopy in pancreatic tumor surgery

Shihang Xi[1#], Wei Zhang[2#], Daohai Qian[1], Chiyi He[3], Xueliang Zuo[4], Juan Cai[5], Lin Li[3], Huiming Cai[6], Chawla Akhil[7], Xiaoming Wang[1]

[1]Department of Hepatobiliary Surgery, First Affiliated Hospital of Wannan Medical College, Wuhu, China; [2]Jiangsu Institute of Medical Device Testing, Nanjing, China; [3]Department of Gastroenterology, First Affiliated Hospital of Wannan Medical College, Wuhu, China; [4]Department of Gastrointestinal Surgery, First Affiliated Hospital of Wannan Medical College, Wuhu, China; [5]Department of Oncology, First Affiliated Hospital of Wannan Medical College, Wuhu, China; [6]Nanjing Nuoyuan Medical Devices Co., Ltd., Nanjing, China; [7]Division of Surgical Oncology, Northwestern University Feinberg School of Medicine, Northwestern Medicine Cancer Centers, Robert H. Lurie Comprehensive Cancer Center, Chicago, IL, USA

Contributions: (I) Conception and design: S Xi, X Wang; (II) Administrative support: X Wang; (III) Provision of study materials or patients: X Wang, D Qian, C He, X Zuo, J Cai, L Li; (IV) Collection and assembly of data: S Xi; (V) Data analysis and interpretation: X Wang, D Qian, S Xi, H Cai, W Zhang, C Akhil; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

[#]These authors contributed equally to this work as co-first authors.

Correspondence to: Xiaoming Wang, MD. Department of Hepatobiliary Surgery, First Affiliated Hospital of Wannan Medical College, 2 Zheshan West Road, Wuhu 241000, China. Email: wxm6901@aliyun.com.

Background: Fluorescent laparoscopy is rarely used in pancreatic surgery. The aim of this study was to investigate the value of fluorescent laparoscopy in pancreatic tumor surgery.

Methods: A total of 19 patients with pancreatic tumors who were treated in the Department of Hepatobiliary Surgery at the First Affiliated Hospital of Wannan Medical College from January 2021 to August 2022 were selected. Fluorescent laparoscopy was used intraoperatively, and the imaging characteristics of different tumors were recorded and analyzed.

Results: Among the 19 participants, postoperative pathology confirmed 12 cases of pancreatic cancer (8 cases of moderately differentiated adenocarcinoma, 3 cases of moderately-poorly differentiated adenocarcinoma, and 1 case of acinar cell carcinoma), 4 cases of pancreatic cystic tumors (1 case of microcystic serous cystadenoma, 1 case of serous cystadenoma, 1 case of solid pseudopapillary tumor, and 1 case of solid-cystic pseudopapillary tumor), 1 case of pancreatic neuroendocrine tumor (G1 stage), and 2 cases of inflammatory lesions. There were 8 cases of pancreaticoduodenectomy, 6 cases of distal pancreatectomy, 3 cases of middle pancreatectomy, 1 case of local pancreatectomy, and 1 case of duodenum-preserving pancreatic head resection. One minute after intravenous injection of indocyanine green (ICG), 10 of the 12 patients with pancreatic cancer showed tumor peritumor imaging; 2 cases of pancreatic serous cystic tumors did not show imaging; 2 cases of solid pseudopapillary tumors had tumor body imaging; 1 case of neuroendocrine tumor had tumor body imaging, with complete fluorescence imaging after specimen dissection; there were 2 cases pathologically confirmed as inflammatory lesions, 1 case with tumor body imaging, and 1 case with capsule imaging.

Conclusions: By reasonably controlling the administration time and dose of ICG during surgery, some pancreatic tumors can be fluorescently imaged, which is beneficial for intraoperative tumor localization and margin determination.

Keywords: Fluorescent laparoscopy; indocyanine green (ICG); pancreatic tumors

Submitted Aug 09, 2023. Accepted for publication Oct 16, 2023. Published online Oct 26, 2023.
doi: 10.21037/gs-23-331
View this article at: https://dx.doi.org/10.21037/gs-23-331

Introduction

Pancreatic tumors are one of the common tumors of the gastrointestinal tract, with insidious onset and often no clinical symptoms in the early stage (1). The World Health Organization (WHO) classifies them into three parts: benign epithelial tumors and precursor lesions, malignant epithelial tumors, and neuroendocrine tumors (2). Currently, surgery remains the only curative treatment for pancreatic tumors (3). Although abdominal enhanced thin-layer computed tomography (CT), magnetic resonance imaging (MRI), and the recently emerged 3-dimensional (3D) visualization technology can provide accurate preoperative assessment for patients with pancreatic tumors, there may still be additional findings identified during surgery. In hepatobiliary and pancreatic surgery, fluorescent laparoscopy is a widely applied technique in laparoscopic liver surgery (4), with good clinical application results, providing great assistance to the surgery in terms of identification of the bile leaks (5,6). However, it has not broadly been applied to pancreatic surgery. Currently, attempts at its utilization are in laparoscopic duodenum-preserving pancreatic head resection (LDPPHR), where indocyanine green (ICG) imaging is used to effectively avoid bile duct injury (7-9). However, there are few reports on the study of fluorescent imaging of pancreatic tumors themselves. Moreover, unlike laparoscopic liver surgery, for which there are certain differences in ICG injection time, administrative route, and dosage among various centers (10,11), such parameters are still unclear in pancreatic surgery. However, its use in open pancreatic surgery may be beneficial in tumor localization, margin determination, with the potential to shorten operative time and also avoid excessive resection of pancreatic tissue. The aim of this study was to preliminarily explore the value of fluorescent laparoscopy in the resection of pancreatic tumors and provide guidance for the surgery of patients with pancreatic tumors. We present this article in accordance with the STROBE and AME Case Series reporting checklists (available at https://gs.amegroups.com/article/view/10.21037/gs-23-331/rc).

Highlight box

Key findings

- By reasonably controlling the administration time and dose of indocyanine green during surgery, some pancreatic tumors can be fluorescently imaged, which is beneficial for intraoperative tumor localization and margin determination.

What is known and what is new?

- Fluorescence laparoscopy is widely used in liver surgery, but rarely used in pancreatic surgery;
- Through this application of fluorescence laparoscopy to pancreatic tumors of different pathological types, we found that pancreatic tumors are capable of fluorescence imaging, and the imaging characteristics of tumors of different pathological types are different.

What is the implication, and what should change now?

- Combined with the results of this study, the use of fluorescent laparoscopy in pancreatic tumors can be increased and deserves further clinical promotion.

Methods

Participants

A total of 19 patients diagnosed with pancreatic tumors before surgery from January 2021 to August 2022 in the Department of Hepatobiliary Surgery at the First Affiliated Hospital of Wannan Medical College were selected as the research participants. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by Medical Ethics Committee of Wannan Medical College (No. 2023-161) and individual consent for this retrospective analysis was waived.

The inclusion criteria were as follows: (I) diagnosis of pancreatic tumor by preoperative enhanced CT, MRI, and other appropriate imaging methods, and with surgical resection indications; (II) 18–80 years old; (III) complete case information available.

The exclusion criteria were as follows: (I) patients with a history of allergy to the ICG formulation or iodine were excluded to prevent anaphylactic shock; (II) patients with a past history of iodine allergy (this preparation contains iodine and therefore has a potential to cause iodine allergy).

Study methods

ICG for injection (25 mg; Dandong Medical Creation, Dandong, China) was used. After injecting ICG for 5–10 seconds during surgery, the fluorescence laparoscope (Nanjing Nuoyuan Fluorescence Lens, Nanjing, China) was set to detection of the luminescent ICG, and tumor tissue was marked as green or purple (different brands of fluorescent laparoscopes display different colors). The fluorescence laparoscope was alternated between white

light, fluorescence, and black and white light, to observe and record the imaging characteristics of pancreatic tumors. White light is a normal image seen under laparoscopy; black and white light is the original image under fluorescence laparoscopy; fluorescence is an image processing based on black and white light for observing lesions.

In this study, we used the first window ICG fluorescence imaging (intraoperative intravenous injection of ICG), corresponding second window ICG, which is intravenous injection 24 hours before surgery. The specific method is as follows: dissolve 25 mg in 10 mL of the provided sterile injection water, then dilute with 10 mL of physiological saline, extract 1 mL of the solution, and inject it intravenously. The fluorescence laparoscope can be used to observe the pancreatic tumor fluorescence imaging effect after 1 minute.

Fluorescence effect analysis

The effects of ICG injection time and dosage on tumor imaging were analyzed. Postoperative pathology of each patient's tumor was characterized and correlated with the intraoperative imaging effects. The fluorescence imaging characteristics of different types of pancreatic tumors were recorded and the etiology of these characteristics were assessed with imaging.

Statistical analysis

The statistical software SPSS 20.0 (IBM Corp., Armonk, NY, USA) was used for data analysis. Count data were expressed as n (%), and inter-group comparisons were made using the Chi-square (χ^2) test; measurement data were expressed as $\bar{x}\pm s$, and inter-group comparisons were made using the χ^2 test. The test level (α) was 0.05.

Results

General clinical data of patients

A total of 19 patients were included in this study, with 12 males and 7 females, and a median age of 67 years. They underwent 18 laparoscopic surgeries, including 7 laparoscopic pancreaticoduodenectomies (LPD), 5 laparoscopic radical antegrade modular pancreatosplenectomies (LRAMPS; including 1 case combined with celiac trunk resection), 3 laparoscopic central pancreatectomies (LCP), 1 laparoscopic spleen-preserving distal pancreatectomy, 1 laparoscopic local pancreatectomy, and 1 LDPPHR. One open surgery was performed after laparoscopic exploration, which was pancreaticoduodenectomy (PD) combined with superior mesenteric vein (SMV) resection and reconstruction. Postoperative pathology confirmed 12 cases of pancreatic adenocarcinoma, 4 cases of pancreatic cystic tumors, 1 case of neuroendocrine tumor, and 2 cases of inflammatory lesions. For more details, see *Table 1*.

Tumor fluorescence imaging

Of the 19 pancreatic tumor patients included in this study, 78.9% (15/19) had tumor fluorescence imaging performed successfully. According to the tumor fluorescence imaging characteristics and postoperative pathology, the following 4 categories were identified: (I) pancreatic cancer, with 83.3% imaging performed successfully (10/12): 8 cases of moderately differentiated adenocarcinoma (2 cases without imaging), 3 cases of moderately to poorly differentiated adenocarcinoma, and 1 case of acinar cell carcinoma; (II) pancreatic cystic tumors, 50% with imaging performed successfully (2/4): serous cystadenomas without imaging, solid pseudopapillary tumors with imaging: 1 case of pancreatic microcystic serous cystadenoma, 1 case of serous cystadenoma, 1 case of solid pseudopapillary tumor, and 1 case of solid-cystic pseudopapillary tumor; (III) 1 case of pancreatic neuroendocrine tumor (pNET), with imaging performed successfully; and (IV) 2 cases of inflammatory lesions, both with imaging performed successfully. For specific tumor imaging details, see *Table 2*. And, the pictures of a typical procedure are shown in *Figures 1*-*7*.

Discussion

Pancreatic surgery is challenging due to its unique anatomical location, which is situated in the retroperitoneum and adjacent to important abdominal vessels such as the superior mesenteric artery (SMA) and SMV (12). The risk of complications from pancreatic surgery is high, with complication rates more than 30% (13). With the increasing popularity of minimally invasive surgeries, pancreatic surgery is also trending towards minimally invasive procedures. Fluorescent technology has been widely and successfully applied in laparoscopic liver resection. Thus, this study aimed to explore the use of fluorescent laparoscopy to guide the surgical resection of pancreatic tumors, improve surgical efficiency, and

Table 1 General clinical information of patients

Patient	Gender	Age (years)	BMI, kg/m^2	Tumor marker (U/mL)	Tumor location	Surgical method	Postoperative pathology
1	Male	70	20.42	CA199 >1,200	Pancreatic body-tail	LRAMPS	Moderately to poorly differentiated adenocarcinoma
2	Female	57	23.11	Normal	Pancreatic head-uncinate	LPD	Acinar cell carcinoma
3	Male	80	24.91	CA199 >1,200; CA125 81.50	Pancreatic head	LPD	Moderately differentiated adenocarcinoma
4	Female	73	26.22	CA199 268.00	Pancreatic head	PD (with SMV resection and reconstruction)	Moderately differentiated adenocarcinoma
5	Female	72	21.64	Normal	Pancreatic head	LCP	Microcystic serous cystadenoma
6	Male	67	28.69	CA199 706.51	Pancreatic body-tail	LRAMPS	Moderately differentiated adenocarcinoma
7	Male	74	23.57	CA199 900.72	Pancreatic head-uncinate	LPD	Moderately differentiated adenocarcinoma
8	Male	51	21.30	CA199 >1,200	Pancreatic head-uncinate	LPD	Moderately to poorly differentiated adenocarcinoma
9	Male	64	22.85	Normal	Pancreatic head	LPD	Inflammatory disease
10	Male	45	20.20	Normal	Pancreatic neck	LCP	Neuroendocrine tumor (G1)
11	Female	56	27.41	Normal	Pancreatic neck	LCP	Inflammatory disease
12	Female	69	25.81	CA199 111.54	Pancreatic body-tail	LRAMPS (with celiac trunk resection)	Moderately differentiated adenocarcinoma
13	Male	69	22.66	CA199 124.85	Pancreatic head-uncinate	LPD	Moderately to poorly differentiated adenocarcinoma
14	Female	63	24.03	Normal	Pancreatic head	LDPPHR	Serous cystadenoma
15	Male	48	24.28	Normal	Pancreatic neck	Laparoscopic local resection	Solid pseudopapillary tumor
16	Male	73	26.89	CA125 65.30	Pancreatic body	LRAMPS	Moderately differentiated adenocarcinoma
17	Male	73	24.27	CA199 >1,200; CA125 44.70	Pancreatic head	LPD	Moderately differentiated adenocarcinoma
18	Female	35	24.68	Normal	Pancreatic body	LDP (Kimura)	Solid-pseudopapillary tumor
19	Male	54	24.80	CA199 647.04	Pancreatic body	LRAMPS	Moderately differentiated adenocarcinoma

BMI, body mass index; CA, carbohydrate antigen; LRAMPS, laparoscopic radical antegrade modular pancreatosplenectomy; LPD, laparoscopic pancreaticoduodenectomy; PD, pancreaticoduodenectomy; SMV, superior mesenteric vein; LCP, laparoscopic central pancreatectomy; LDPPHR, laparoscopic duodenum-preserving pancreatic head resection.

accelerate the surgical process.

In this study, we injected ICG intravenously during the surgery and found that 83.3% of pancreatic cancers were visualized under fluorescence. In pancreatic cystic tumors, 2 cases of pancreatic serous cystadenomas were not visualized, whereas 2 cases of solid pseudopapillary tumors were visualized. Additionally, 1 case of pNET was visualized and 2 cases of postoperative pathology confirmed as inflammatory lesions (1 preoperative imaging considered cancer and 1 considered cystic tumor) were 100% visualized, with an overall fluorescence visualization rate of 78.9%. In Newton *et al.*'s study, 11 of 12 pancreatic cancers (91.7%)

Table 2 Features of pancreatic tumor imaging

Patient	Pathology type	Imaging status
1	Moderately-poorly differentiated adenocarcinoma	Tumor peritumor imaging
2	Acinar cell carcinoma	Tumor peritumor imaging
3	Moderately differentiated adenocarcinoma	Tumor peritumor imaging
4	Moderately differentiated adenocarcinoma	Tumor peritumor imaging
5	Microcystic serous cystadenoma	Tumor not imaged
6	Moderately differentiated adenocarcinoma	Tumor peritumor imaging
7	Moderately differentiated adenocarcinoma	Tumor not imaged
8	Moderately-poorly differentiated adenocarcinoma	Tumor peritumor imaging
9	Inflammatory lesion	Tumor body imaging
10	Neuroendocrine tumor (G1)	Tumor body imaging
11	Inflammatory lesion	Tumor peritumor imaging
12	Moderately differentiated adenocarcinoma	Tumor not imaged
13	Moderately-poorly differentiated adenocarcinoma	Tumor peritumor imaging
14	Serous cystadenoma	Tumor not imaged
15	Solid-pseudopapillary tumor	Tumor body imaging
16	Moderately differentiated adenocarcinoma	Tumor peritumor imaging
17	Moderately differentiated adenocarcinoma	Tumor peritumor imaging
18	Solid-pseudopapillary tumor	Tumor body imaging
19	Moderately differentiated adenocarcinoma	Tumor peritumor imaging

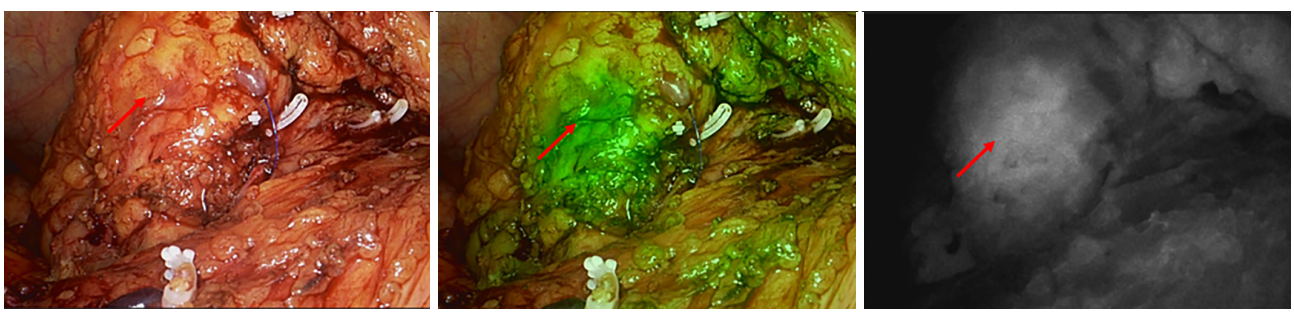

Figure 1 Patient 4 with pancreatic moderately differentiated adenocarcinoma (the tumor is marked by the arrows).

showed fluorescence, whereas only 3 of 8 benign or low-grade malignant pancreatic tumors [3 intraductal papillary mucinous neoplasms (IPMNs), 2 pNETs, 1 serous cystic neoplasm (SCN), 1 SMA tumor, and 1 nonfunctional (NF) tumor] showed fluorescence (37.5%), specifically 2 IPMNs and 1 SMA (14). Shirata *et al.* performed ICG fluorescence imaging on 23 pancreatic tumor patients, with 17 achieving effective visualization, and the visualization rate was 74%; the pancreatic cancer visualization rate was 57.1% (4/7). The pancreatic cystic tumor visualization rate was 9.1% (1/11), with solid pseudopapillary tumors not visualized, and the pNET visualization rate was 100% (5/5) (15). This contrasts with our study, where solid pseudopapillary tumors were visualized.

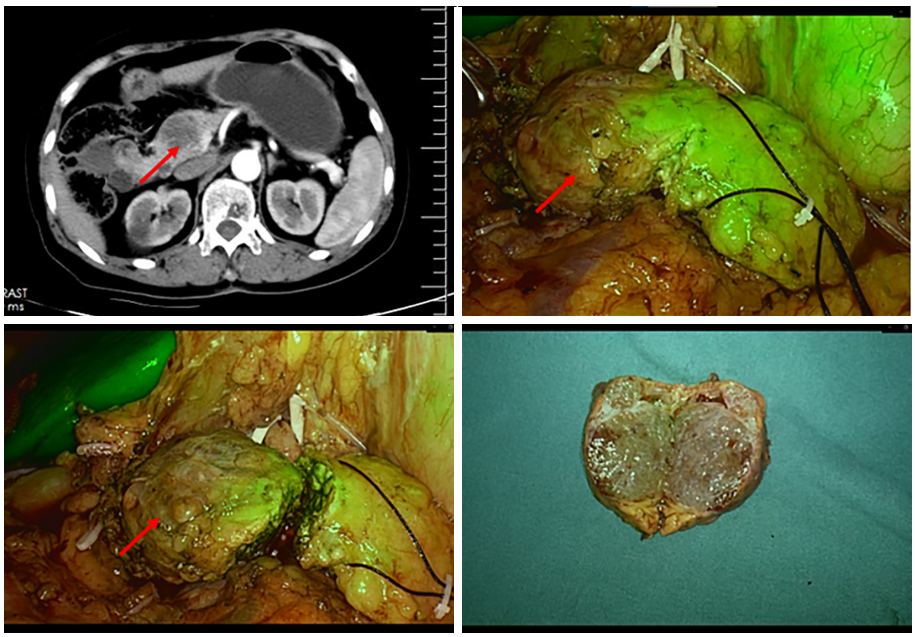

Figure 2 Patient 5 with pancreatic microcystic serous cystadenoma (tumor marked by arrows).

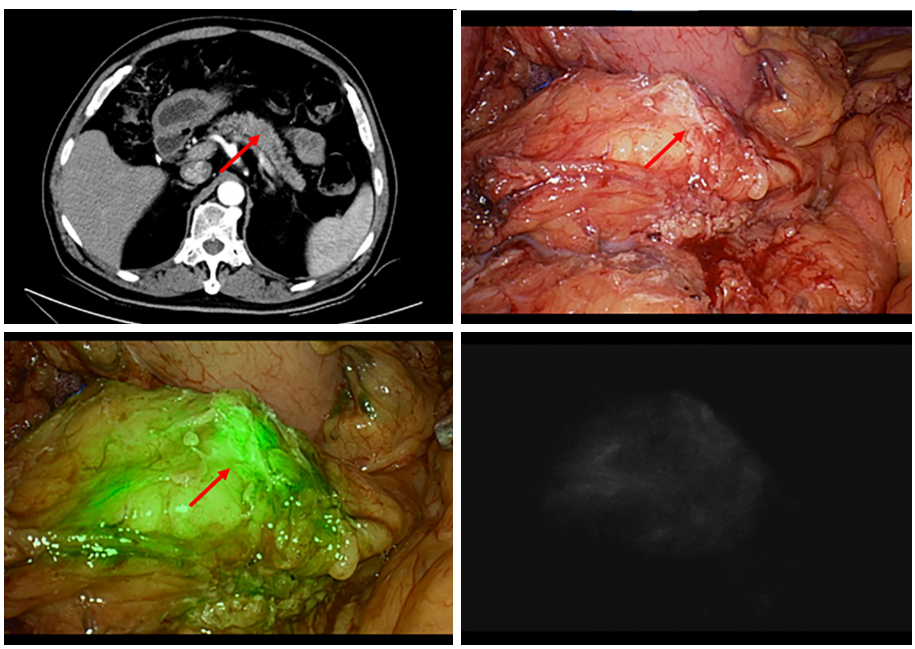

Figure 3 Patient 6 with moderately differentiated pancreatic adenocarcinoma (indicated by the arrows).

Regarding the choice of ICG injection time, dose, and route, this study used the first window ICG (ICG intravenously injected during surgery). The first window ICG was first studied by Hutteman *et al.* in 2011, who believed that after intravenous injection of ICG during surgery, there was no clear boundary between the pancreas and the tumor, but the bile duct and choledochojejunostomy could be clearly identified (16). Newton *et al.*'s study demonstrated that the second window ICG accumulates in pancreatic malignant tumors and can provide real-time

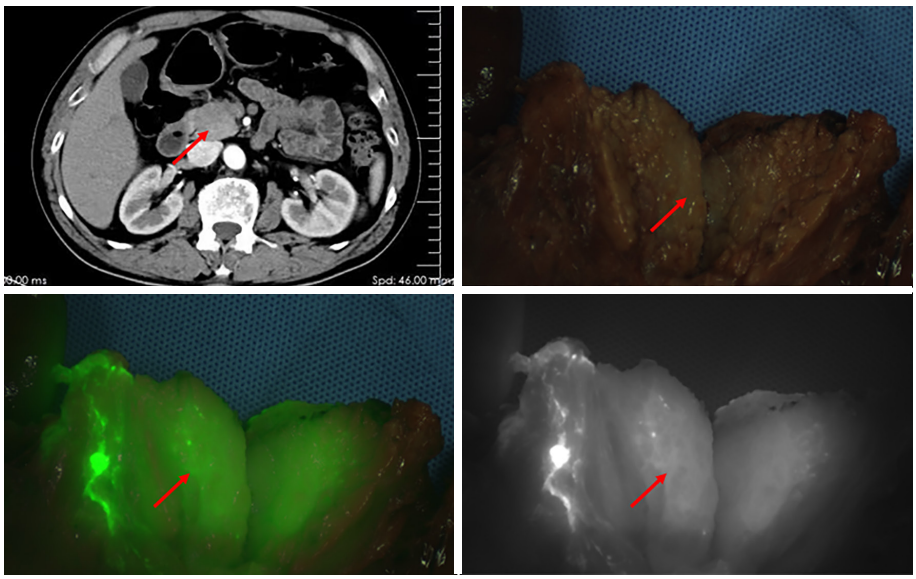

Figure 4 Patient 9 with inflammatory lesion (tumor marked by arrows).

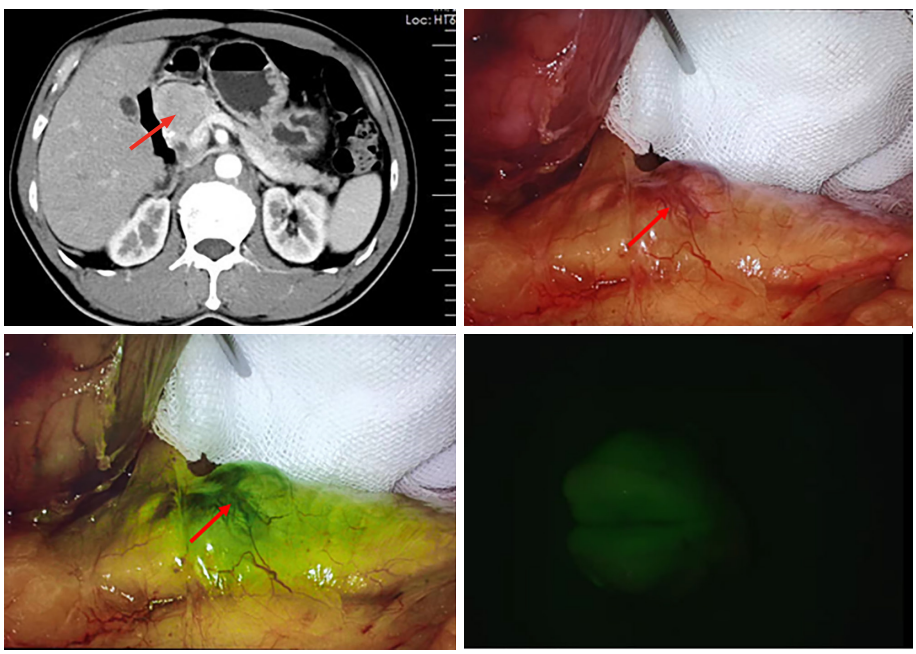

Figure 5 Patient 10 with pancreatic neuroendocrine tumor (tumor marked by arrows).

feedback during pancreatic surgery. Shirata *et al.*'s study showed that the first window ICG can visualize pancreatic tumors during surgery. We have previously used the second window ICG (ICG intravenously injected 24 hours before surgery), but the fluorescence visualization of pancreatic tumors was not satisfactory, and some patients experienced allergic reactions and phlebitis (12). At present, most studies on the first or second window ICG are single-center, small-sample studies, and the pathological distribution of pancreatic tumors varies, so there is no definitive conclusion on which is superior.

Furthermore, we found that the fluorescence

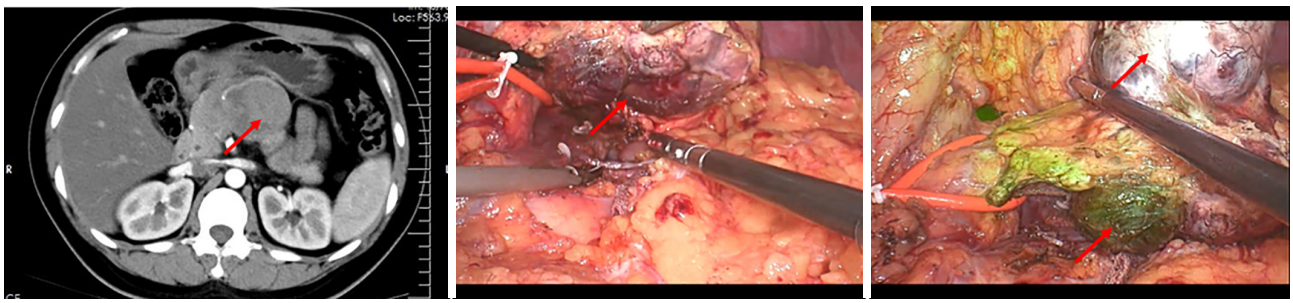

Figure 6 Patient 18 with pancreatic cystic and solid pseudopapillary tumor (arrows indicate tumor location, with tumor body protruding from the pancreatic serosa without showing fluorescence).

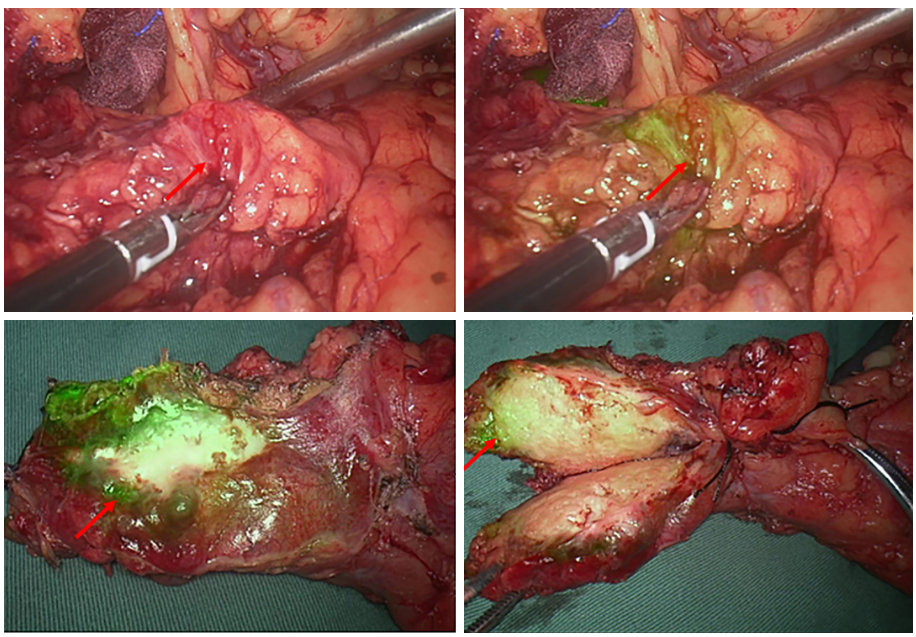

Figure 7 Patient 19 with moderately differentiated adenocarcinoma of the pancreas (indicated by arrows).

visualization effect varies for different pathological types of pancreatic tumors. Since ICG is widely distributed throughout the body after intravenous injection, it is selectively and efficiently taken up by hepatocytes and then excreted as free form into bile, entering the intestine through the bile duct and being excreted with feces (17). Therefore, ICG is widely and maturely used in fluorescence imaging technology for liver cancer. Studies have found that the fluorescence imaging characteristics of hepatocellular carcinoma (HCC) tissues with different degrees of differentiation vary. Moderate to well-differentiated HCCs exhibit uniform fluorescence imaging, whereas poorly differentiated HCCs and intrahepatic cholangiocarcinomas exhibit ring-shaped fluorescence imaging. Other benign tumors, such as liver cirrhosis nodules and focal nodular hyperplasia (FNH), are similar to moderate to well-differentiated HCCs. This phenomenon is mainly related to the ability of liver cells to uptake ICG (18). Pancreatic cells cannot uptake ICG like liver cells, and there are very few studies on fluorescence imaging of related pancreatic tumors. In this study, out of 9 patients with pancreatic cancer, 7 showed capsular imaging, whereas 2 did not. Under fluorescent laparoscopy, tumors often appeared as capsular imaging. The possible reason is that the tumor peritumor indicates a higher vascular density than the normal pancreatic tissue capsule. Pancreatic cancer is characterized by its invasiveness and early metastasis, which inevitably depends on the role

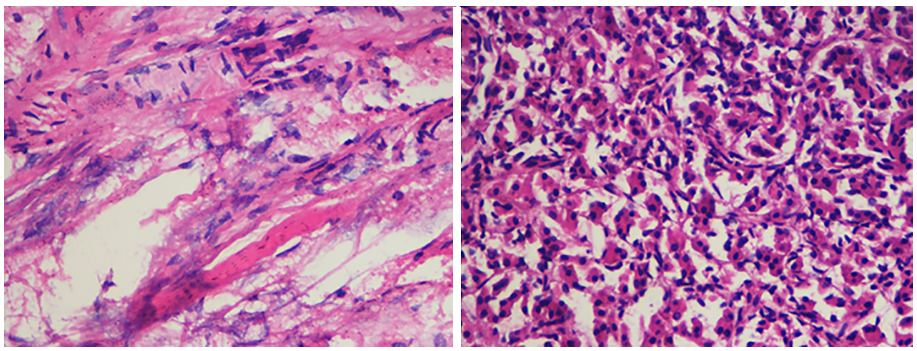

Figure 8 Comparison of vascular density between normal pancreatic capsule (left) and tumor pancreatic capsule (right) (HE, ×400). HE, hematoxylin and eosin.

of tumor angiogenesis (19). At present, there are few studies on the role of neovascularization in the growth and development of pancreatic cancer (20). In this study, we also observed the vascular density of the tumor peritumor tissue and normal pancreatic tissue capsule under a microscope during the surgery, and found that the vascular density of the tumor peritumor tissue was significantly higher than that of the normal capsule tissue (*Figure 8*). This is in line with our hypothesis, and we plan to continue to conduct further verification. Similarly, capsular imaging of pancreatic cancer was beneficial for intraoperative tumor localization, accelerating the surgical process, and reducing excessive exploration and dissection. Pancreatic serous cystic tumors could not be imaged, whereas pNETs and inflammatory lesions could be fully and clearly imaged. This may also be related to the richer vascular supply around the tumor compared to the surrounding pancreatic parenchyma. However, the samples, types of pancreatic cystic tumors and neuroendocrine tumors included in this study were small, and no effective conclusions can be drawn yet. In 2018, Shirata *et al.* found that fluorescent laparoscopy could identify 100% of neuroendocrine tumors, and 90.9% of pancreatic cystic tumors could not be imaged. They pointed out that fluorescent laparoscopy could define the tumor range and believe that fluorescence imaging was based on differences in vascular levels.

Conclusions

In summary, in this study, we used our center's ICG administration method to visualize pancreatic tumors, which was found to be beneficial for intraoperative tumor localization. We also conducted a preliminary analysis of the imaging characteristics of different pathological types of tumors, which has certain guiding significance for clinical laparoscopic pancreatic tumor surgery. We plan to continue to increase the sample size and further explore the best methodology fluorescent laparoscopic imaging of pancreatic tumors.

Acknowledgments

Funding: This work was supported by Academic Funding Program for Top Talents of Higher Education in Anhui Province (No. jxbjZD17); Research Capability "Peak" Spire Project of Yijishan Hospital, Wannan Medical College (No. KGF2019T02); Science and Technology Innovation Team of Yijishan Hospital, Wannan Medical College "Climbing" Project (No. KPF2019011); The fifth Batch of Innovative Leading Talents of Provincial "Special Support Plan" (No. TZ2019001); AnHui Province Educational Natural Science Project (2023AH040254).

Footnote

Reporting Checklist: The authors have completed the STROBE and AME Case Series reporting checklists. Available at https://gs.amegroups.com/article/view/10.21037/gs-23-331/rc

Data Sharing Statement: Available at https://gs.amegroups.com/article/view/10.21037/gs-23-331/dss

Peer Review File: Available at https://gs.amegroups.com/article/view/10.21037/gs-23-331/prf

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://gs.amegroups.

com/article/view/10.21037/gs-23-331/coif). HC is from Nanjing Nuoyuan Medical Devices Co., Ltd., Nanjing, China. The other authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by Medical Ethics Committee of Wannan Medical College (No. 2023-161) and individual consent for this retrospective analysis was waived.

References

1. Strauss J, Heery CR, Schlom J, et al. Phase I Trial of M7824 (MSB0011359C), a Bifunctional Fusion Protein Targeting PD-L1 and TGFβ, in Advanced Solid Tumors. Clin Cancer Res 2018;24:1287-95.
2. Nagtegaal ID, Odze RD, Klimstra D, et al. The 2019 WHO classification of tumours of the digestive system. Histopathology 2020;76:182-8.
3. Halbrook CJ, Lyssiotis CA, Pasca di Magliano M, et al. Pancreatic cancer: Advances and challenges. Cell 2023;186:1729-54.
4. Pesce A, Piccolo G, Lecchi F, et al. Fluorescent cholangiography: An up-to-date overview twelve years after the first clinical application. World J Gastroenterol 2021;27:5989-6003.
5. Achterberg FB, Sibinga Mulder BG, Meijer RPJ, et al. Real-time surgical margin assessment using ICG-fluorescence during laparoscopic and robot-assisted resections of colorectal liver metastases. Ann Transl Med 2020;8:1448.
6. Zhang P, Luo H, Zhu W, et al. Real-time navigation for laparoscopic hepatectomy using image fusion of preoperative 3D surgical plan and intraoperative indocyanine green fluorescence imaging. Surg Endosc 2020;34:3449-59.
7. Hong D, Cheng J, Wu W, et al. How to Perform Total Laparoscopic Duodenum-Preserving Pancreatic Head Resection Safely and Efficiently with Innovative Techniques. Ann Surg Oncol 2021;28:3209-16.
8. Cai Y, Zheng Z, Gao P, et al. Laparoscopic duodenum-preserving total pancreatic head resection using real-time indocyanine green fluorescence imaging. Surg Endosc 2021;35:1355-61.
9. Chen S, Gao P, Cai H, et al. Indocyanine Green-Enhanced Fluorescence in Laparoscopic Duodenum-Preserving Pancreatic Head Resection: Technique with Video. Ann Surg Oncol 2020;27:3926-7.
10. Uchiyama K, Ueno M, Ozawa S, et al. Combined intraoperative use of contrast-enhanced ultrasonography imaging using a sonazoid and fluorescence navigation system with indocyanine green during anatomical hepatectomy. Langenbecks Arch Surg 2011;396:1101-7.
11. He K, Hong X, Chi C, et al. Efficacy of Near-Infrared Fluorescence-Guided Hepatectomy for the Detection of Colorectal Liver Metastases: A Randomized Controlled Trial. J Am Coll Surg 2022;234:130-7.
12. Ahmad SA, Duong M, Sohal DPS, et al. Surgical Outcome Results From SWOG S1505: A Randomized Clinical Trial of mFOLFIRINOX Versus Gemcitabine/Nab-paclitaxel for Perioperative Treatment of Resectable Pancreatic Ductal Adenocarcinoma. Ann Surg 2020;272:481-6.
13. van Dongen JC, Suker M, Versteijne E, et al. Surgical Complications in a Multicenter Randomized Trial Comparing Preoperative Chemoradiotherapy and Immediate Surgery in Patients With Resectable and Borderline Resectable Pancreatic Cancer (PREOPANC Trial). Ann Surg 2022;275:979-84.
14. Newton AD, Predina JD, Shin MH, et al. Intraoperative Near-infrared Imaging Can Identify Neoplasms and Aid in Real-time Margin Assessment During Pancreatic Resection. Ann Surg 2019;270:12-20.
15. Shirata C, Kawaguchi Y, Kobayashi K, et al. Usefulness of indocyanine green-fluorescence imaging for real-time visualization of pancreas neuroendocrine tumor and cystic neoplasm. J Surg Oncol 2018;118:1012-20.
16. Hutteman M, van der Vorst JR, Mieog JS, et al. Near-infrared fluorescence imaging in patients undergoing pancreaticoduodenectomy. Eur Surg Res 2011;47:90-7.
17. Kjærgaard K, Frisch K, Sørensen M, et al. Obeticholic

acid improves hepatic bile acid excretion in patients with primary biliary cholangitis. J Hepatol 2021;74:58-65.
18. de Graaf W, Häusler S, Heger M, et al. Transporters involved in the hepatic uptake of (99m)Tc-mebrofenin and indocyanine green. J Hepatol 2011;54:738-45.
19. Yamaue H, Tsunoda T, Tani M, et al. Randomized phase II/III clinical trial of elpamotide for patients with advanced pancreatic cancer: PEGASUS-PC Study. Cancer Sci 2015;106:883-90.
20. Friess H, Langrehr JM, Oettle H, et al. A randomized multi-center phase II trial of the angiogenesis inhibitor Cilengitide (EMD 121974) and gemcitabine compared with gemcitabine alone in advanced unresectable pancreatic cancer. BMC Cancer 2006;6:285.

Cite this article as: Xi S, Zhang W, Qian D, He C, Zuo X, Cai J, Li L, Cai H, Akhil C, Wang X. Study on the application value of fluorescent laparoscopy in pancreatic tumor surgery. Gland Surg 2023;12(10):1403-1413. doi: 10.21037/gs-23-331