INDOCYANINE GREEN: UTILITY FOR GENERAL SURGICAL ONCOLOGY AS EVALUATED BY SENIOR AND JUNIOR SURGEONS

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Objective

The objective of this study was two-fold: to assess whether intraoperative Indocyanine Green (ICG) fluorescence with a handheld system can be used to change the course of routine clinical practice, beyond preselected cases, and also to learn how a population of senior and junior surgeons of a large academic center feels about incorporating it.

Introduction

The two devices used were Stryker's SPY Fluorescence Portable Handheld Imager (PHI) and the Karl Storz (KS) NIR/ICG fluorescence imaging system. Both visualize with laser generated, near-infrared light using ICG as the imaging agent. Upon injection ICG binds to proteins within the blood and can be detected during arterial, capillary, and venous washout phases.

Methods

We used ICG intraoperatively on 12 (6 with PHI and 6 with KS to avoid favoring one device over another) routine surgical oncology procedures covering gastric, hepatobiliary, colorectal, and neuroendocrine cases. ICG imaging was performed at different stages of these cases to assess variables including perfusion, identifying lymph nodes, checking anastomoses, and screening for active bleeding after mass resection. The goal of using these devices in such a manner was to evaluate whether operators would find utility from incorporating ICG into daily use. Patients were followed for up to 30 days to monitor for early specific procedure-related complications such as ischemic necrosis and postoperative bleeding. No complications were noted during this time frame. A sample of 16 surgeons who participated in these procedures were asked to complete a 20-question survey that covered four broader categories: Utility, Ease of Use, Ease of Learning to Use, and Future Utility. Each item response was scored 1-7 on a Likert Scale, where 1 = Totally Disagree and 7 = Totally Agree. Analysis was done using the Real Statistics Resource Pack.

PROCEDURE	AGE	GENDER	COMPLICATIONS (30 Day)
Gastrointestinal anastomosis	65	FEMALE	NONE
Partial pancreatectomy and anastomosis	78	MALE	NONE
Distal pancreatectomy	61	MALE	NONE
Parastomal hernia	54	MALE	NONE
Liver hemangioma	52	MALE	NONE
HCC resection	61	MALE	NONE
Peritoneal carcinomatosis	56	MALE	NONE
Intestinal fistula, small bowel resection and reanastomosis	53	MALE	NONE
Neuroendocrine tumor resection	67	MALE	NONE
Pancreatoduodenectomy	71	MALE	NONE
GIST partial gastrectomy	77	MALE	NONE
Subtotal gastrectomy with reanastomosis	66	MALE	NONE

Table 1. List of routinely planned procedures in which ICG was incorporated

	USEFUL						EASE OF USE					
	It is useful in my work	It gives me a sense of more control	It is an advantage over eyesight alone to assess ischemia	It influenced my decision-making	It made my work easier	**Useful Mean**	Simple to use	User Friendly	Doesn't require mental effort	Easy to interpret results	Associated with high possibility for errors	**Ease of Use Mean**
R	4.7	4.7	5.7	5.0	3.7	**4.7**	6.0	4.7	6.0	5.3	5.0	**5.4**
A	5.8	5.7	6.0	5.2	4.8	**5.5**	6.4	6.4	5.5	5.0	3.6	**5.4**
A vs R	1.1	1.0	0.3	0.2	1.2	**0.8**	0.4	1.7	-0.5	-0.3	-1.4	**0.0**
Mann-Whitney Test for Two Independent Samples							**Mann-Whitney Test for Two Independent Samples**					
Attending vs Resident							Attending vs Resident					
		one tail	two tail					one tail	two tail			
p-norm		0.08756011	0.17512023				p-norm	0.22235806	0.44471613			
p-exact		0.08846405	0.1769281				p-exact	0.22430387	0.44860774			

	EASE OF LEARNING TO USE						FUTURE USEFULNESS					
	I learned to use it quickly	I understood the 3 visual modalities	Doesn't require prior knowledge to use	Stage of operation influenced timing of ICG injection	It did not interfere with the operation	**Ease of Learning to Use Mean**	I feel confident in the accuracy of results	I would recommend it to my colleagues	I will want to have it in my future work	It will be easy to adjust to using it in practice	I am satisfied with it	**Future Usefulness Mean**
R	6.3	5.3	3.3	4.3	4.0	**4.7**	4.3	4.7	5.7	5.0	4.7	**4.9**
A	6.2	6.2	4.8	6.2	5.4	**5.8**	5.5	5.8	6.2	6.3	5.9	**5.9**
A vs R	-0.1	0.9	1.4	1.8	1.4	**1.1****	1.1	1.1	0.6	1.3	1.3	**1.1****
Mann-Whitney Test for Two Independent Samples							**Mann-Whitney Test for Two Independent Samples**					
Attending vs Resident							Attending vs Resident					
		one tail	two tail					one tail	two tail			
p-norm		0.006499	0.012998				p-norm	0.00024292	0.00048583			
p-exact		0.00608391	0.01216783				p-exact	0.00014573	0.00029147			

Table 2. ICG questionnaire breakdown by category, color scale denoting magnitude by which Attending (A) responses differed from Residents (R). ** denotes statistically significant difference between categories

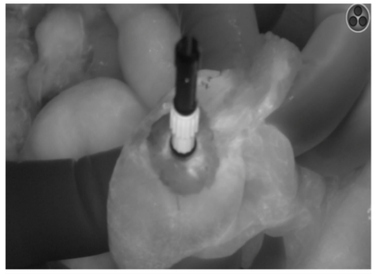


Figure 1. Contrast fluorescence to assess perfusion and leaks.

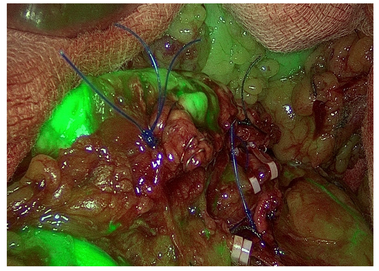


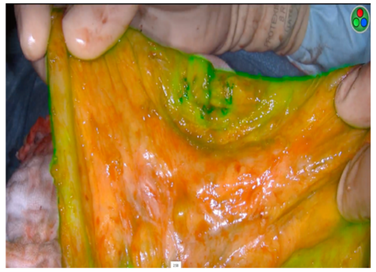
Figure 2. Overlay fluorescence during final stages of distal pancreatectomy.



Figure 3. Overlay fluorescence in HCC resection to screen for slow bleeds.



Figure 4. small bowel resection to screen for adequate perfusion and slow leaks



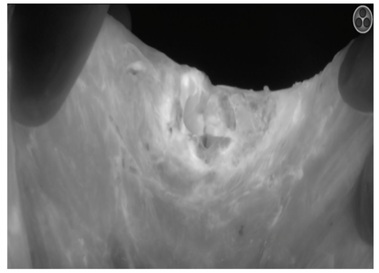


Figure 5. ICG overlay fluorescence and contrast of neuroendocrine tumor to identify resectable area.

Results

Senior surgeons regarded the Ease of Learning and Future Utility categories significantly higher than resident respondents (5.8 vs 4.7, Mann-Whitney $p<0.01$; 5.9 vs 4.9, Mann-Whitney $p<0.001$), and generally found ICG more useful (5.8 vs 4.7), that it provided more control (5.7 vs 4.7), simplified their work (4.8 vs 3.7), was less prone to error (3.6 vs 5.0, question posed as "associated with high error possibility"), were more likely to recommend continued intraoperative ICG use (5.8 vs 4.7), and believed ICG would be easy to incorporate into their practice (5.9 vs 4.7). Senior surgeons noted that timing of the ICG injection relative to stage of the procedure was critical as the field diffusion effect of ICG could lead to false positive results, e.g., good perfusion where in fact it was poor.

Conclusions

ICG fluorescence offers a promising, unobtrusive tool that can be integrated into routine surgical oncology practice rather than just select procedures.

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