형광발현을 이용한 복강경 대장암 수술

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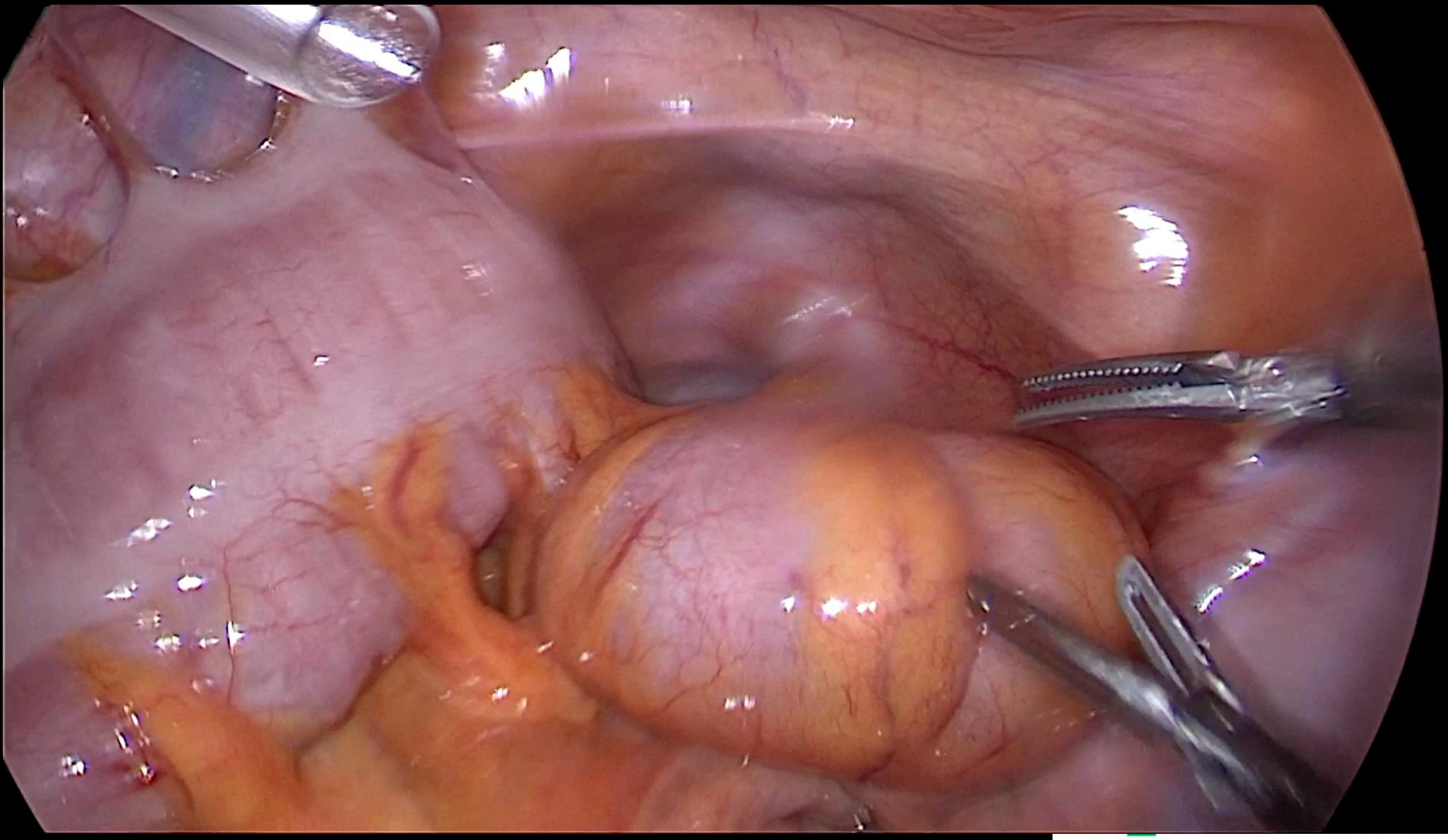
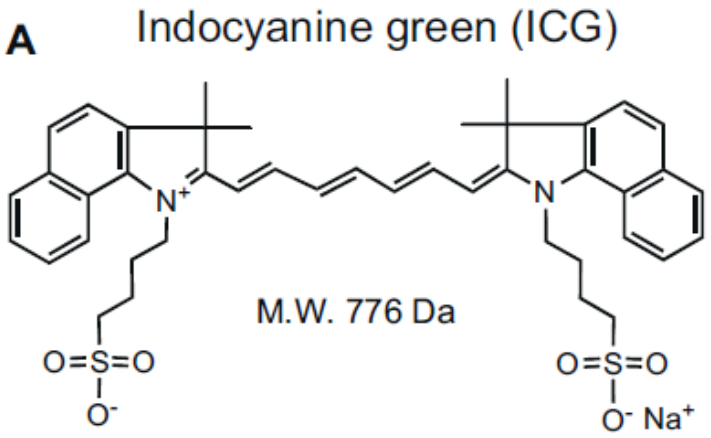
초기 대장암 환자의 병변확인



Near infrared (NIR) imaging and ICG



Properties in serum
Excitation peak: 807 nm
Extinction coefficient ($M^{-1}cm^{-1}$): 121,000
Emission peak: 822 nm

- Indocyanine green (ICG) → fluorescence dye
- **FDA approval 1959** (!)
- Indications:
  - measurement of cardiac output,
  - hepatic function,
  - ophthalmic angiography
  - organ perfusion
- Vials: 25 mg powder
- Doses: 0.1-0.5 mg/kg
- ICG half-life: 3-5 min
- Removed in liver, no metabolic change
- **Cost ~ 50€ / vial**

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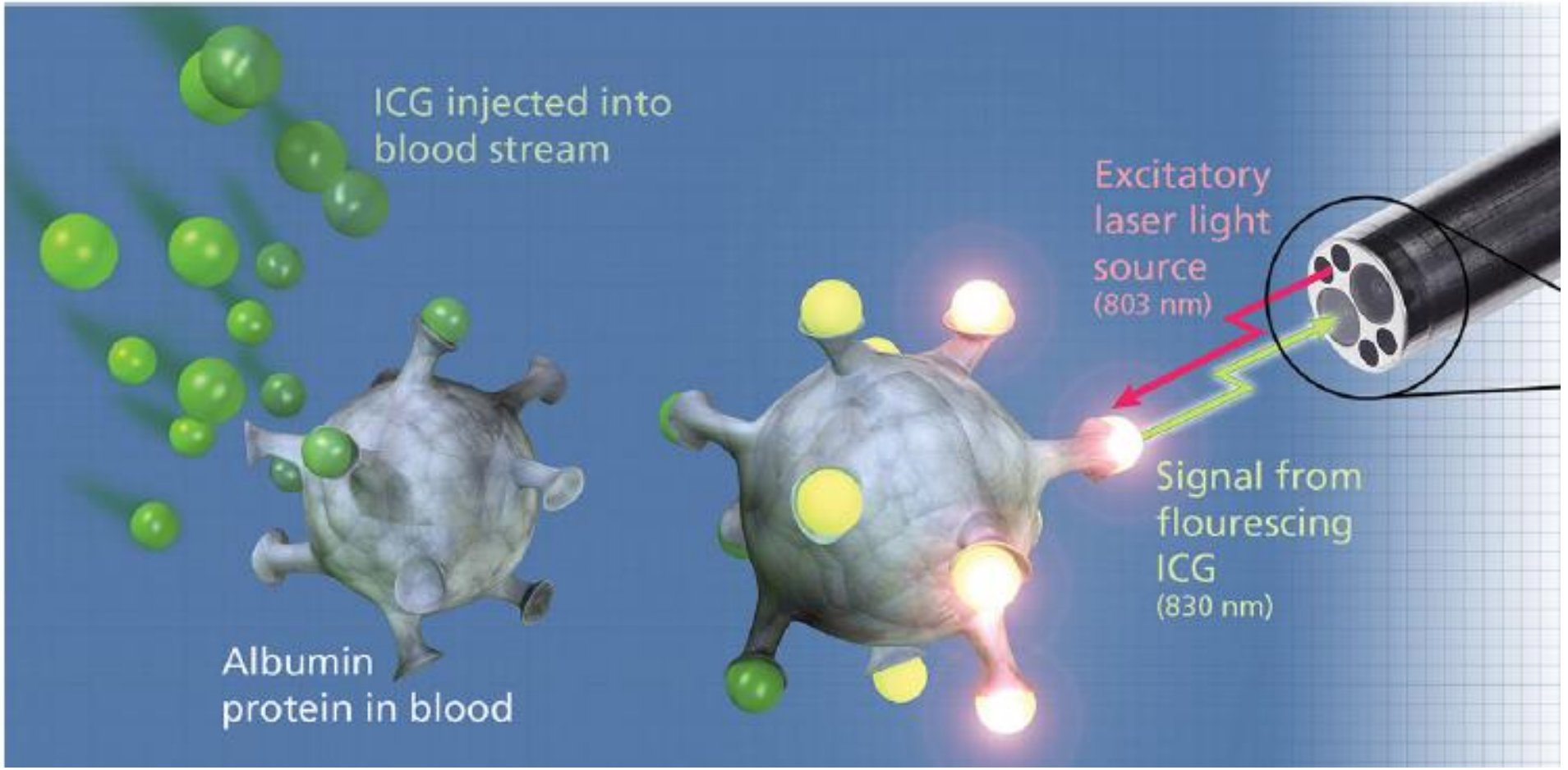
ICG 형광 발현 탐지의 원리



Surg Endosc (2014) 28:1695–1702

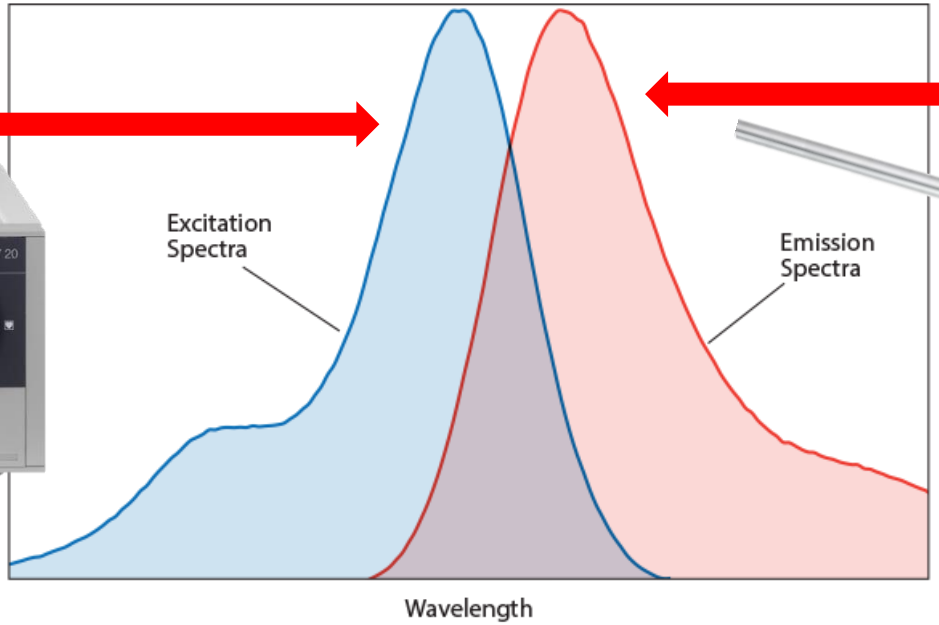
ICG 형광 복강경 시스템

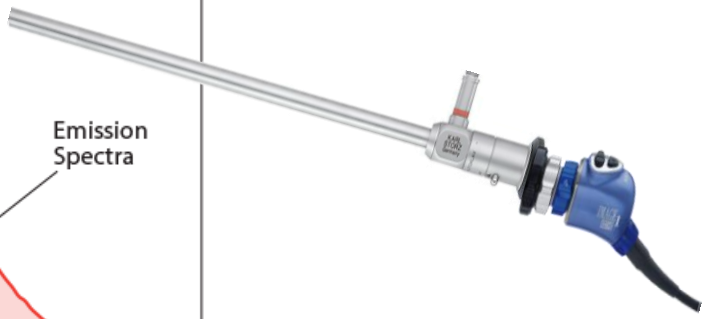
ABSORBANCE
(excitation)

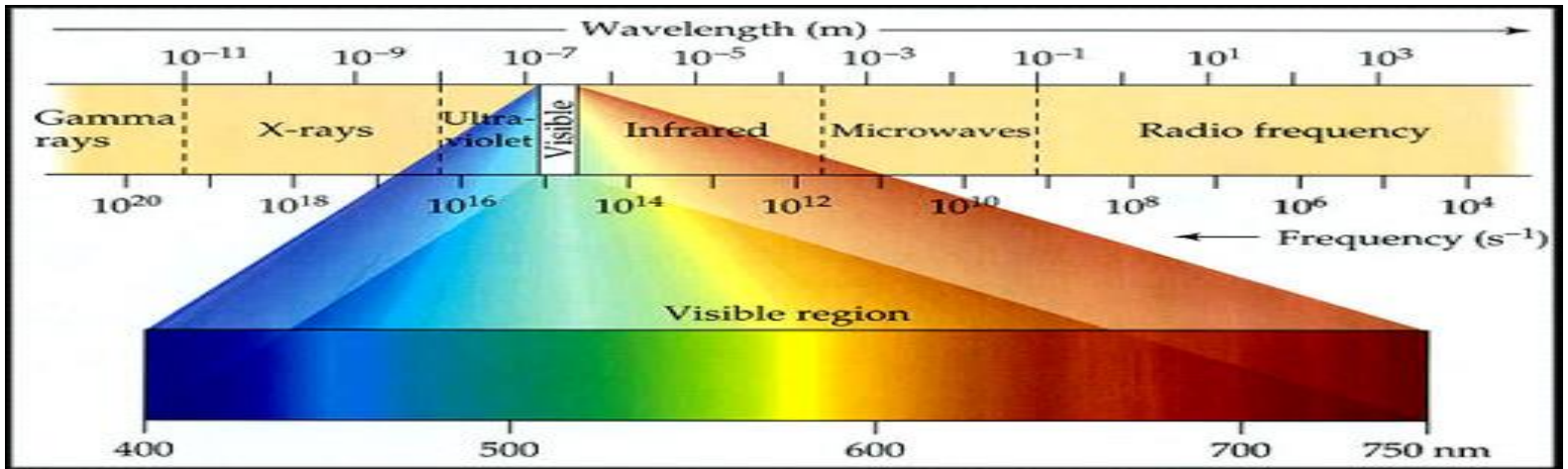
$\lambda_{Excitation}$ 805 nm

$\lambda_{Emission}$ 835 nm

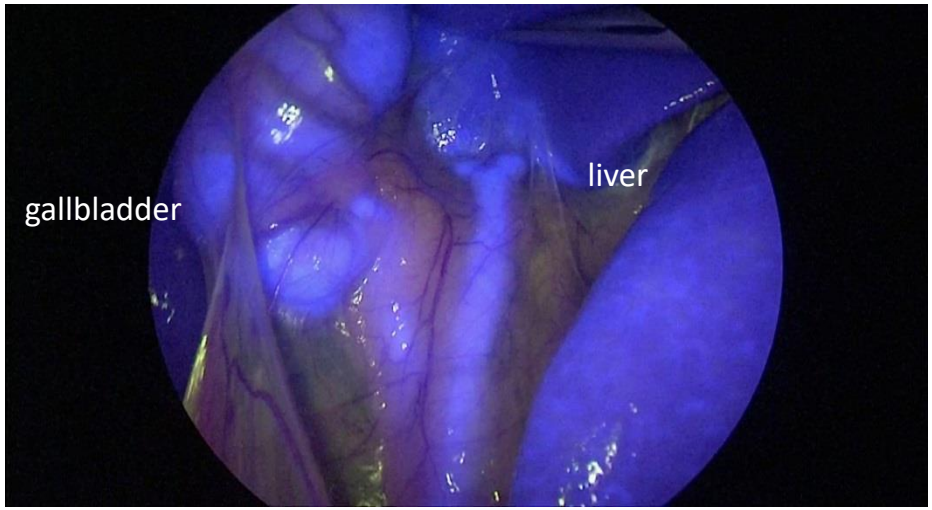
EMISSION
(fluorescence)

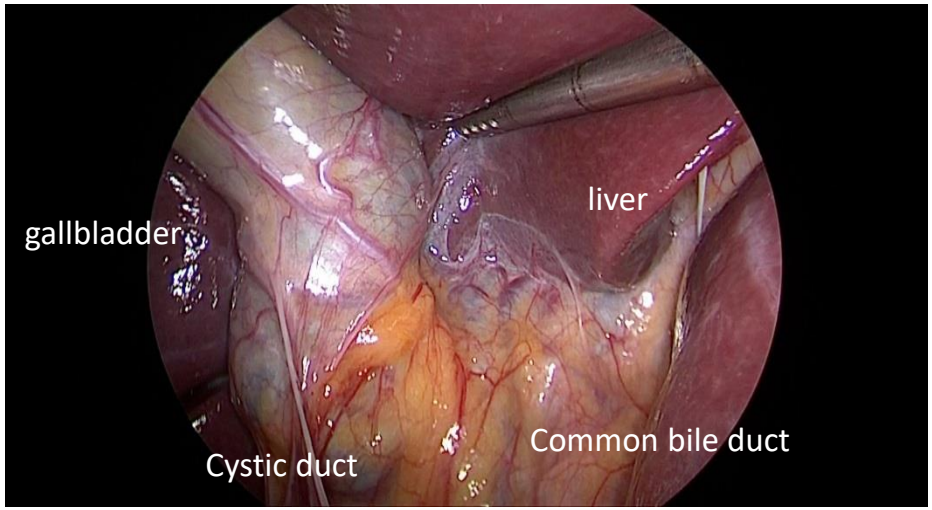


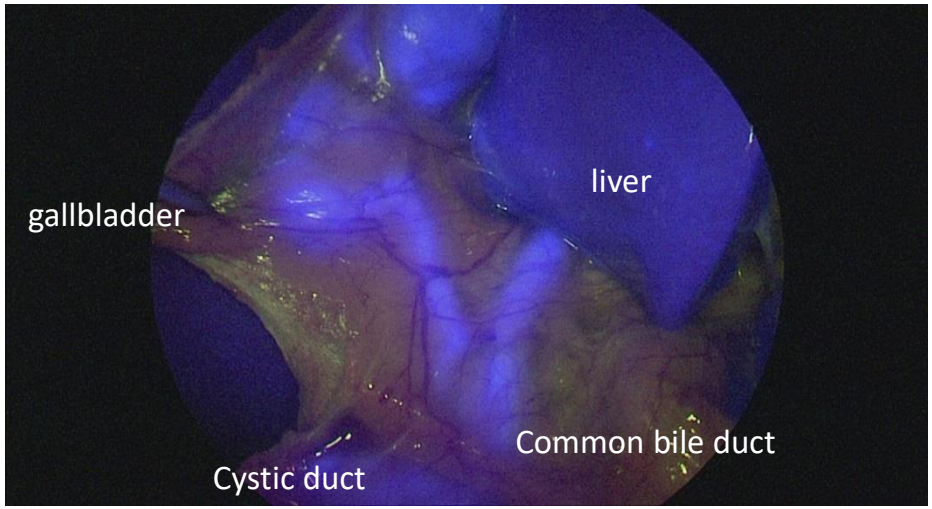




Fluorescence identification of the biliary tree







Fluorescence of the biliary tree during a laparoscopic cholecystectomy.

By courtesy of Prof. Luigi Boni, University of Insubria, Varese, Italy

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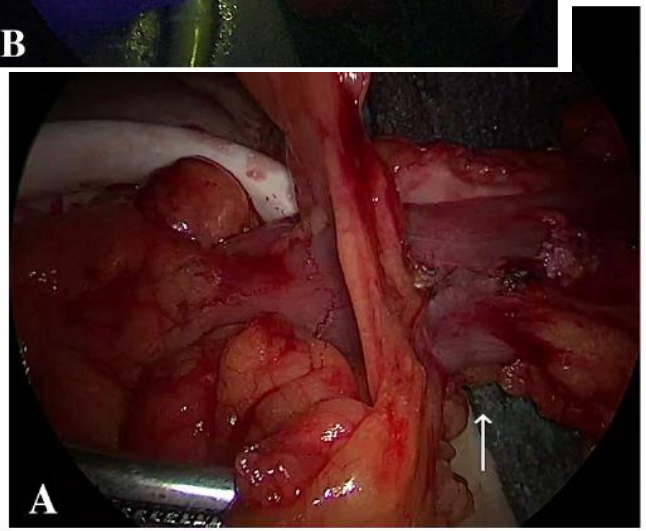
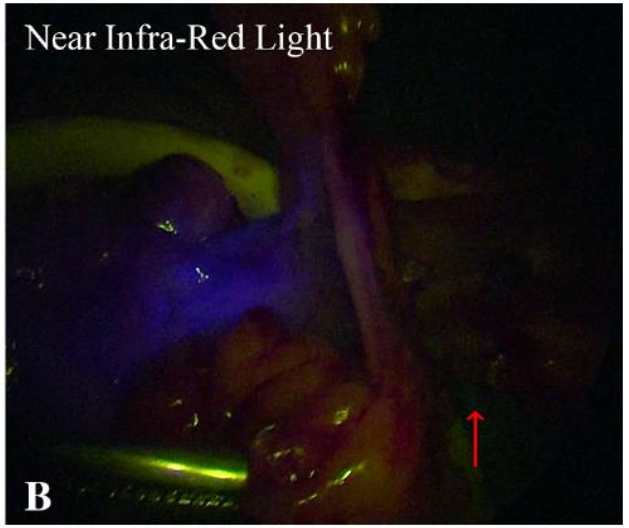
Indocyanine green-enhanced fluorescence to assess bowel perfusion during laparoscopic colorectal resection

Luigi Boni[1] · Giulia David[1] · Gianlorenzo Dionigi[1] · Stefano Rausei[1] · Elisa Cassinotti[1] · Abe Fingerhut[2,3]

Blood perfusion assessment of colon section in a colorectal cancer patient





Surg Endosc (2016) 30:2736–2742

ICG lymphangiography

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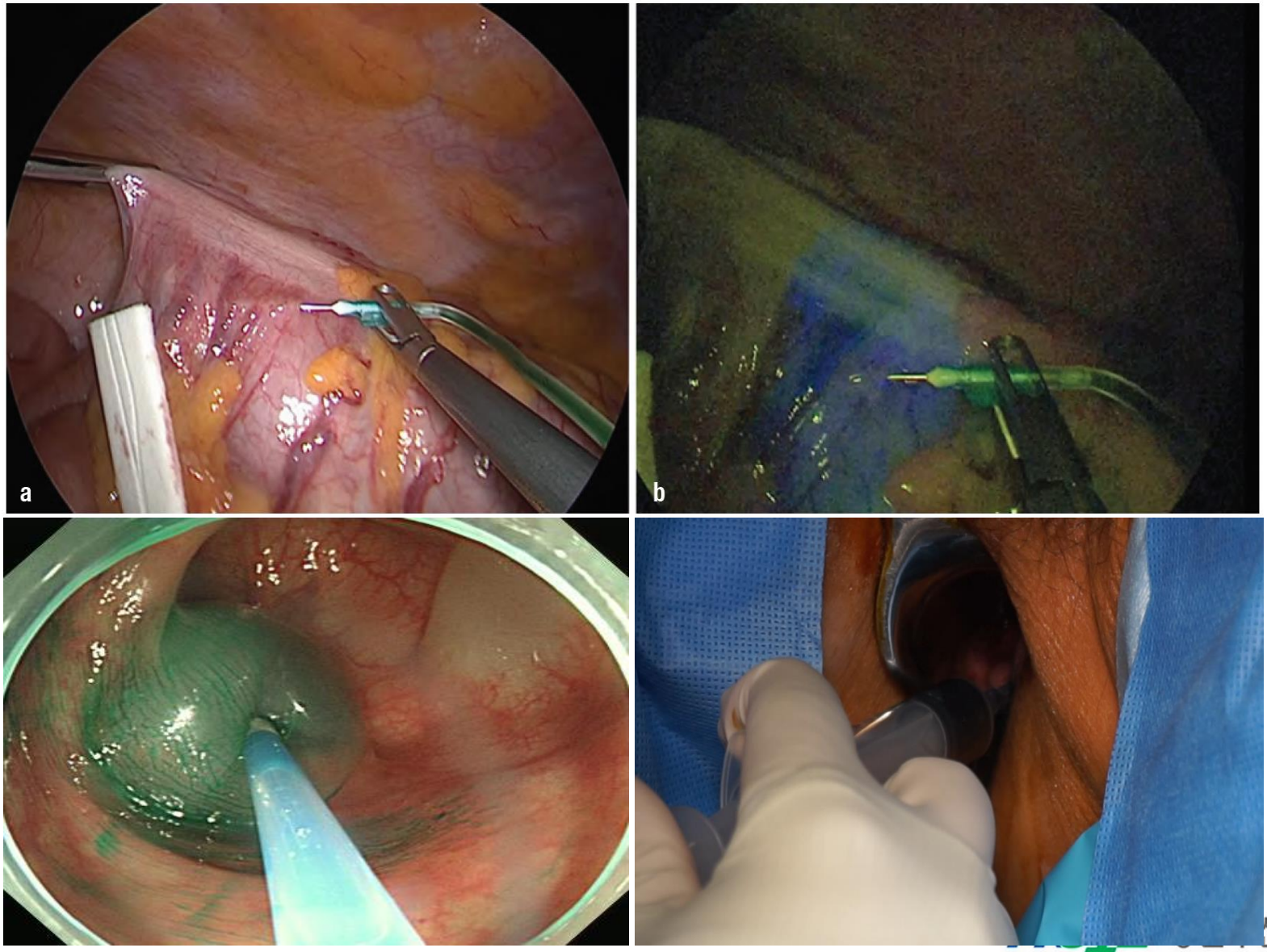
ICG Injection methods of lymph node mapping for colorectal cancer



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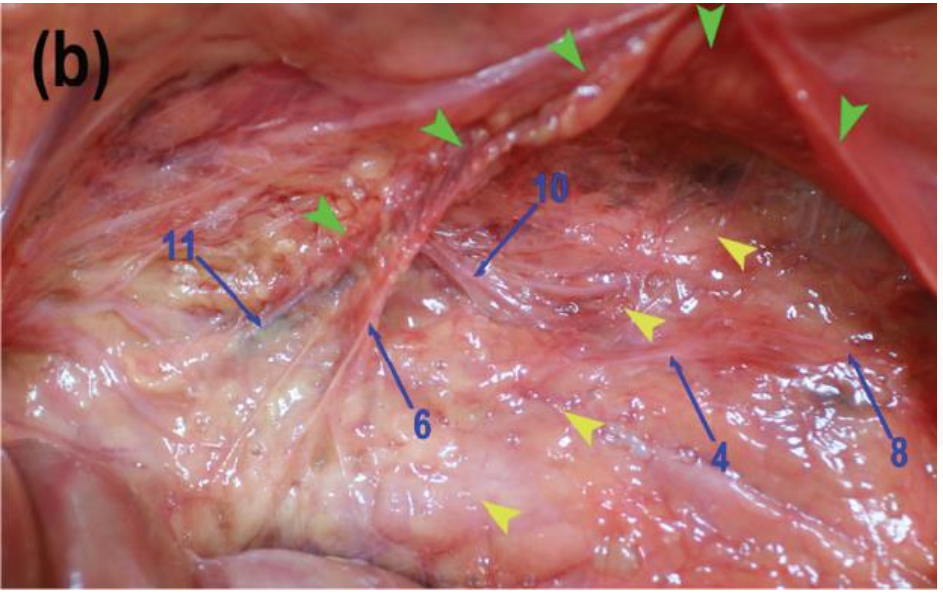
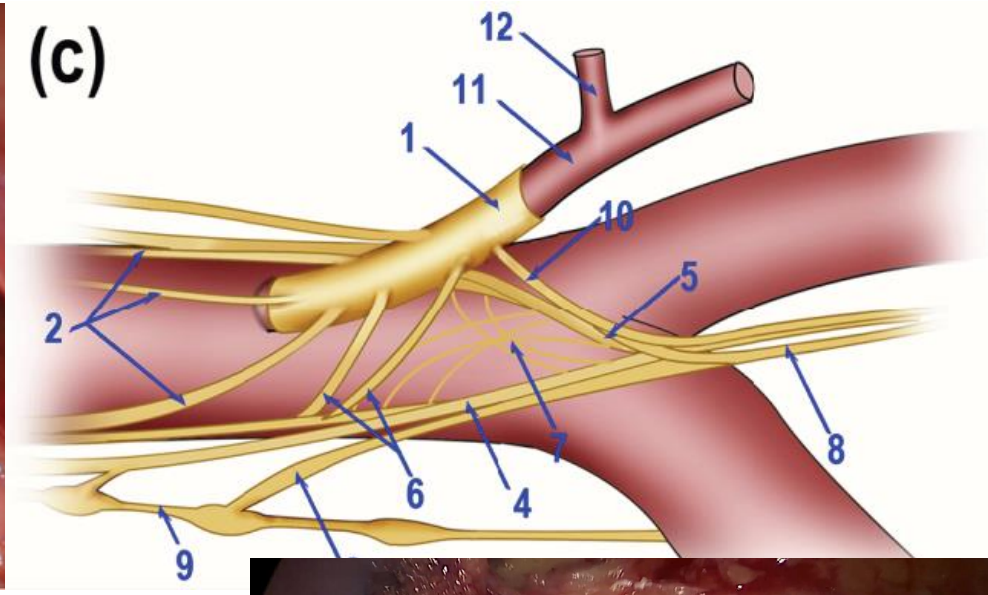
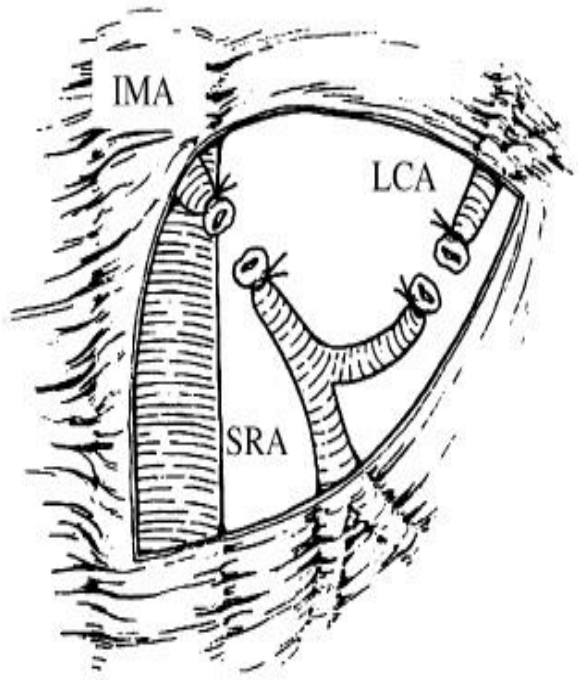
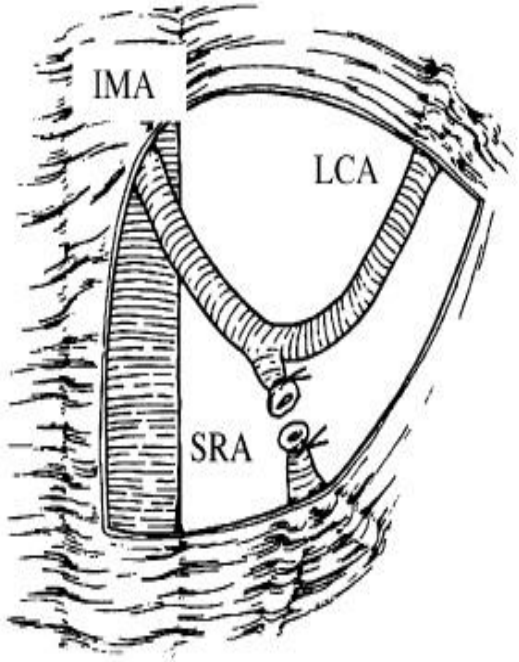
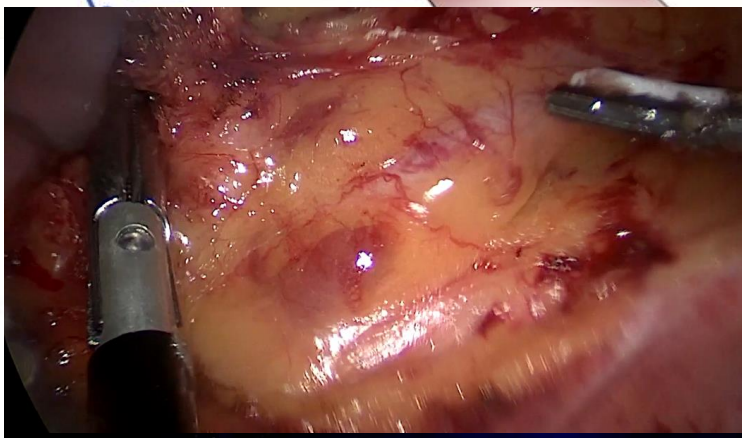
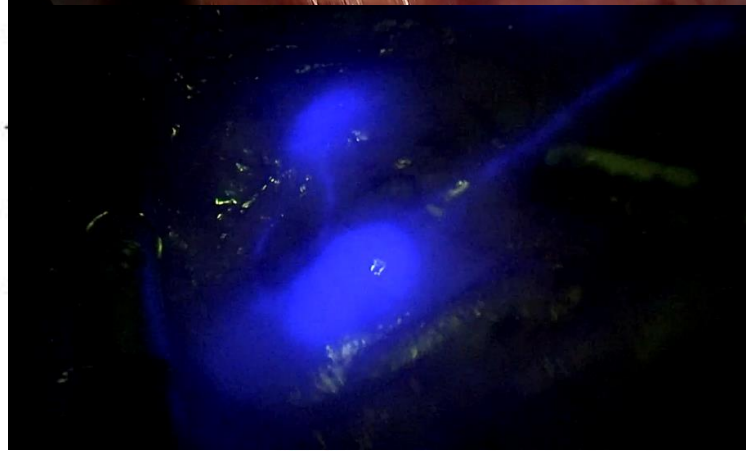

(b)
11
10
6
4
8


(c)
12
11
1
10
5
2
8
7
6
4
9


IMA
LCA
SRA


IMA
LCA
SRA





ICG lymphangiography

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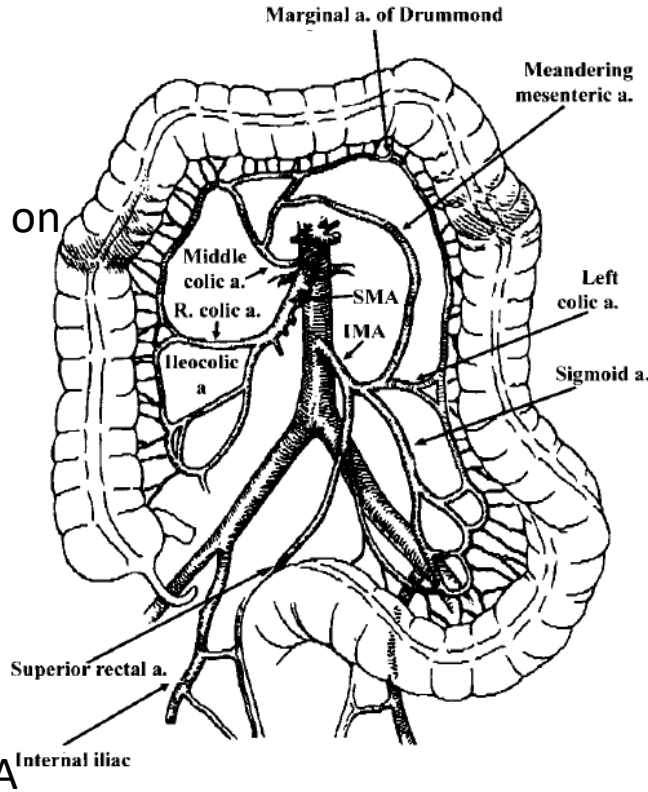
Introduction

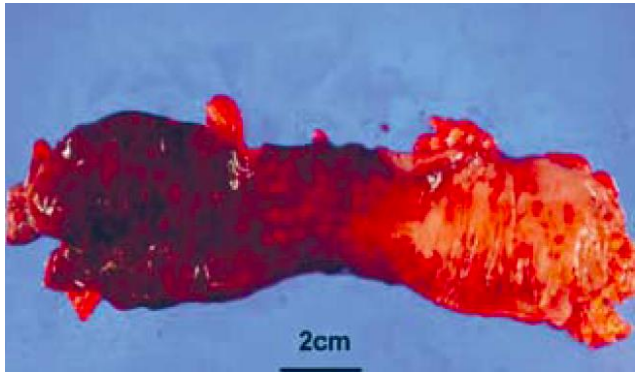
Vascular supply of left colon

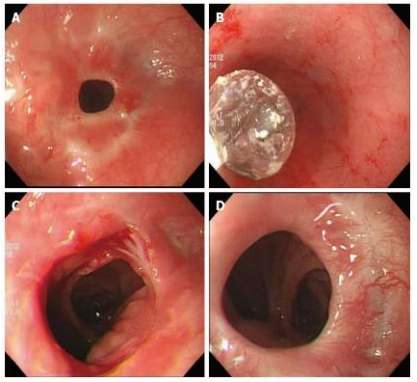
- After high ligation of IMA, adequate vascular supply depend on
  - Patency of MCA
  - Marginal Drumond artery
  - Riolan arcade

- Anatomic variation
  - Absence of middle colic artery, Arc of Riolan
  - Inadequate vascularization from SMA
  - Up to 25 %

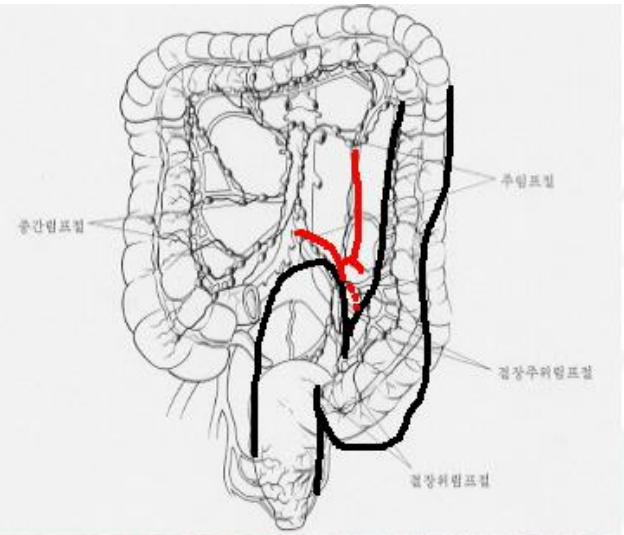


- **Hypoperfusion** of proximal colon after high ligation of IMA
- **Colon ischemia** ; **colon necrosis, anastomotic leakage, stricture**





Acute ischemic colitis and Colon necrosis after laparoscopic low anterior resection for obstructive rectal cancer patient



9 days

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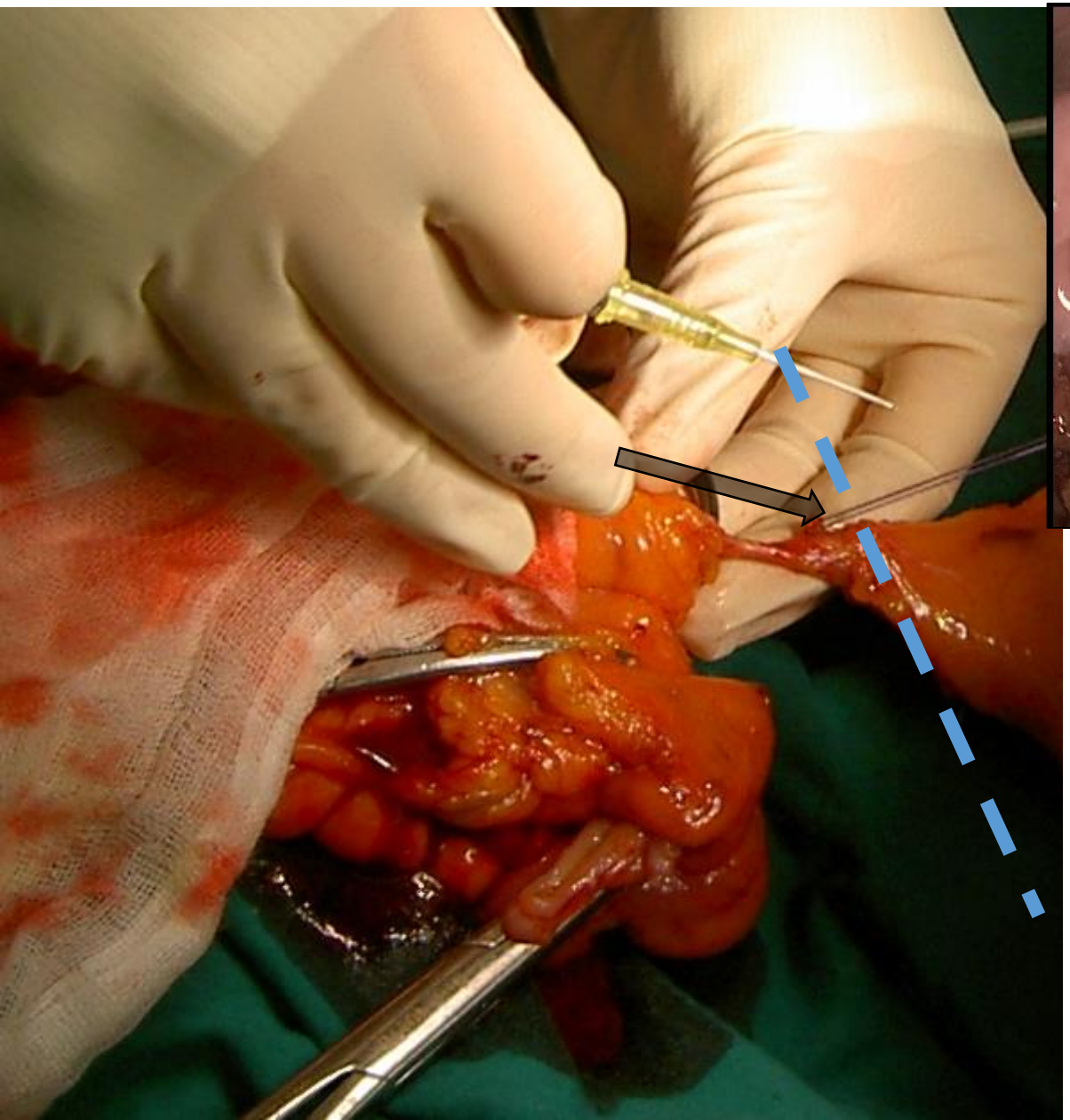
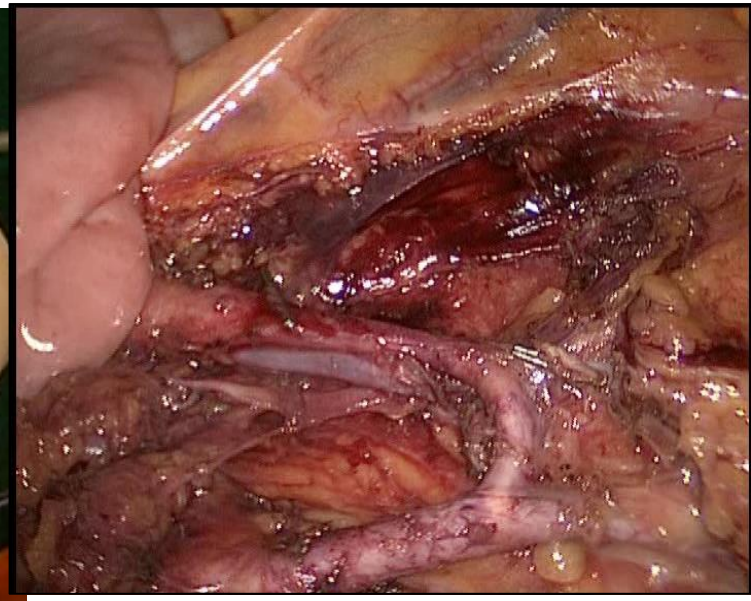
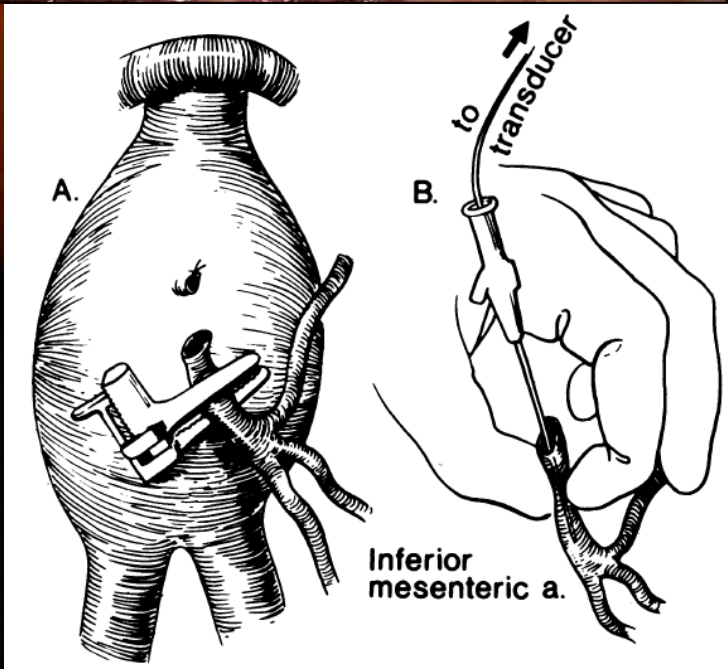
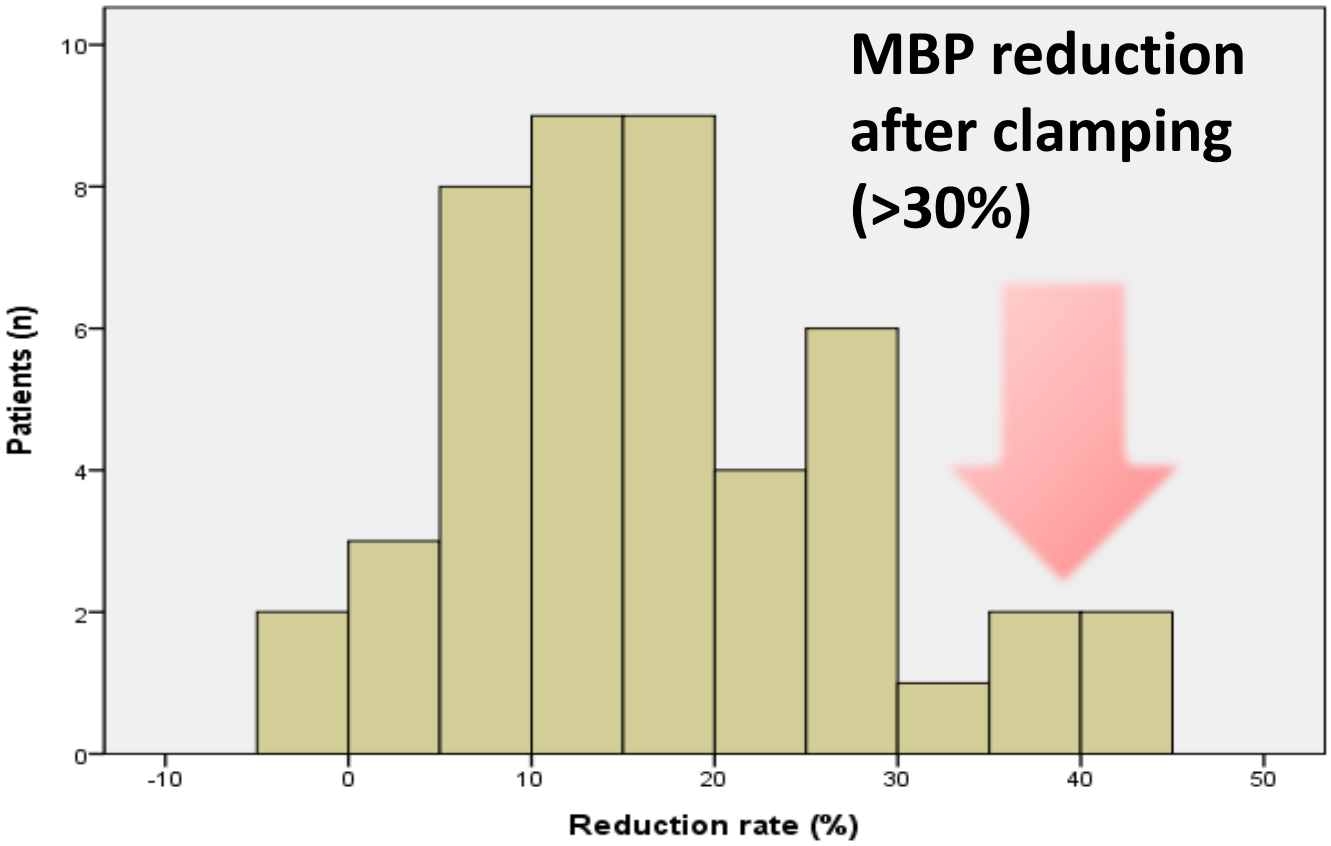
Marginal artery BP of sigmoid colon







Distribution of reduction rates of marginal artery pressure after IMA clamping

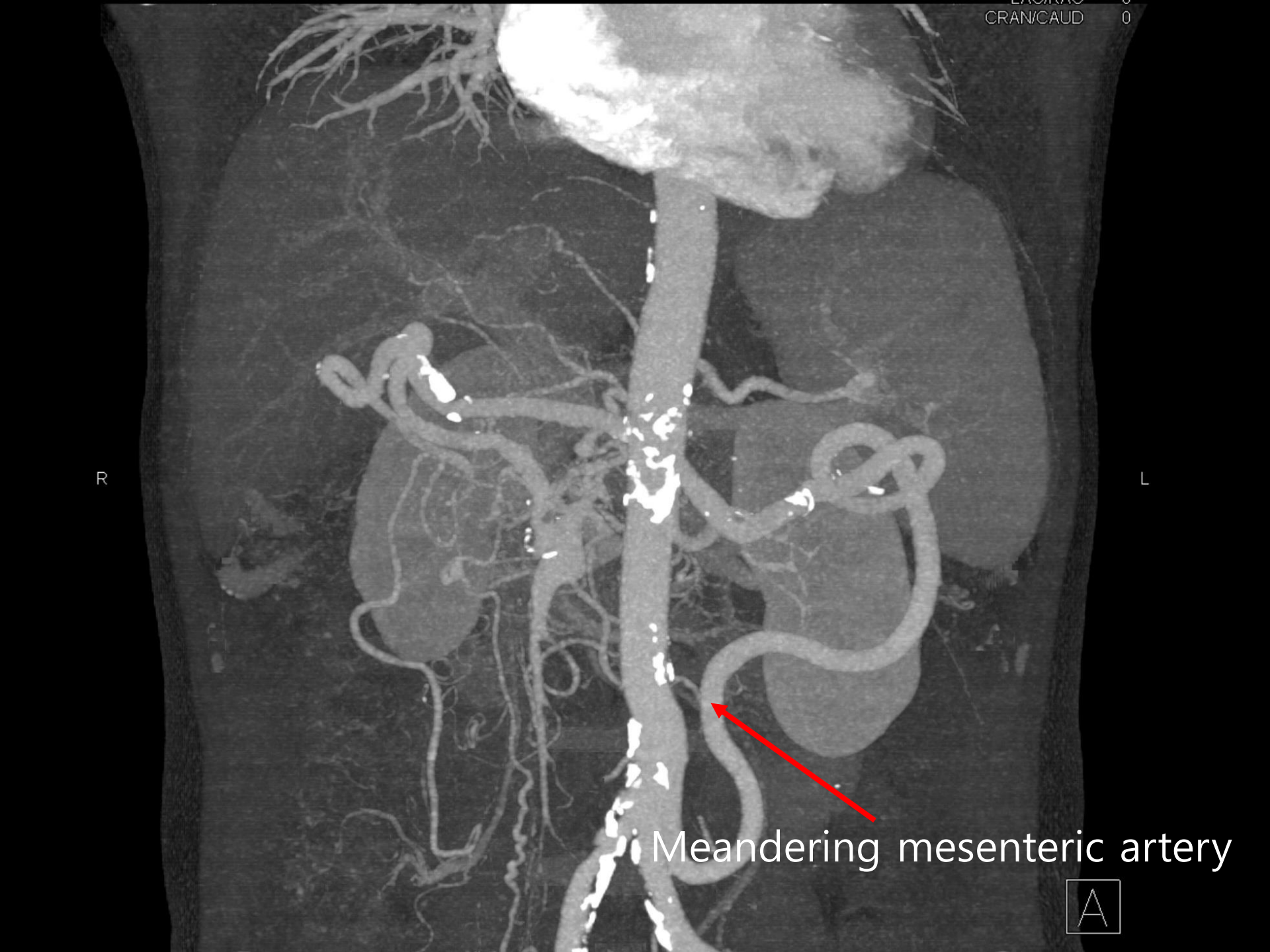


Grouping (Total = 46)

Moderate reduction group (Reduction rate: < 30%, n = 41)

Severe reduction group (Reduction rate: ≥ 30%, n = 5)

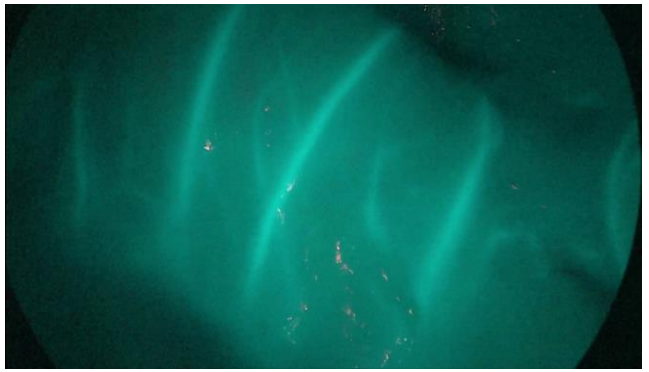
A
B


CRAN/CAUD 0
R
L
Meandering mesenteric artery
A

ICG angiography and Perfusion study

Laparoscopic colorectal cancer surgery

- Period, 2015 ~ 2017
- Intravenous ICG injection (0.2 ~ 0.25 mg/kg)
- Comparison of planned transection line and perfusion line
- Anastomotic complications (leakage, stenosis...)
- Quantitative analysis of perfusion



Poor perfusion and colon necrosis case

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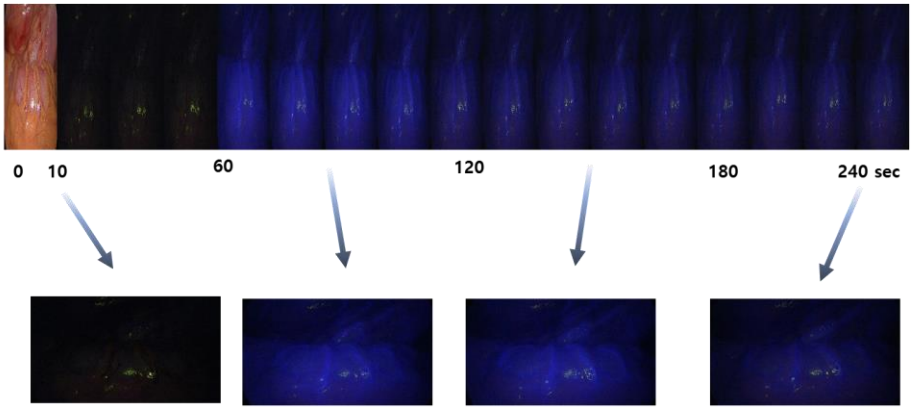
Quantitative analysis of perfusion

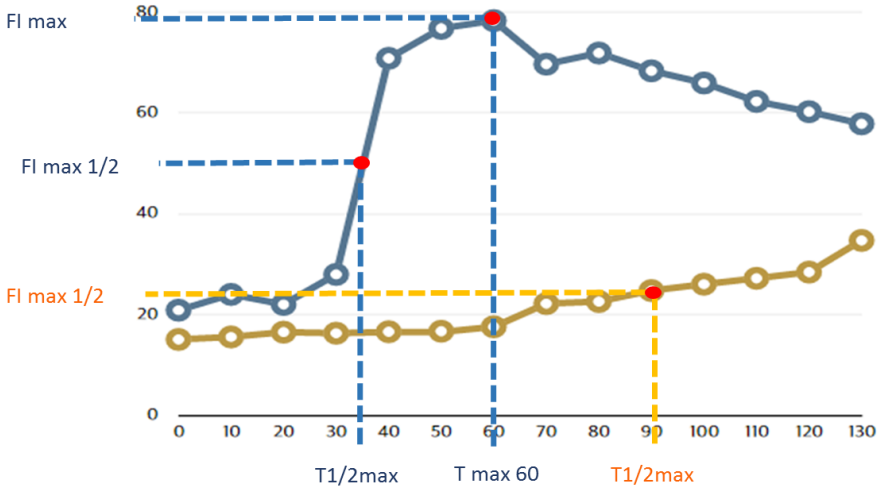
ICG enhancing video frames

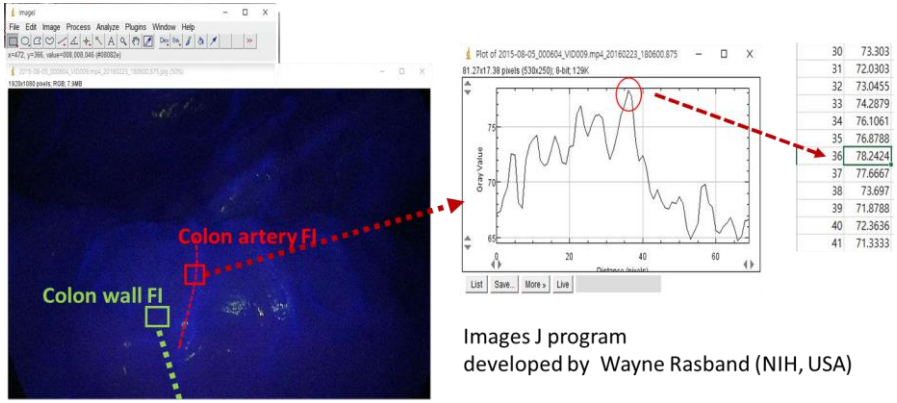


Freeze-Frames (interval = 10 seconds)

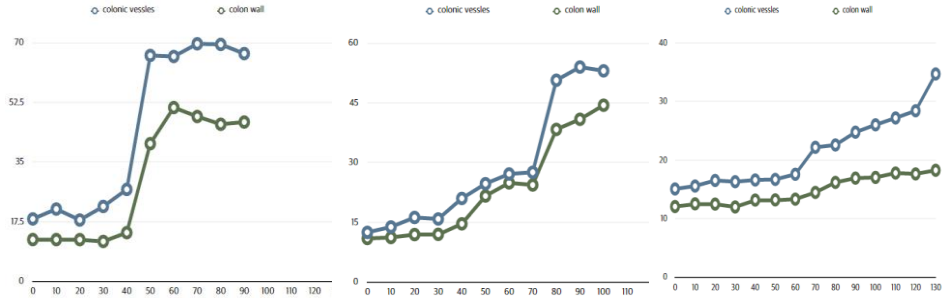
Fluorescence intensity

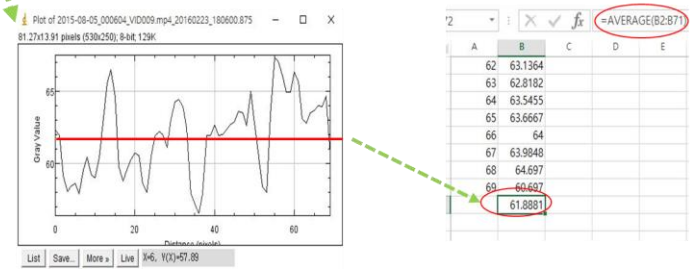
(A) Good perfusion (B) Poor perfusion



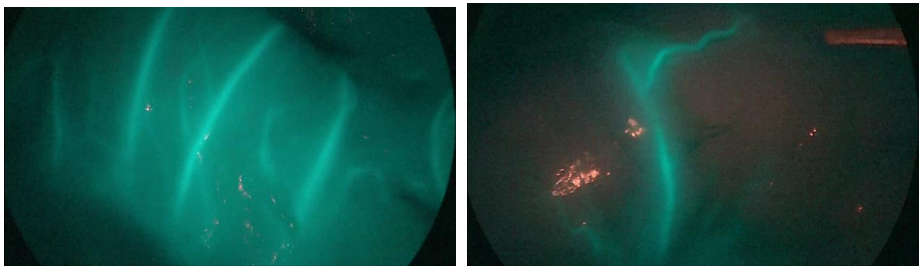


Images J program
developed by Wayne Rasband (NIH, USA)

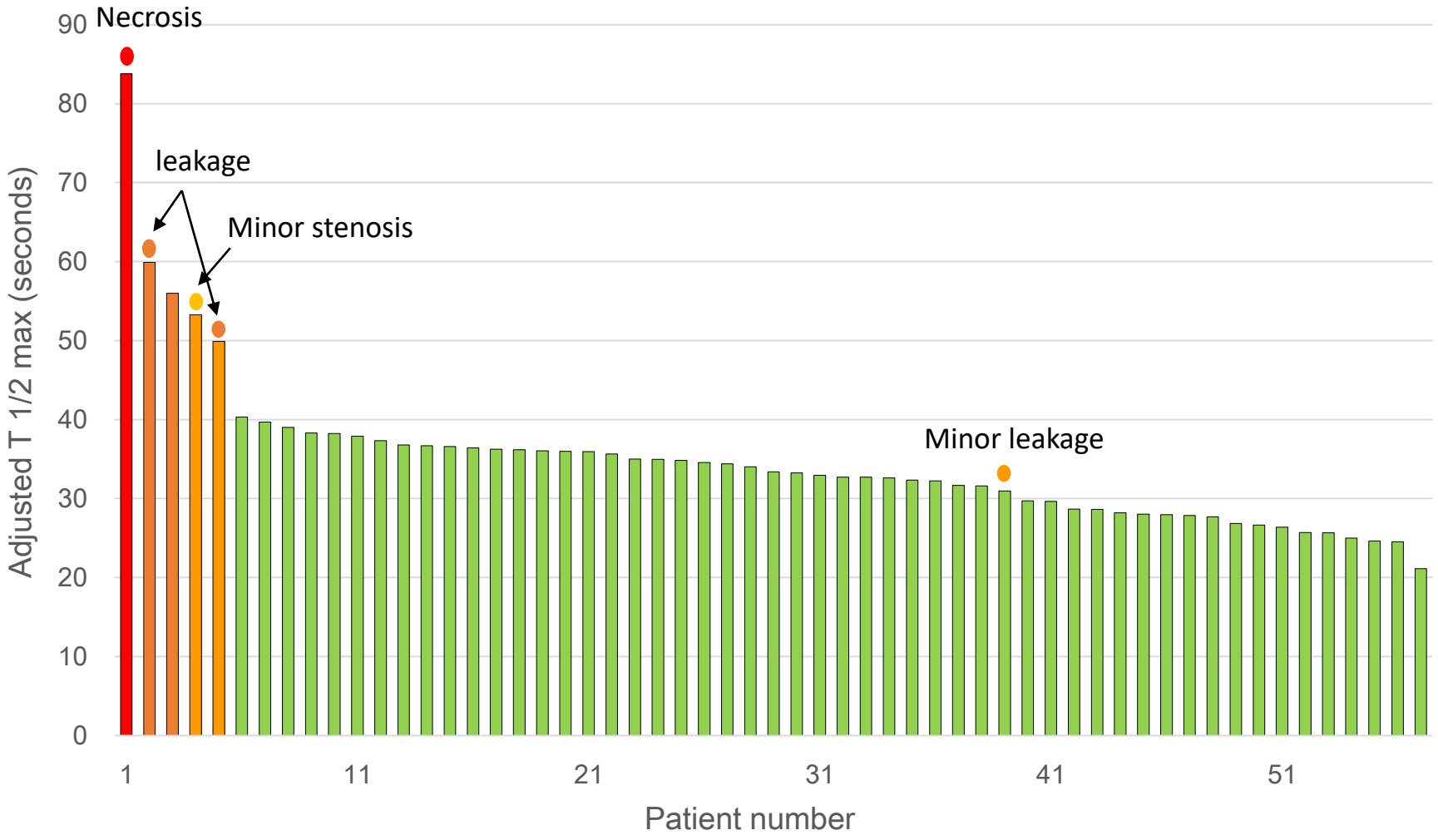




* ICG enhancing pattern ; fast ($T_{1/2max}$≤45) *vs.* moderate ($T_{1/2max}$;46-60) to slow ($T_{1/2max}$>60)



Distribution of adjusted T1/2 max values



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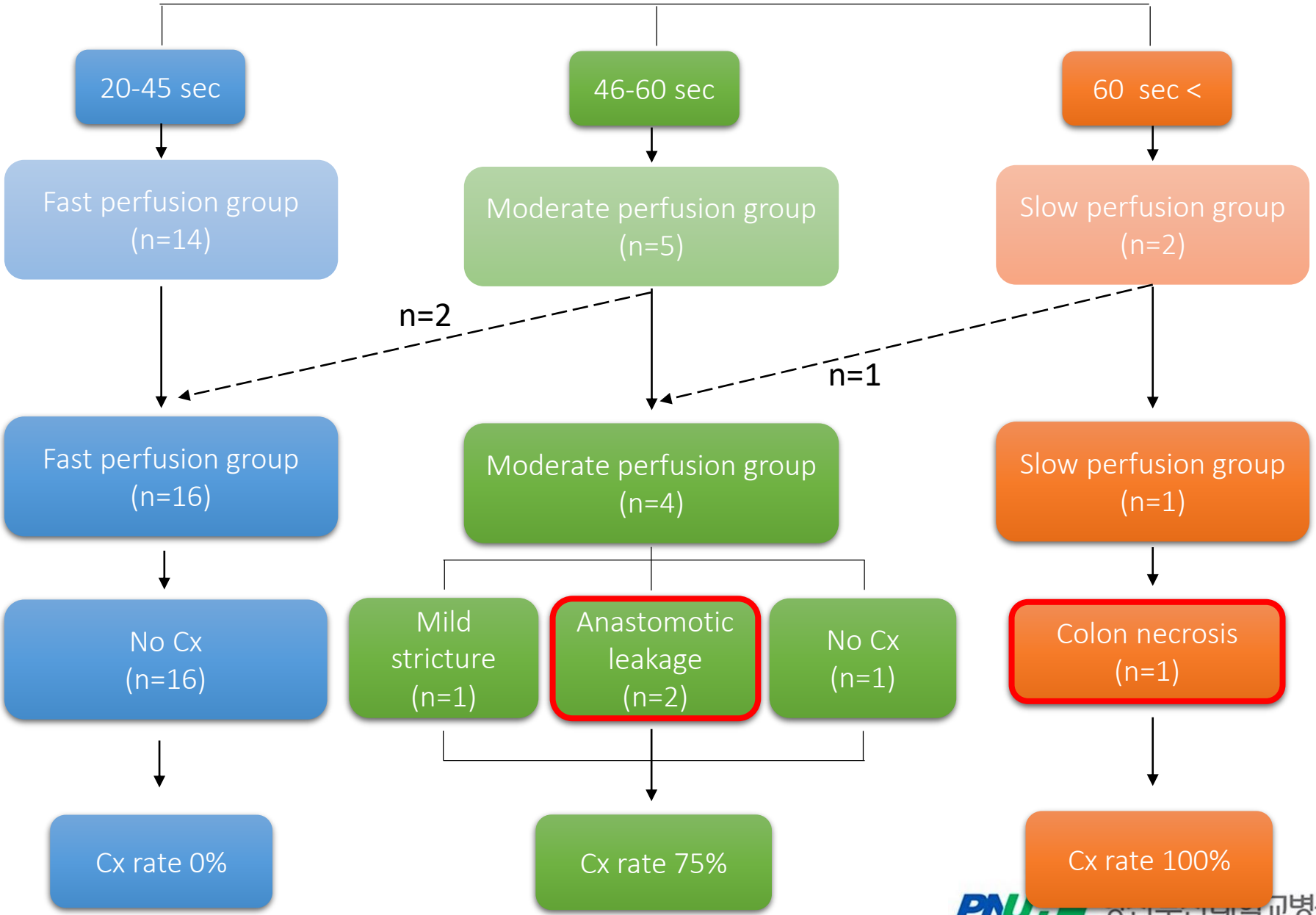
Adjusted $T_{1/2max}$ of ICG angiography (2015)



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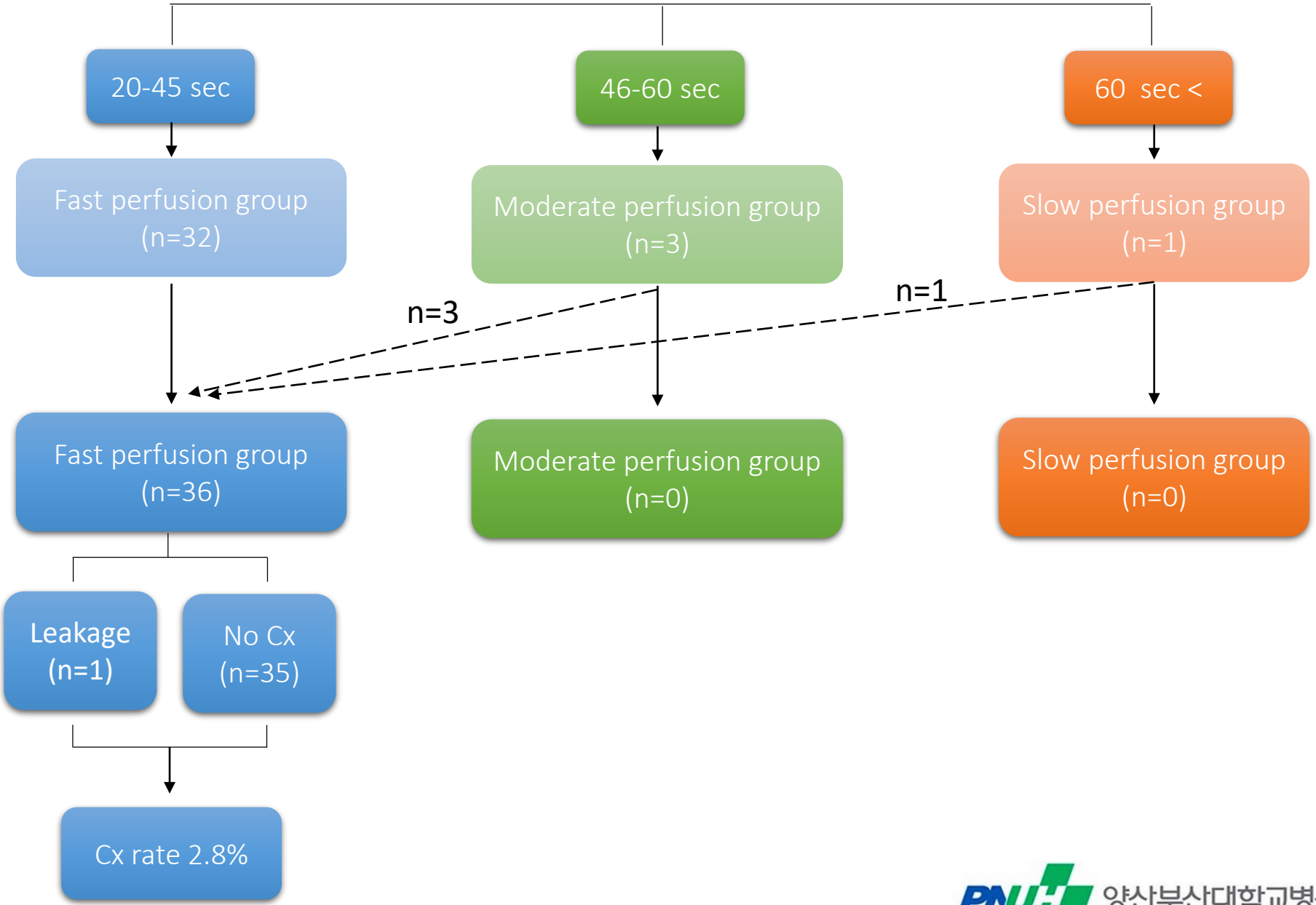
Adjusted $T_{1/2max}$ of ICG angiography (2016)



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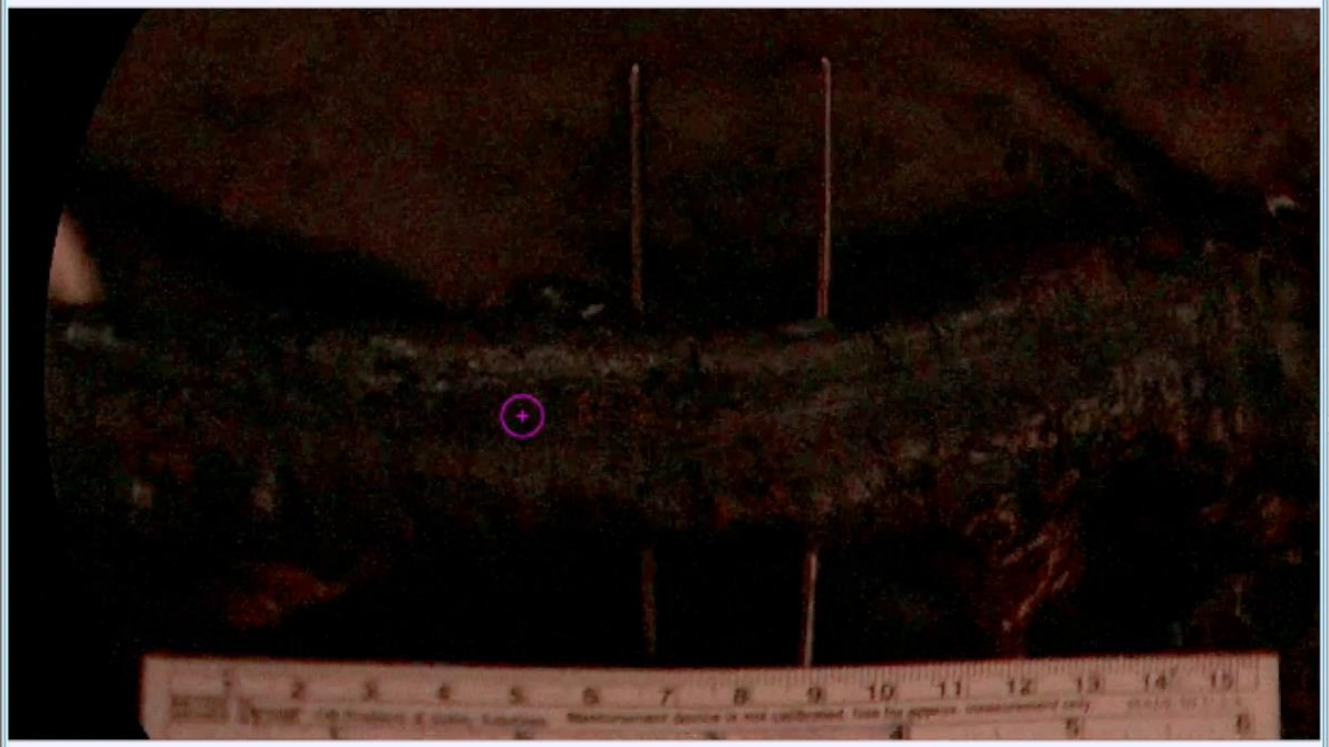
트랙 컨트롤

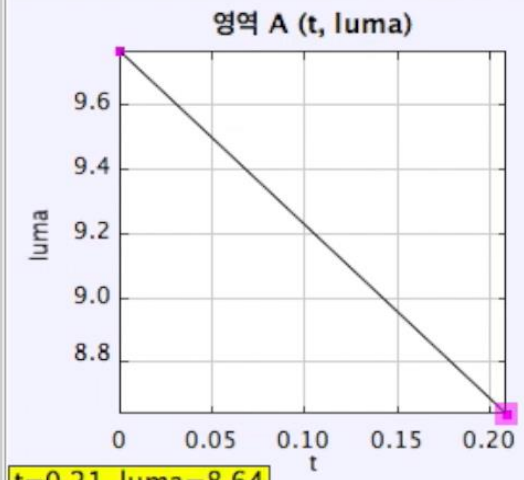
영역 A



x=-2.088E2 y=-6.026E1

0.21 100% 5

그래프 영역 A



t=0.21 luma=8.64

데이터 영역 A

t	x	y	luma
0.000	-208.8	-60.26	9.8
0.209	-208.8	-60.26	8.6

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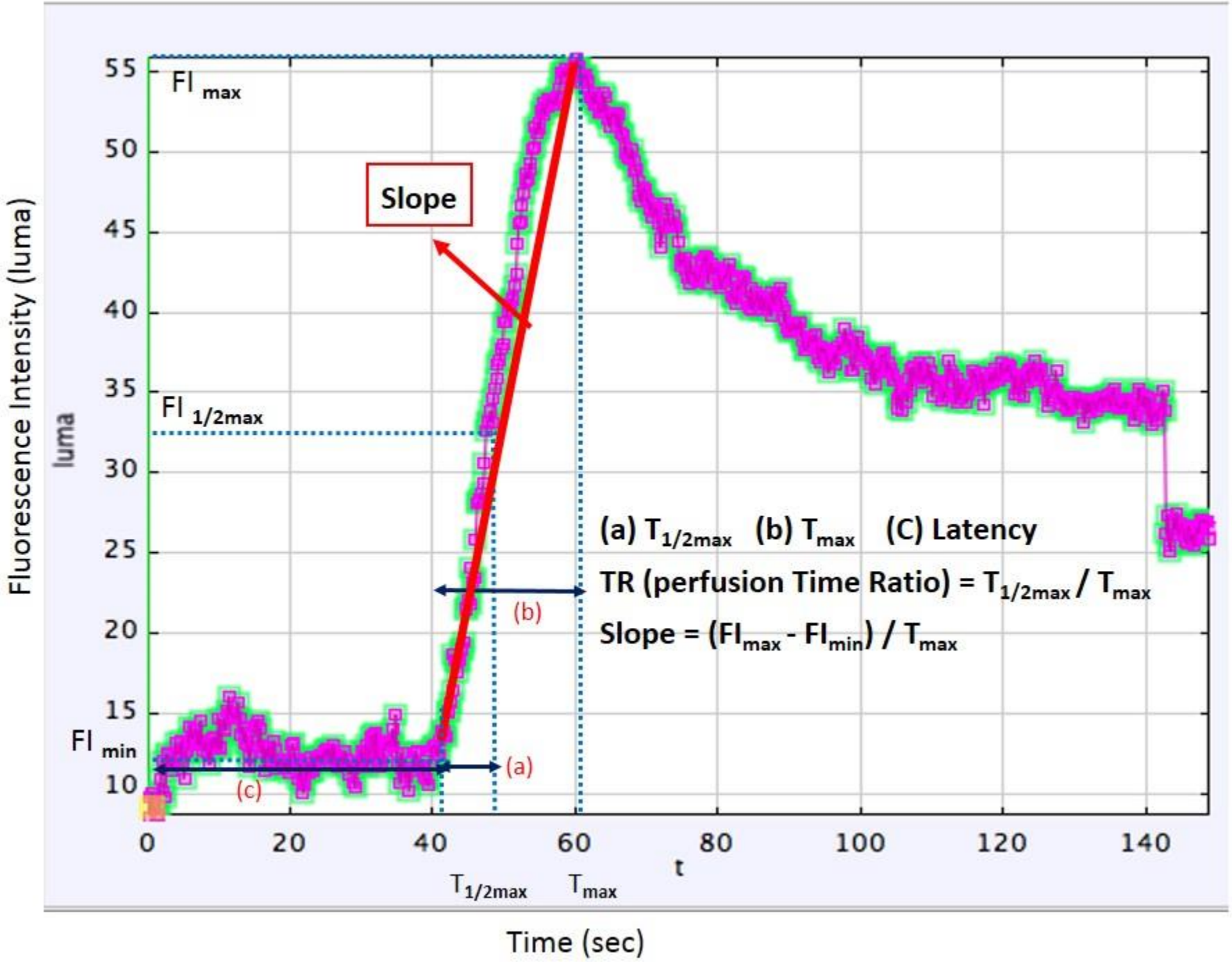
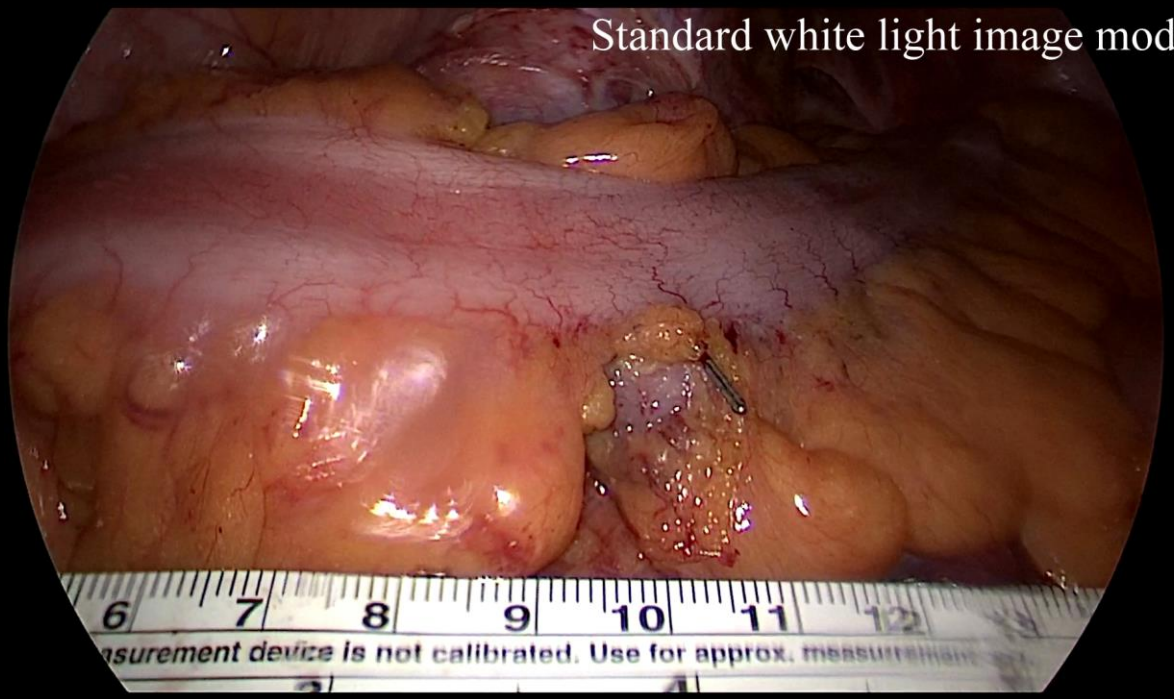
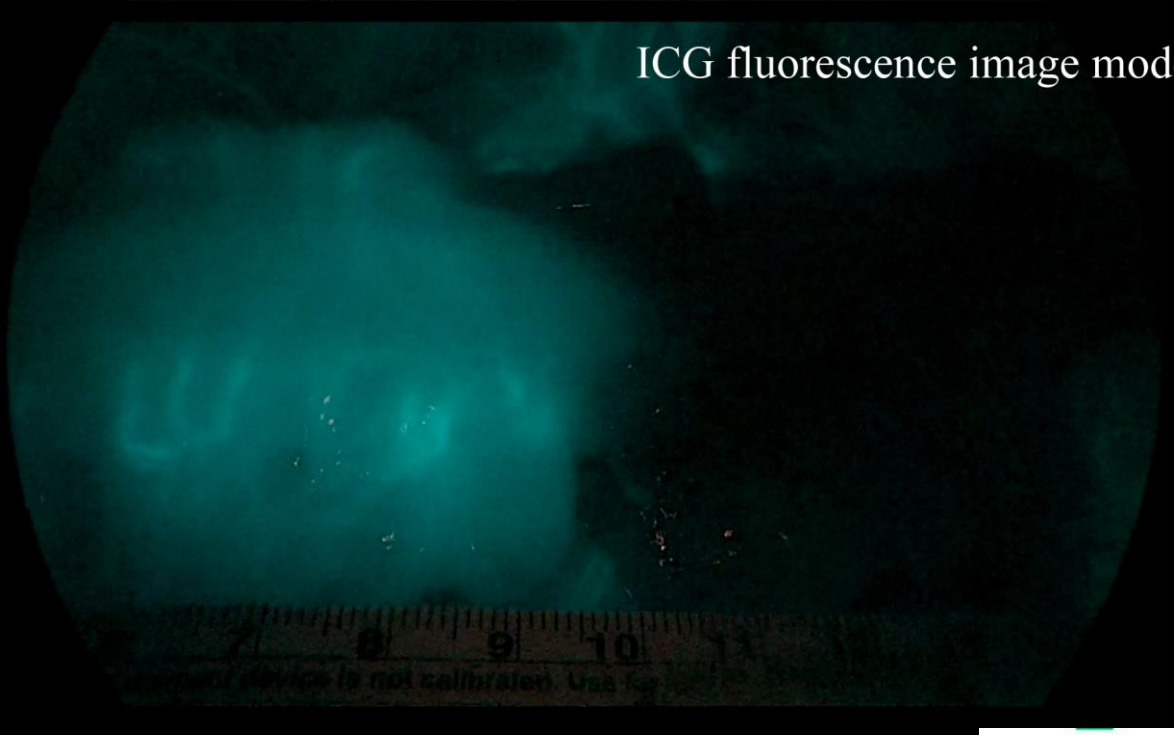

Fluorescence Intensity (luma)
luma
55
50
45
40
35
30
25
20
15
10
FI max
FI 1/2max
FI min
Slope
(a) T1/2max (b) Tmax (C) Latency
TR (perfusion Time Ratio) = T1/2max / Tmax
Slope = (FImax - FImin) / Tmax
(a)
(b)
(c)
0
20
40
60
80
100
120
140
t
T1/2max
Tmax
Time (sec)

Standard white light image mode



ICG fluorescence image mode



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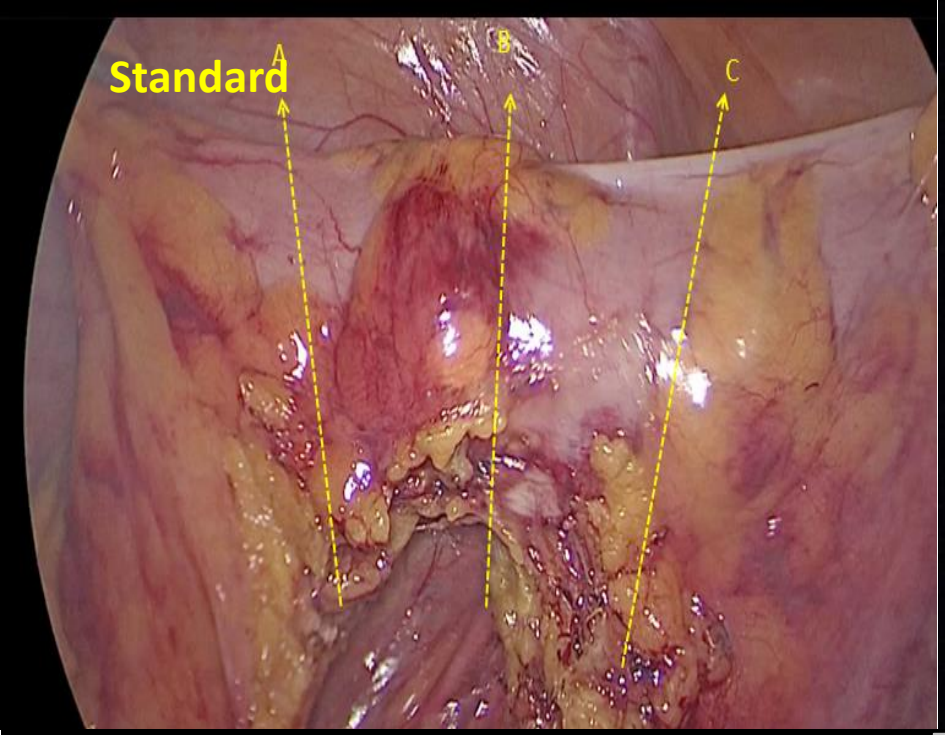
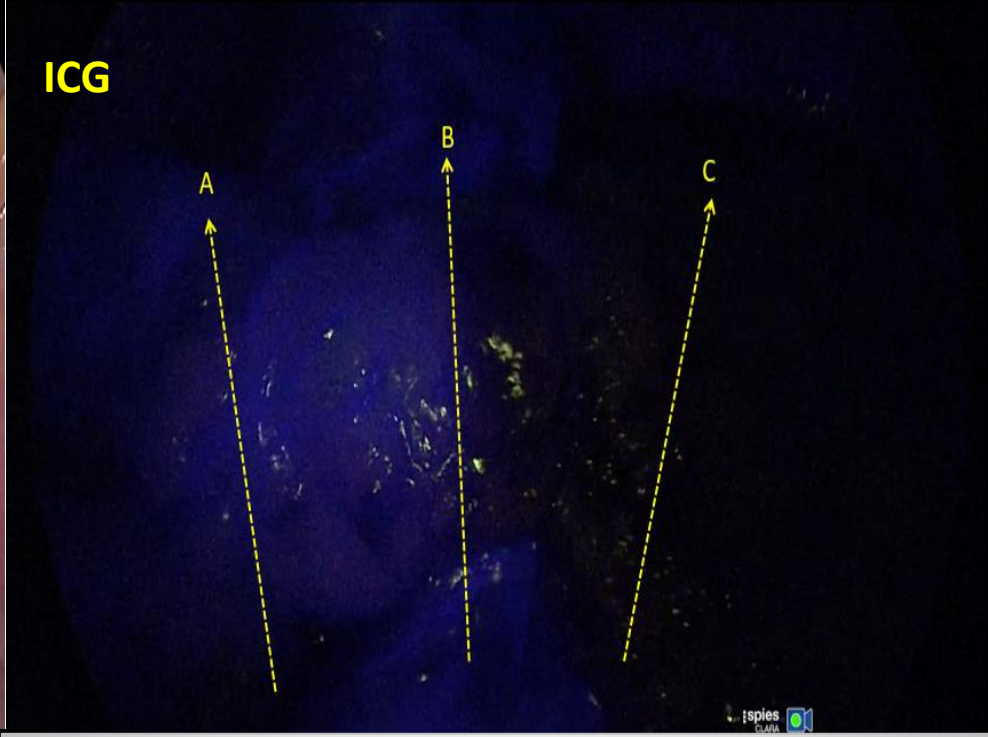
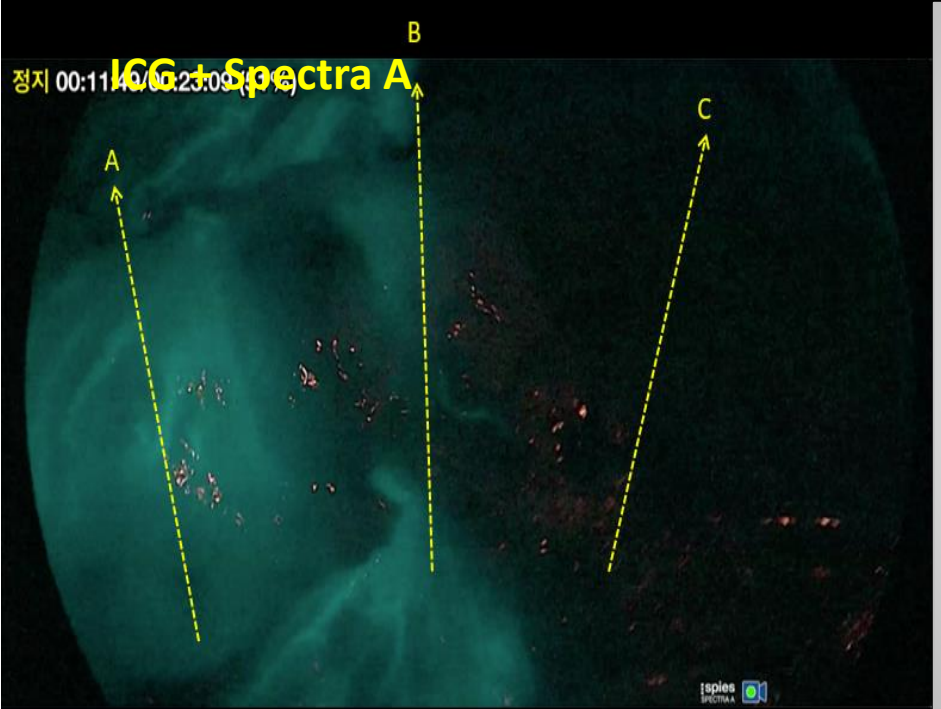
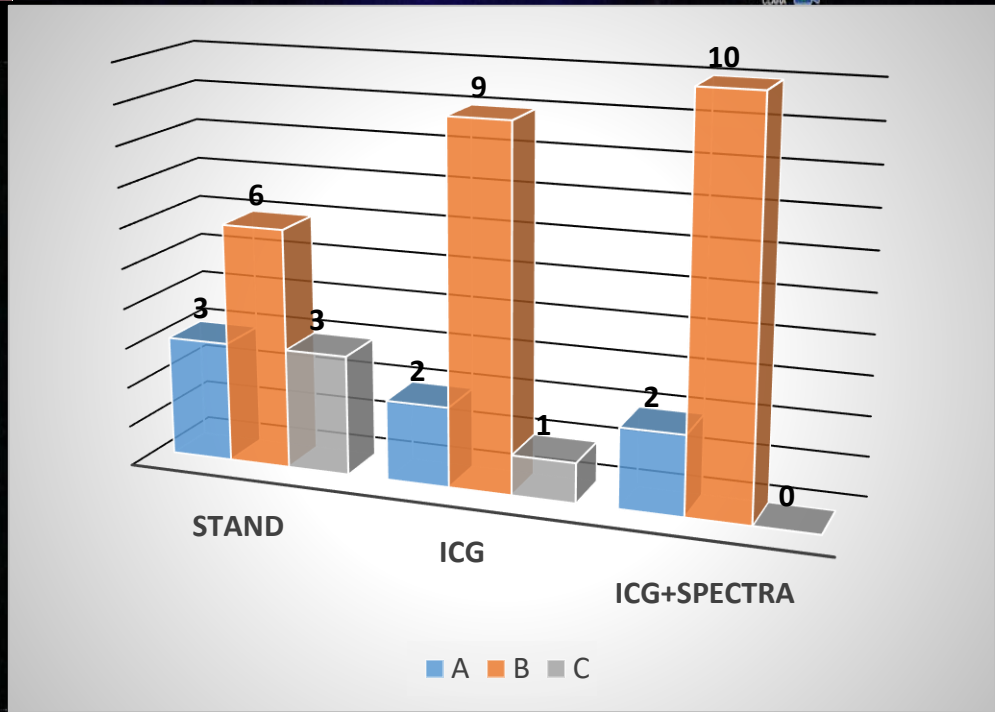

Standard
A
B
C


ICG
A
B
C

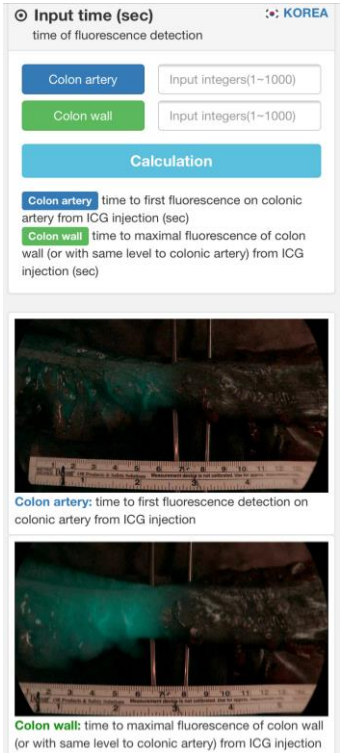

ICG + Spectra A
B
A
C

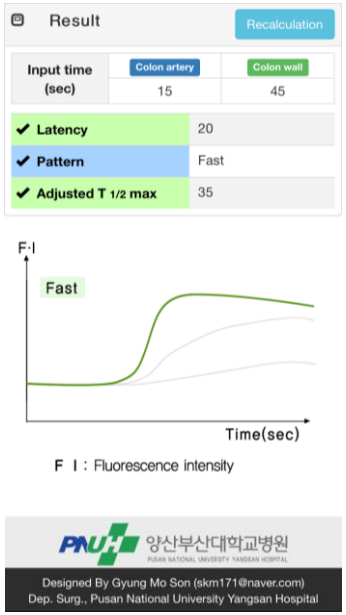

10
9
6
3
3
2
1
2
0
STAND
ICG
ICG+SPECTRA
A
B
C

CPASP

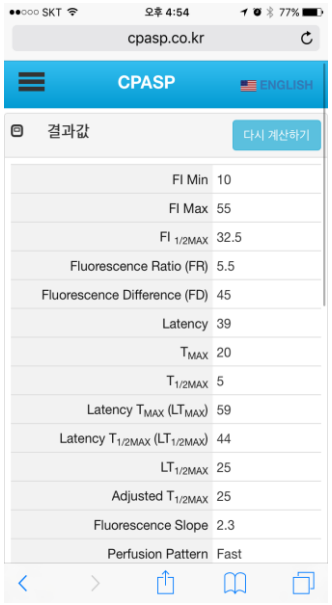
(Calculator for Colon Perfusion Analysis using Smart Phone)

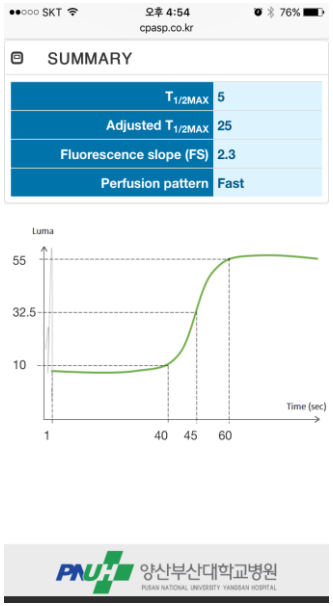
Version 1.1





Version 2.0





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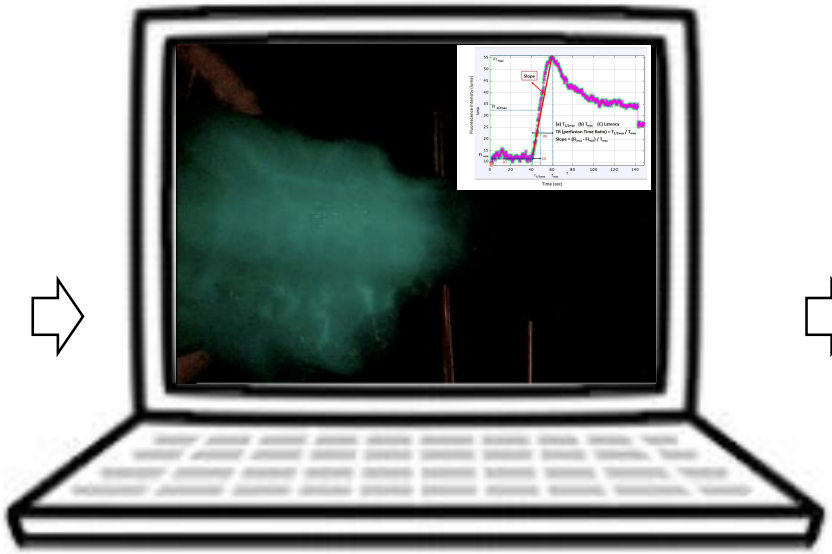
Real-time Quantitative analysis for ICG perfusion status

ICG laparoscopic camera

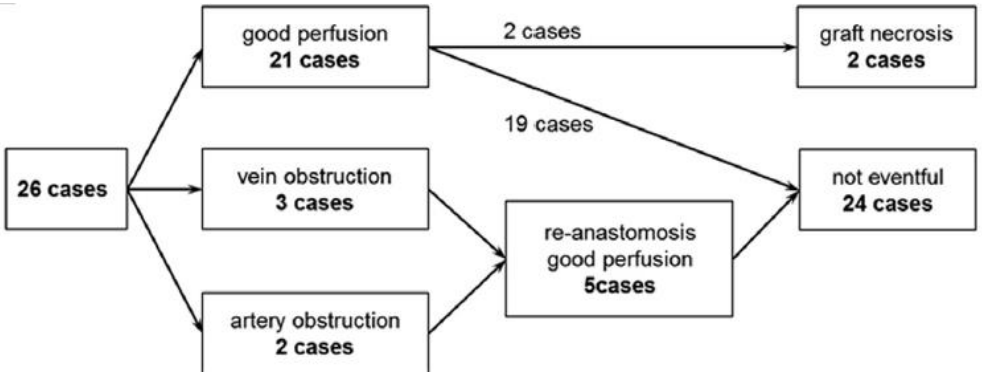


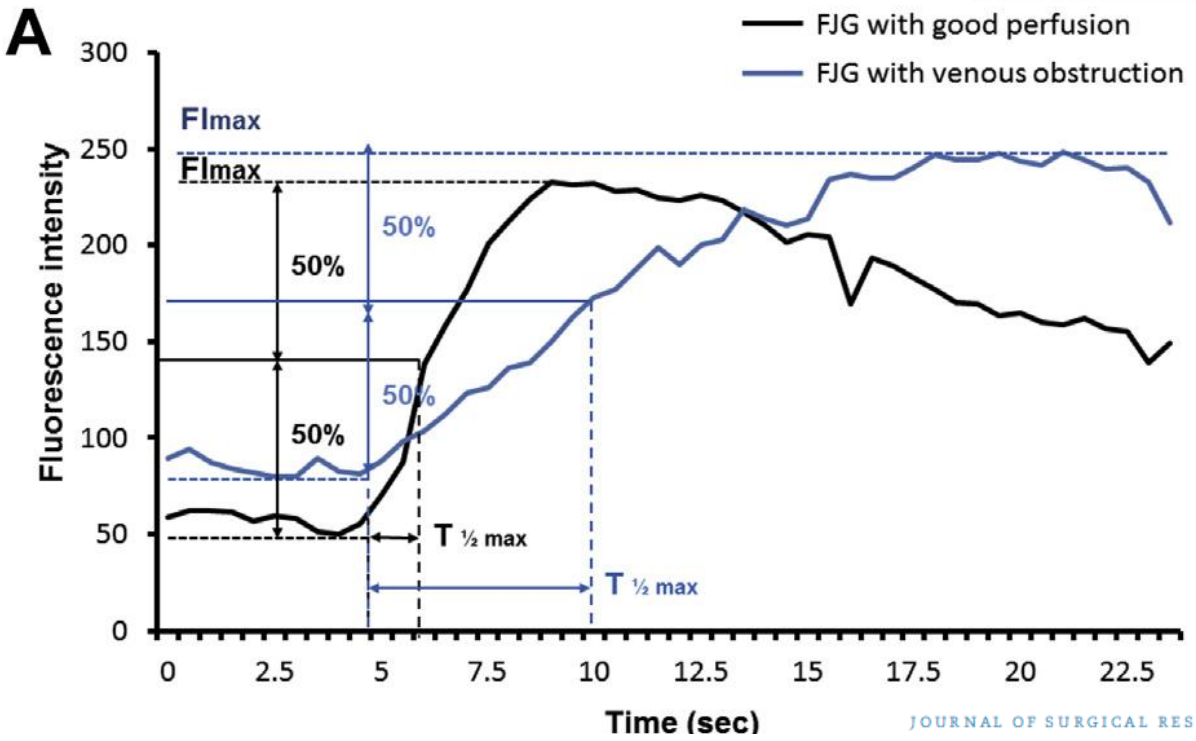
Video tracking program in the operation field

CPASP
(**C**alculator for colon **P**erfusion **A**nalysis using **S**mart **P**hone)

Smart phone application

Vision 2020
대한민국을 넘어 세계로
..
양산부산대학교병원
감사합니다





Quantification of Fluorescence intensity

Variations of fluorescence intensity

- Perfusion status
- Room lighting
- Distance from camera to targeting tissue
- Fluid in the op filed
- Visceral fat

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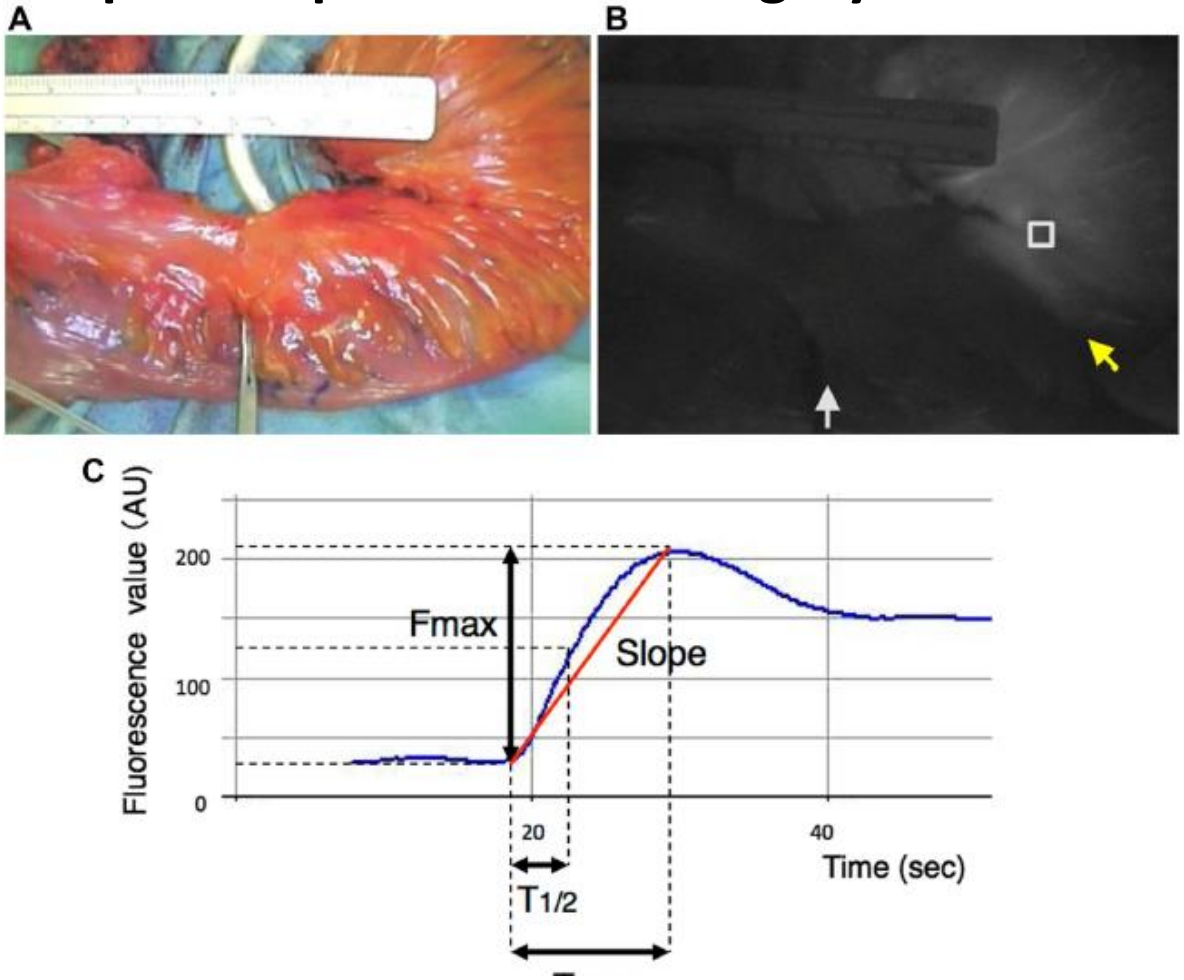
ICG fluorescence imaging for quantitative evaluation of colonic perfusion in laparoscopic colorectal surgery



- ICG fluorescence imaging is useful for assessing anastomotic perfusion in colorectal surgery, which can result in more precise operative decisions tailored for an individual patient.

Surg Endosc (2017)

Interpretative Guidelines and Possible Indications for Indocyanine Green Fluorescence Imaging in Robot-Assisted Sphincter-Saving Operations

Jin Cheon Kim, M.D., Ph.D.[1,2] • Jong Lyul Lee, M.D.[1,2] • Seong Ho Park, M.D., Ph.D.[3]

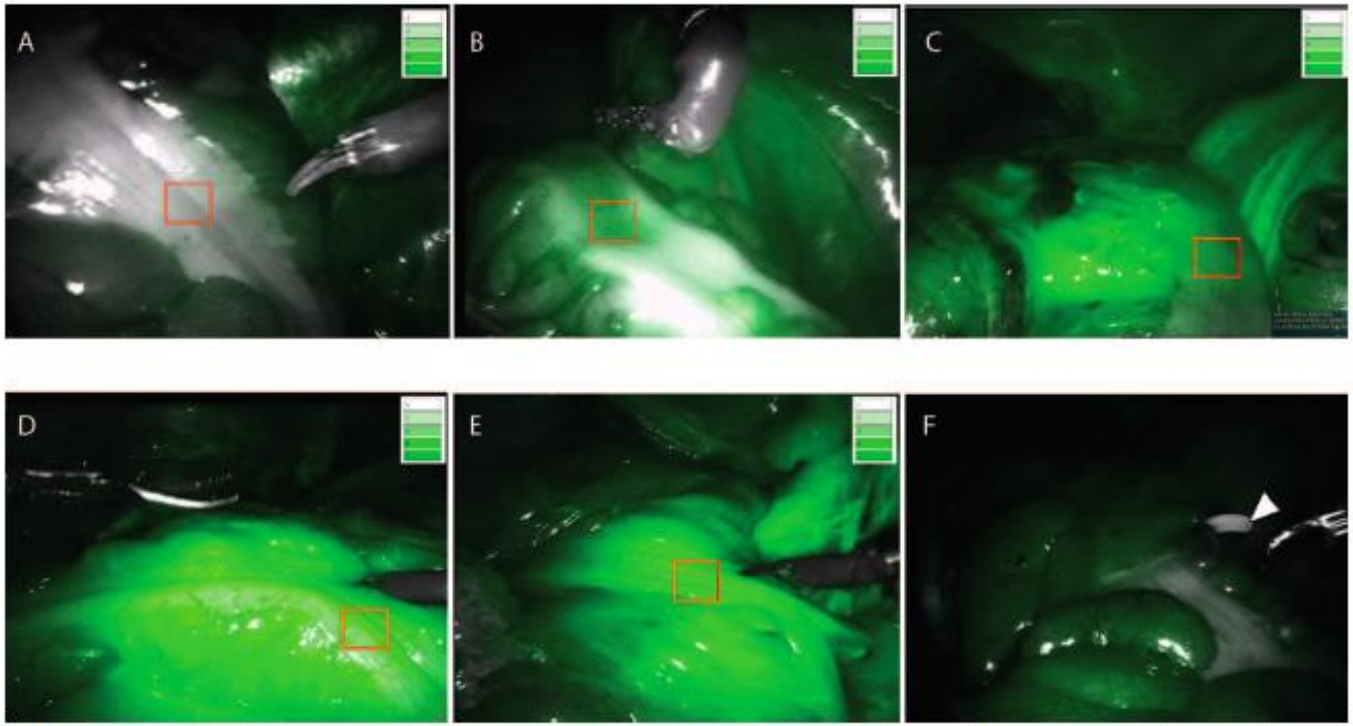
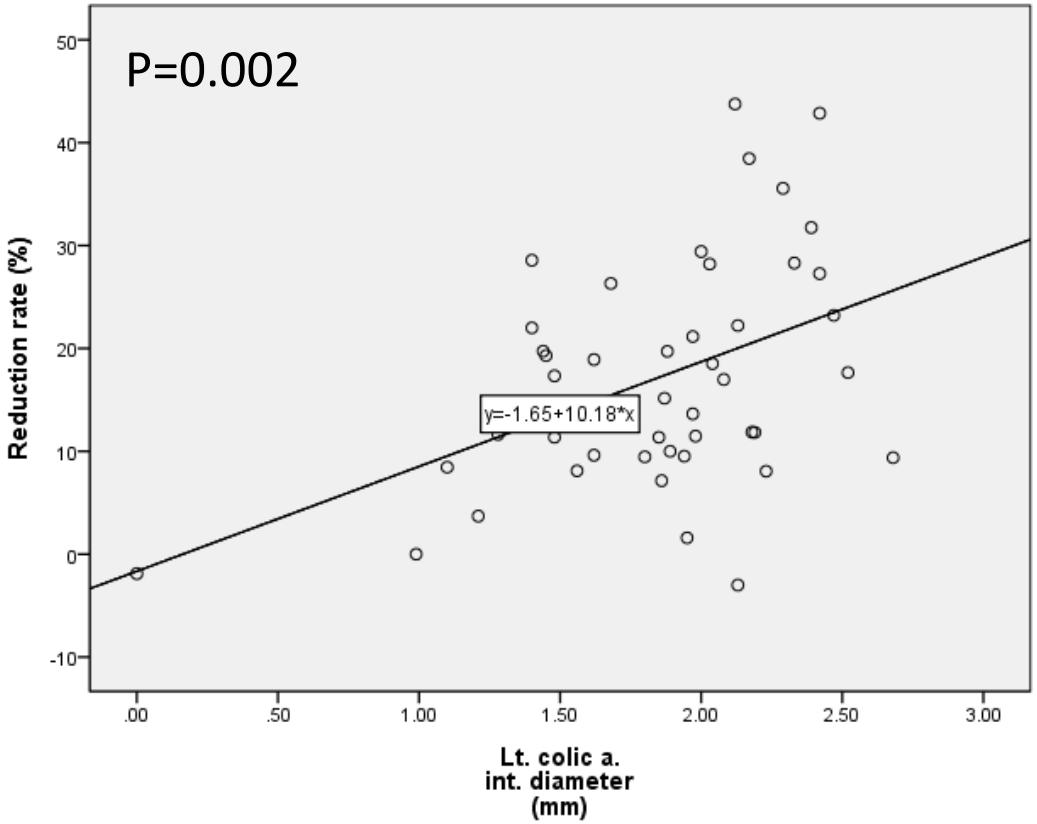


FIGURE 2. Perfusion intensity was divided into five grades using a standard color that was decreased in transparency in increments of 25% from 100% (grade 1) to 0% (grade 5) (A -E). A representative intensity in each patient is marked with a red quadrangle (inset, standard intensity indicator). Points of deficient perfusion demarcated using a clip (F, arrowhead).

Dis Colon Rectum 2017; 60: 376–384

Linear regression analysis of LCA diameter with reduction rates of marginal artery pressure



Variable	R^2	β	95% CI	p-value
LCA int. diameter	0.199	0.446	3.97 – 16.39	0.002

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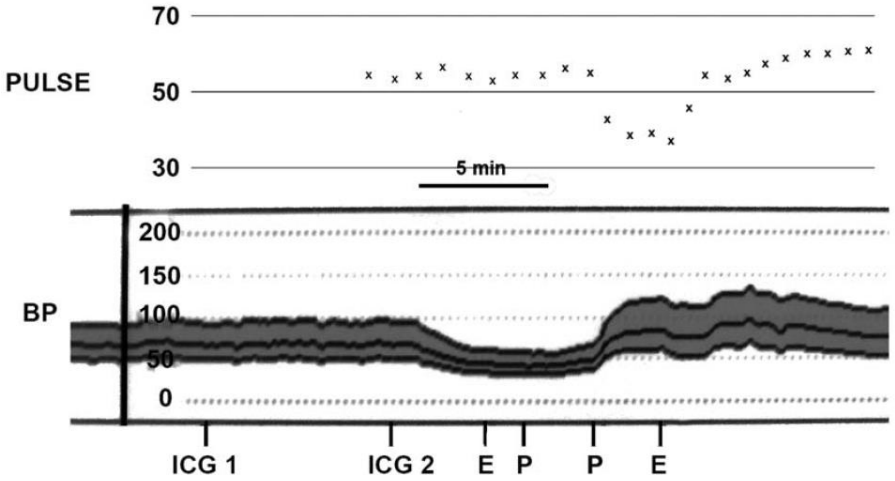
ICG Safety



- Usually, No adverse effect
- Rare, but possible allergic reaction
  - Incidence: 1/300,000
  - ICG Contains <5% sodium iodide
  - Caution in patients with history of allergy to iodides or iodinated imaging agent
  - Case report ;
    - Severe hypotension (A&A Case Reports 2013;1:26-30)

    1. ICG 5mg inj. During basilar tip aneurysm op
    2. ICG 2.5mg inj. During carotid bypass op

    - anaphylactic death (IC-Green product) during cardiac catheterization
- History of allergy to contrast agent
- Slowly intravenous injection

J Am Coll Surg

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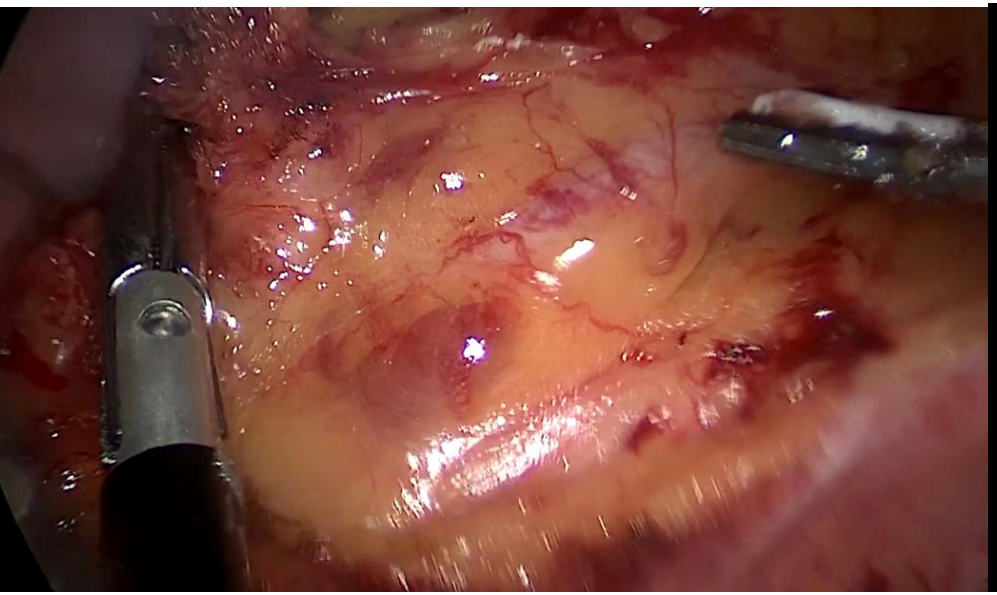
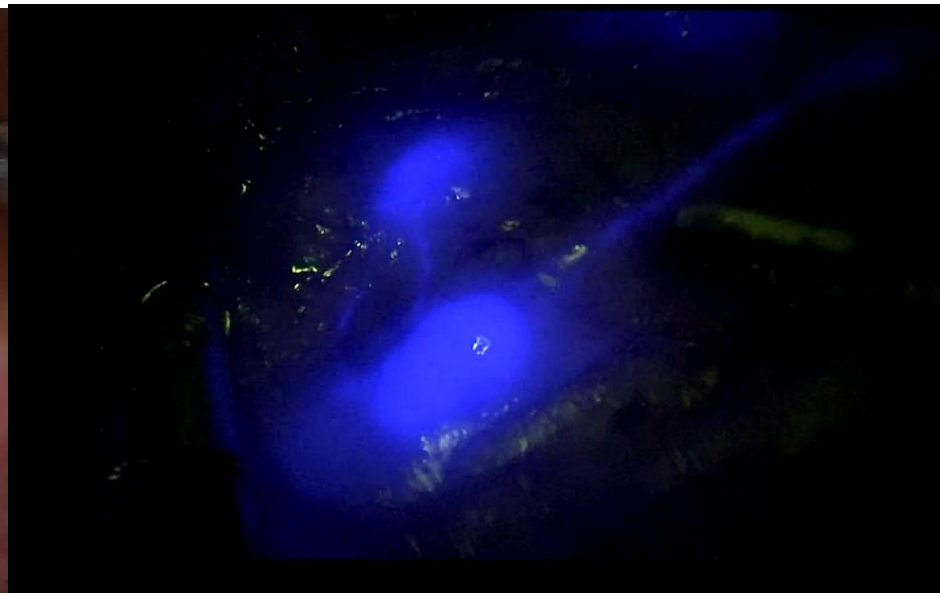
Lymph Node Mapping





ICG lymphangiography for lymph node mapping
Laparoscopic low anterior resection for rectal cancer

Transanal ICG injection (2.5ml, concentration = 2.5mg/ml) after induction of general anesthesia in operation room.

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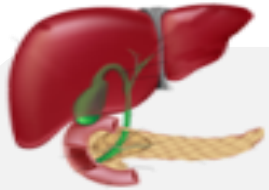
Conclusions

- ICG enhancement pattern could be applied to detect good perfusion segment for optimal anastomosis and to reduce anastomotic complications during laparoscopic colorectal surgery.

- In the near future, the **real-time analysis program** could be usable for laparoscopic surgeons to decide colonic perfusion status easily.

Indications for ICG fluorescence



- Bile detection:
  - Bile duct identification
  - Bile leakage visualisation

0.3 mg/kg 24 h before
<0.3 mg/kg just before
the surgery

- Blood perfusion:
  - Anastomosis assessment
  - Visualisation of ischemic area

0.2 - 0.4 mg/kg
just at the time

- Lymph node visualisation:
  - Lymphangiography

0.5 mg/kg 20 min before

FOR INFORMATION ONLY