Supplementary Table 3: Lung segmentation

Ref. No.	Author	Country	Journal	Year	Study design	Patient selection		Imaging techniques						Endpoint measures			Adverse effects	Learning curve	Cost analysis	Other comments	Ref. detail
						Subject	N (cases)	Fluorogenic agent	Dose	Route	Timing	Imaging system	Quantitative measurement	Main endpoints	Imaging accuracy/success rate	Clinical impact, changes in intraoperative decision-making and outcomes	Clinical impact, advantages in postoperative outcomes					
1	Misaki	Japan	J Thorac Cardiovasc Surg	2010	Case series	Lung tumors	8	ICG	3.0 mg/kg	IV	After division of the dominant pulmonary arterys of the target segment	Olympus (CLV-260SL)	NA	Visualization of lung segments	100%	NA	NA	None	NA	NA	Maximum staining intensity was attained 28 seconds after dye injection, and the observation duration was 3.5 minutes	Misaki N, Chang SS, Igai H, Tarumi S, Gotoh M, Yokomise H. J Thorac Cardiovasc Surg. 2010 Oct;140(4):752-6
2	Sekine	Japan	J Thorac Cardiovasc Surg	2012	Prospective	Lung cancer	10 (+10 control)	ICG	10-15mg	Transbronchial injection	After indication of general anesthesia	Olympus (prototype)	NA	Visualization of intersegmental planes	100%	NA	Length of stay was shorter in the ICG than in the control group (P = .055).	None	NA	NA	Compared with traditional lobectomy without fluorescence imaging	Sekine Y, Ko E, Oishi H, Miwa M. J Thorac Cardiovasc Surg. 2012 Jun;143(6):1330-5.
3	Kasai	Japan	Eur J Cardiothorac Surg	2013	Prospective	Segmentectomy	30	ICG	3 mg/kg (2-wavelength method) and 0.5 mg/kg (1-wavelength method)	IV	After ligation of the major artery and bronchus of the resecting segment	Infrared thoracoscope	NA	Identify lung intersegmental borders and compare efficacy with two-wavelength imaging versus one-wavelength imaging	90% success rate/ (2-wavelength method) and 19 out of 20 patients (1-wavelength method)	NA	NA	None	NA	NA	Staining duration was longer in the 1-wavelength method. Image clarity was better in the 2-wavelength method	Kasai Y, Tarumi S, Chang SS, Misaki N, Gotoh M, Go T, et al. Eur J Cardiothorac Surg. 2013 Dec;44(6):1103-7
4	Pardolesi	Italy	J Thorac Cardiovasc Surg	2014	Case series	Robotic anatomic segmentectomy	2	ICG	2.5 mg in 10 mL	IV	After division of the target segment bronchus, vein, and artery	Not stated	NA	Identify the intersegmental plane	100%	NA	No complications	None	NA	NA		Pardolesi A, Veronesi G, Solli P, Spaggiari L. J Thorac Cardiovasc Surg. 2014 Aug;148(2):757-8
5	Tarumi	Japan	Eur J Cardiothorac Surg	2014	Prospective	Video-assisted thoracoscopic segmentectomy	13	ICG	3 mg/kg in 11 patients; 0.5 mg/kg in 2 patients as a trial dose	IV	After interrupting the dominant arteries	Infrared thoracoscope (IRT, Olympus)	NA	Reveal the intersegmental line by blood flow differences	85% success rate	NA	2 cases of pulmonary fistula	None	NA	NA		Tarumi S, Misaki N, Kasai Y, Chang SS, Go T, Yokomise H. Eur J Cardiothorac Surg. 2014 Jul;46(1):117-5
6	Kuroda	Japan	J Thorac Dis	2016	Consecutive	Thoracoscopic anatomical segmentectomy	12	ICG	The authors state "2 mL/body"	IV	When forming the segmental plane	Karl Storz	NA	Identify the segmental plane	Not reported	NA	Minor air leak	None	NA	LigaSure may reduce the cost of the staple technique	Kuroda H, Dejima H, Mizumo T, Sakakura N, Sakao Y. J Thorac Dis. 2016 Jun;8(6):1210-6
7	Iizuka	Japan	J Thorac Dis	2016	Prospective	Thoracoscopic anatomical segmentectomy (sublobar resection)	71	ICG	5 mg/kg	IV	Unclear from the text	Karl Storz	NA	Determine factors predicting ICG visualization during this type of procedure	98.60%	NA	NA	None	NA	NA	Visibility may be obscured in patients who were heavy smokers or have a low attenuation area	Iizuka S, Kuroda H, Yoshimura K, Dejima H, Seto K, Naomi A, et al. J Thorac Dis. 2016 May;8(5):985-91
8	Ito	Japan	Eur J Cardiothorac Surg	2017	Case report	Thoracoscopic anatomical segmentectomy	1	ICG	5 mg	IV	After ligation of the target segmental vein, artery, and bronchus; after injection, the pulmonary vein is clamped to delay washout	Not reported	NA	Identify the intersegmental plane but delay the washout of ICG to increase visualization time	100%	NA	NA	None	NA	NA		Ito A, Takao M, Shimamoto A, Shimpo H. Eur J Cardiothorac Surg. 2017 Dec 1;52(6):1225-1226
9	Yamanashi	Japan	Ann Thorac Surg	2017	Case report	Thoracoscopic basilar segmentectomy	1	ICG	5 mg/kg	IV	After transecting the V9-10 area	Stryker (Novadaq)	NA	Identify the intersegmental plane	100% success rate	NA	NA	None	NA	NA		Yamanashi K, Okumura N, Otsuki Y, Matsuoka T. Ann Thorac Surg. 2017 Nov 104(5):e399-e407
10	Guigard	Switzerland	Interact Cardiovasc Thorac Surg	2017	Retrospective	Segmentectomy by video-assisted thoracoscopic surgery	22	ICG	2.5 mg/mL in 5 mL	IV	After ligation of arterial branches	PINPOINT	NA	Identify the intersegmental plane and vascular supply	100%	In 3 patients, ICG imaging prevented incomplete resection or devascularization	2 patients experienced prolonged air leak with pneumonia, 1 patient experienced gastroparesis, and 1 patient experienced colonic ileus; no one required chest drainage or rehospitalization	None	NA	NA		Guigard S, Triponez F, Bédat B, Vidal-Fortuny J, Licker M, Kurmovics W. Interact Cardiovasc Thorac Surg. 2017 Nov 1;25(5):793-799
11	Mun	Japan	J Vis Surg	2017	Prospective	Thoracoscopic anatomical segmentectomy	20 (15 primary lung cancer and five metastatic lung tumors)	ICG	0.25 mg/kg	IV	After ligating the target artery and bronchus	Karl Storz	NA	Define the intersegmental plane	95% success rate	NA	Slight renal dysfunction in one patient	None	NA	NA		Mun M, Okumura S, Nakao M, Matsuura Y, Nakagawa K. J Vis Surg. 2017 Jun 7:140
12	Mao	China	J Biomed Opt	2017	Case series	Validate use of the thoracoscope in lung cancer patients	3	ICG	0.4 mg/kg	IV	After ligation of the segmental pulmonary arteries	Near-infrared thoracoscope developed by the authors	NA	Define the intersegmental plane	100% success rate	NA	NA	None	NA	NA		Mao Y, Wang K, He K, Ye J, Yang F, Zhou J, et al. J Biomed Opt. 2017 Jun 1;22(6):66002
13	Hsieh	Taiwan	Surg Endosc	2017	Case report	Robotic segmentectomy	1	ICG	NA	IV	Not stated (this document is the abstract to a video)	Not stated (this document is the abstract to a video)	NA	Visualize the intersegmental plane	100% success rate	NA	NA	None	NA	NA		Hsieh CP, Liu YH, Wu YC, Hsieh MJ, Chao YK. Surg Endosc. 2017 Aug;31(8):3347-3348
14	Pischik	Russia	J Thorac Dis	2018	Prospective	Video-assisted thoracic lung segmentectomy	86 (90 segmentectomies)	ICG	0.15 mg/kg (more was added when necessary)	IV	After division of the target vascular and bronchial branches	Karl Storz	NA	Identify the intersegmental plane	100%	Well-defined borders were observed in 86 of the 90 procedures; ICG highlighted technical problems in the other 4 cases (artery mis-clamping, artery mis-dividing, weak fluorescence in a patient with severe emphysema, and the presence of multiple collateral vessels)	19 patients experienced air leaks, 1 patient developed pneumonia, and 2 patients experienced atrial fibrillation	None	NA	NA	COPD reduces the duration of ICG staining	Pischik VG, Kovalenko A. J Thorac Dis. 2018 Nov;10(Suppl 31):S3704-S3711
15	Zhang	China	J Thorac Dis	2018	Case report	Uniportal video-assisted thoracic S8 segmentectomy and S1a subsegmentectomy	1	ICG	2.5 mg/mL in 1 mL saline	IV	After transection of the bronchus	Infrared thoracoscope (no more details)	NA	Identify the intersegmental plane	100% success rate	NA	NA	None	NA	NA		Zhang G, Yu Z, Wang L, Shen G, Chai Y. J Thorac Dis. 2018 Jul;10(7):4475-4481
16	Meacci	Italy	J Vis Surg	2018	Case series	Uniportal video-assisted thoracic lung segmentectomy	2	ICG	2.5 mg in 10 mL	IV	After ligation of the segmental artery	Not reported	NA	Identify the intersegmental plane	100% success rate	NA	NA	None	NA	NA		Meacci E, Nachira D, Congedo MT, Chiappetta M, Petracca Ciavarella L, Margaritora S. J Vis Surg. 2018 Jun 18:4:17
17	Elkhouly	Italy	Asian Cardiovasc Thorac Ann	2018	Case series	Thoracoscopic anatomical segmentectomy	2	ICG	30 mL of 10% saline-diluted ICG	Injection into the viable bronchi	After interruption of the bronchi targeted for resection	Not reported	NA	Identify the intersegmental plane	100% success rate	NA	NA	None	NA	NA		Elkhouly AG, Cristino B, Pompeo E. Asian Cardiovasc Thorac Ann. 2018 Mar;26(3):247-249
18	Sun	China	Thorac Cancer	2019	Retrospective	Lung segmentectomy	19	ICG	2 mL of 25 mg/10 mL	IV	After transecting the target segment structures	PINPOINT	NA	Identify the intersegmental plane	100% success rate	NA	3 patients experienced complications	None	NA	The cost of the imaging system is discussed and considered acceptable		Sun Y, Zhang Q, Wang Z, Shao F, Yang R. Thorac Cancer. 2019 Oct;10(10):2013-2021
19	Nakanishi	Japan	Thorac Cancer	2019	Case report	Thoracoscopic lobectomy	1	ICG	NA	IV	After transection of the arteries	Not reported	NA	Detect the interlobar fissure boundary	Apparently successful	NA	NA	None	NA	NA		Nakanishi K, Kuroda H, Nakada T, Ueno H, Sakakura N. Thorac Cancer. 2019 Jul;10(7):1654-1656
20	Chao	Taiwan	Surg Endosc	2019	Retrospective	Video-assisted thoracoscopic lung resection	11	ICG	0.3-0.5 mL at 0.125 mg/mL	IV	After inserting a needle into the thorax	PINPOINT	NA	Identify the lesions	100% success rate	NA	NA	None	NA	NA		Chao YK, Leow OQY, Wen CT, Fang HY. Surg Endosc. 2019 Nov;33(11):3858-3863
21	Jin	China	Surg Innov	2019	Retrospective	Video-assisted thoracoscopic anatomical segmentectomy	21	ICG	0.5 mg/kg	IV	After ligation and transection of the ssemental artery	Not reported	NA	Visualize the segmental fissure	Not reported	NA	2 patients developed pneumonia, 3 patients developed arrhythmia, and 1 patient experienced prolonged air leak	None	NA	NA		Jin Y, Wang M, Xue L, Zhao X. Surg Innov. 2019 Aug;26(4):473-477
22	Genci	US	Ann Thorac Surg	2019	Retrospective	Robotic segmentectomy	245 (all 245 received IV ICG, but only 93 also received ICG bronchoscopically)	ICG	25 mg dissolved in 10 mL; of that quantity, 0.5 mL was administered bronchoscopically and the remaining 9.5 mL was IV	Bronchoscopically in some cases and then intravenously in all cases	The intravenous dose was given after artery ligation	The authors only say "Firefly," which is the software, not the instrument	NA	Compare usefulness of ICG administered intravenously and bronchoscopically in localizing nodules	100% success rate in delineation of the intersegmental plane Bronchoscopy with ICG correctly identified the lesion in 80 of the 85 cases	NA	2 patients developed postoperative pneumonia; 1 patient had a stroke; there were no mortalities up to 90 days after surgery; postoperative complications occurred in 65 patients (26.5%), typically air leak and atrial fibrillation	None	NA	NA		Genci TC, Ferrari-Light D, Kent A, Michaud G, Zervos M, Pass HI, et al. Ann Thorac Surg. 2019 Aug;108(2):363-369
23	Yajima	Japan	Ann Thorac Surg	2019	Prospective	Upper lobe thoracoscopic segmentectomy	16	ICG	0.5 mg/kg	IV	After isolation of the target segment artery and bronchus	Infrared thoracoscope (Olympus)	NA	Identify the intersegmental border	75%	NA	None reported	None	NA	NA	Temporary compression of the interlobular pulmonary artery improves visualization with ICG	Yajima T, Shimizu K, Mogi A, Ibe T, Ohtaki Y, Obayashi K, et al. Ann Thorac Surg. 2019 Aug;108(2):e141-e143

24 Motono	Japan	J Thorac Dis	2019	Prospective	Video-assisted thoracic segmentectomy	20	ICG	5 mg	IV	After ligating the target arteries, veins, and bronchi	Karl Storz	NA	Visualize the demarcation line	90%	NA	5 of the 20 patients experienced complications (air leak that required pleurodesis)	None	NA	NA	Motono N, Iwai S, Funasaki A, Sekimura A, Usuda K, Uramoto H. J Thorac Dis. 2019 Mar;11(3):702-707
25 Zhang	China	Thorac Cancer	2019	Not stated	Sublobar resection	46 (35 for wedge resection and 11 for segmentectomy)	ICG	10-12.5 mg (IV) 0.25-0.5mg (percutaneous injection)	Percutaneous injection (wedge resection) and IV (segmentectomy)	Preoperatively (wedge resection) and during surgery before resection (segmentectomy)	Neus-infrared thoracoscope (no other details given)	NA	Localize pulmonary nodules	In 2 wedge resection patients, ICG failed to localize the nodules	NA	No adverse postoperative events	None	NA	NA	Zhang C, Lin H, Fu R, Zhang T, Nie Q, Dong S, et al. Thorac Cancer. 2019 Apr;10(4):624-630
26 Chen	China	Surg Innov	2019	Prospective	Video-assisted pulmonary segmentectomy	19	ICG	25 mg	IV	After ligation of dominant arteries	PINPOINT	NA	Identify the intersegmental plane	100%	NA	Postoperative air leak in 2 patients	None	NA	NA	Chen R, Ma Y, Li C, Li Y, Yang B, Guo J, et al. Surg Innov. 2019 Jun;26(3):337-343
27 Mehta	Canada	J Thorac Cardiovasc Surg	2019	Prospective	Robotic segmentectomy	31	ICG	15-20 mg	IV	After ligation of the segmental artery, vein, and bronchus	da Vinci Si	NA	Compare the predicted and true intersegmental plane	100%	ICG mapping showed that in 74% of cases, the true intersegmental plane was different from the intersegmental plane predicted by 2 surgeons	10 out of 53 patients experienced air leaks or atrial fibrillation	None	NA	NA	Mehta M, Patel YS, Yasufuku K, Waddell TK, Shargall Y, Fahim C, et al. J Thorac Cardiovasc Surg. 2019 May;157(5):2029-2035
28 Sekine	Japan	Semin Thorac Cardiovasc Surg	2019	Prospective	Pulmonary sublobar resection	58	ICG	25 mg in 10 mL	Transbronchial instillation	After inflation of a balloon catheter	PINPOINT	NA	Assess border clarity under ICG and compare with predicted location	89.2%	NA	None reported	None	NA	NA	All procedures performed by one surgeon (the first author)	Sekine Y, Itoh T, Toyoda T, Kaiho T, Koh E, Kamata T, et al. Semin Thorac Cardiovasc Surg. 2019 Autumn;31(3):495-497
29 Can	Czech Republic	Ann Transl Med	2019	Case report	Pulmonary segmentectomy (non-intubated)	1	ICG	0.1 mg/kg	Not reported	After cutting the segmental artery	PINPOINT	NA	Identify the resection line	Clear borders were not detected (presumably because of low concentration of ICG)	NA	None reported	None	NA	NA		Can V, Kala Z, Feola L, Hudacek K, Kala V, Kodytkova A, et al. Ann Transl Med. 2019 Jun;7(7):158
30 Matsuura	Japan	Ann Transl Med	2019	Prospective	Video-assisted thoracoscopic segmentectomy	149	ICG	0.25 mg/kg	IV	After division of the target arteries and bronchus	Karl Storz	NA	Visualize segmental boundaries	98% (146 patients)	NA	None; 5-year overall and recurrence-free survival rates were 91.8% and 98%, respectively	None	NA	NA		Matsuura Y, Mun M, Ichinose J, Nakao M, Nakagawa K, Okumura S. Ann Transl Med. 2019 Jun;7(7):157
31 Matsui	Japan	J Surg Res	2020	Prospective	Thoracoscopic anatomical segmentectomy	106	ICG	NA	Not reported	Not stated	Not stated	NA	Identify the intersegmental boundary	100%	NA	None reported	None	NA	NA		Matsui T, Takahashi Y, Nakada T, Matsushita H, Oya Y, Sakakura N, et al. J Surg Res. 2020 Dec 1;250:10_16.
32 Yazawa	Japan	Multimed Man Cardiothorac Surg	2020	Case report	Dorsal segmentectomy of right upper lobe	1	ICG	0.3 mg/kg in 10 mL	IV	After division of the artery, vein, and bronchus	Not stated in the tutorial (perhaps visible in the video)	NA	Identify the intersegmental plane	100% success rate	NA	None reported	None	NA	NA		Yazawa T, Igai H, Matsuura N, Ohsawa F, Fumisawa S, Kamiyoshihara M. Multimed Man Cardiothorac Surg. 2020 Nov 3:7070
33 Yanagiya	Japan	Surg Case Rep	2020	Case report	Extended segmentectomy	1	ICG	NA	IV	After dissecting the target structures	Not stated	NA	Identify the intersegmental plane	100% success rate	NA	None	None	NA	NA		Yanagiya M, Hiyama N, Matsumoto J. Surg Case Rep. 2020 Oct 27;6(1):273
34 Matsuoka	Japan	Gen Thorac Cardiovasc Surg	2020	Case series	Pulmonary sequestration	3	ICG	0.25 mg/kg	IV	After ligation of the blood vessels	VISERA ELITE II or Karl Storz	NA	Identification of aberrant arteries, draining veins, and resection margins	100% success rate	NA	None	None	NA	NA		Matsuoka S, Eguchi T, Takeda T, Miura K, Hamanaka K, Shimizu K. Gen Thorac Cardiovasc Surg. 2020 Oct 19
35 Liu	China	J Cardiothorac Surg	2020	Retrospective	Video-assisted thoracoscopic segmentectomy	92	ICG	2.5 mg/mL for 6-10 mL	IV	After ligation of the artery, bronchus, and vein	PINPOINT	NA	Visualize the intersegmental plane	91% success rate	ICG did not change the operative course (stated specifically)	In comparison with a group that received the inflation-deflation method but not ICG, the patients who received ICG had fewer cases of air leakage but longer hospital stays	None	The original number of patients was 122, but the authors excluded 30 cases because of the "learning curve" of the surgical team	NA		Liu Z, Yang R, Cao H. J Cardiothorac Surg. 2020 Oct 7;15(1):303
36 Yanagiya	Japan	J Cardiothorac Surg	2020	Case report	Video-assisted left apicoposterior segmentectomy	1	ICG	NA	IV	After cutting the arteries and bronchus	Not stated	NA	Identify the intersegmental plane	100% success rate	NA	NA	None	NA	NA		Yanagiya M, Yamaguchi H, Hiyama N, Matsumoto J. J Cardiothorac Surg. 2020 Sep 29;15(1):274.
37 Funai	Japan	J Thorac Dis	2020	Prospective	Pulmonary segmentectomy	10	ICG	5 mL (12.5mg?)	ICG was mixed with autologous blood and sprayed through the resected bronchi	After separating the artery, vein, and bronchi	PDE camera (Hamamatsu)	NA	Identify the intersegmental plane	80% (failed in 2 patients with severe emphysema)	NA	ICG did not affect the pathological diagnosis 2 patients died of other diseases	None	NA	NA		Funai K, Kawase A, Shimizu K, Sekihara K, Yamashita T, Shiiya N. J Thorac Dis. 2020 Sep;12(9):4817-4824
38 Motohashi	Japan	Gen Thorac Cardiovasc Surg	2020	Case report	Video-assisted thoracoscopic left basilar segmentectomy	1	ICG	0.1 mg/kg	IV	After division of the pulmonary artery and vein	Not stated	NA	Identify the perfusion area and abnormal blood flow from aberrant arteries	100% success rate	NA	NA	None	NA	NA		Motohashi Y, Kato T, Aragaki M, Fujiwara-Kuroda A, Hida Y, Wakasa S, et al. Gen Thorac Cardiovasc Surg. 2020 Aug 6
39 Wada	Japan	Ann Thorac Surg	2020	Prospective	Pulmonary segmentectomy	15	ICG	0.125 mg/mL (at the ratio of 0.04 or 0.08 according to volumes of target segments)	Injection into the target bronchi	After intubation	PINPOINT	NA	100% success rate	81%	NA	1 patient experienced recurrent air leakage	None	NA	NA		Wada H, Yamamoto T, Morimoto J, Sakairi Y, Suzuki H, Nakajima T, et al. Ann Thorac Surg. 2020 Feb;109(2):386-40

NA, Not available or not assessed