**Supplementary Table 1: Perfusion assessment in CABG**

| 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 | Clinical impact, advantages in postoperative outcomes | | | | | |
| 1 | Rubens | Canada | Heart Surg Forum | 2002 | Prospective | CABG or MIDCAB | 20 | ICG | 0.5 mL (0.5-5.0 mg/mL) | IV | IV, via the antegrade cardioplegia cannula, or via the cardiopulmonary bypass circuit | A portal laser diode/infrared camera device | NA | Visualization of coronary anatomy and grafts | 90% | 5% graft revision | NA | None | NA | NA | | Rubens FD, Ruel M, Fremes SE. A new and simplified method for coronary and graft imaging during CABG. Heart Surg Forum. 2002;5(2):141-144. |
| 2 | Balacumaraswami | UK | J Thorac Cardiovasc Surg | 2004 | Prospective | CABG (on- and off-pump) | 200 (533 conduits) | ICG | 1mL(0.03mg/kg weight) | IV | Into the oxygenator in the ONCABG group or through the central venous line in the OPCABG group | SPY Novadaq | NA | Assessment of intraoperative graft patency | 96% in patient, 98% in graft | Eight (1.5%) grafts in 8 (4%) patients demonstrated no fluorescence within the conduits during image acquisition. The occluded grafts were revised, after which the grafts were reimaged and patency was confirmed with the IFI system. | NA | None | NA | NA | Our previously reported preliminary experience of 84 patients is included in this study. | Balacumaraswami L, Abu-Omar Y, Anastasiadis K, et al. Does off-pump total arterial grafting increase the incidence of intraoperative graft failure? J Thorac Cardiovasc Surg. 2004;128(2):238-244. |
| 3 | Reuthebuch | Switzerland | Chest | 2004 | Prospective | Off-pump CABG, nonemergent | 38 (124 grafts) | ICG | 1.25-2.5mg | IV | Through the central venous line | SPY Novadaq | NA | Assessment of the quality of anastomoses and grafts | 86% | 5% graft revision | NA | None | NA | NA | | Reuthebuch O, Häusler A, Genoni M, et al. Novadaq SPY intraoperative quality assessment in off-pump coronary artery bypass grafting. Chest. 2004;125(2):418-424. |
| 4 | Takahashi | Japan | Interact Cardiovasc Thorac Surg | 2004 | Prospective | Off-pump CABG(0 MIDCAB, 64 OPCAB) | 72 (290 distal anastomoses) | ICG | 2.5 mg | IV | Into the central venous line | SPY Novadaq | NA | Visualization of anastomoses | 100% | 1.4% graft revision | NA | None | NA | In Europe, the cost of the procedure may be around 200-350 e. This will include use of the device, ICG and the drape. | | Takahashi M, Ishikawa T, Higashidani K, Kaneh H. SPY: an innovative intra-operative imaging system to evaluate graft patency during off-pump coronary artery bypass grafting. Interact Cardiovasc Thorac Surg. 2004;3(3):479-483. |
| 5 | Balacumaraswami | UK | J Thorac Cardiovasc Surg | 2005 | Prospective | CABG (on- and off-pump) | 100 (266 bypass grafts) | ICG | 1mL, 0.03mg/kg | IV | Into the oxygenator in the ONCABG group or through the central venous line in the OPCABG group | SPY Novadaq | Poor flow with the intraoperative fluorescence imaging system was defined if there was an absence of fluorescence or if it did not appear within 15 seconds in the graft. | Assessment of graft patency | 241(91%) grafts in 75(75%) patients had good flow in both IFI and TTFM. 10(3.8%) grafts in 10(10%) patients had good flow only in IFI, not TTFM. No grafts had poor IFI flow but good TTFM flow. | Both intraoperative fluorescence imaging and transit-time flowmetry confirmed persistent poor flow in 8 (3%) grafts in 8 (8%) patients that necessitated graft revision. However, in a further 10 (3.8%) grafts in 10 (10%) patients, transit-time flowmetry indicated persistently poor flows on the basis of mean graft flow and pulsatility index values, whereas the intraoperative fluorescence imaging system demonstrated satisfactory flow. These grafts were not revised. | NA | None | NA | NA | Comparison of IFI with TTFM | Balacumaraswami L, Abu-Omar Y, Choudhary B, Pigott D, Taggart DP. A comparison of transit-time flowmetry and intraoperative fluorescence imaging for assessing coronary artery bypass graft patency. J Thorac Cardiovasc Surg. 2005;130(2):515-520. |
| 6 | Yasuda | Japan | J Thorac Cardiovasc Surg | 2005 | Prospective | OPCAB (LITA-LAD graft) | 10 (10 grafts) | ICG | 2mL | IV | Directly into the ascending aorta just below the brachiocephalic artery | SPY Novadaq | NA | Assesment of a LITA graft | 100% for anastomosis | NA | NA | None | NA | NA | | Yasuda T, Watanabe G, Tomita S. Transaortic injection technique in fluorescence imaging: novel intraoperative assessment of anastomosis in off-pump coronary artery bypass grafting. J Thorac Cardiovasc Surg. 2005;130(2):560-561. |
| 7 | Desai | Canada | J Am Coll Cardiol | 2005 | Prospective | CABG (on- and off-pump) | 120 (348 grafts) | ICG | In-situ grafts on-pump (2.5mg injection into aortic cannula; In-situ grafts off-pump (1.25 mg injection into central venous line); Free grafts distal anastomosis (0.0125 mg direct graft injection), Free grafts proximal anastomosis (1.25 mg injection into central venous line after weaning from cardiopulmonary bypass) | IV, or aortic cannula/graft injection | Injection into aortic cannula or central venous line / direct graft injection before proximal anastomosis construction | SPY Novadaq | NA | Visualization of anastomoses | Sensitivity and specificity of the ICG angiograms for graft stenosis 50% was 100% | 4.2% major graft revisions and 3.3% minor revisions | NA | None | Inter-rater agreement among two surgeons, one experienced and one inexperienced with the technique, was 100% for assessing total graft occlusion and 97% for assessing graft revisions when 35 ICG angiograms were reviewed off-line. (TIMI 60%) | NA | As part of a pilot study investigation for RCT, on patients, with a total of 22 bypass grafts, underwent post-operative X-ray angiography. | Desai ND, Miwa S, Kodama D, et al. Improving the quality of coronary bypass surgery with intraoperative angiography: validation of a new technique. J Am Coll Cardiol. 2005;46(8):1521-1525. |
| 8 | Desai | Canada | J Thorac Cardiovasc Surg | 2006 | Prospective (within-patient randomization) | CABG (on- and off-pump, elective and urgent) | 106 (339 grafts) | ICG | In-situ grafts on-pump (2.5mg injection into aortic cannula; In-situ grafts off-pump (1.25 mg injection into central venous line); Free grafts distal anastomosis (0.0125 mg direct graft injection), Free grafts proximal anastomosis (1.25 mg injection into central venous line after weaning from cardiopulmonary bypass) | IV, or aortic cannula/graft injection | Injection into aortic cannula or central venous line / direct graft injection before proximal anastomosis construction | SPY Novadaq | NA | Assessment of grafts | Sensitivity, specificity, PPV, and NPV of ICG angiography to detect greater than 50% setnosis or occlusion was 83.3%, 100%, 100%, and 98.4% (TTF; 25%, 98.4%, 60%, and 93.2%). | ICG Angiography detected 10 (7.2%) graft errors including 7 errors that TTF missed. | There were nosignificant differences in clinical outcomes between all-on-rolled patients and those who underwent x-ray angiography. | None | NA | NA | Comparison of IFI with TTFM and x-ray angiography. IFI provides significantly better diagnostic accuracy for detecting clinically significant graft errors than does TTFM | Desai ND, Miwa S, Kodama D, et al. A randomized comparison of intraoperative indocyanine green angiography and transit-time flow measurement to detect technical errors in coronary bypass grafts. J Thorac Cardiovasc Surg. 2006;132(3):585-594. |
| 9 | Handa | Japan | Interact Cardiovasc Thorac Surg | 2009 | Prospective | Isolate OPCAB | 49 (116 grafts) | ICG | NA | IV | NA | A new color CCD camera consists of a combination of custom-made optical filters and an ultra-high sensitive CCD image sensor | Fluorescence intensity | Assessment of graft and perfusion | The sensitivity and the specificity of ICG angiography for graft failure was 100% and 100% (TFM, 93% and 0%). | 1.7% graft revision | The sensitivity and the specificity of ICG angiography for graft failure was 100% and 100% (TFM, 93% and 0%). | None | NA | NA | Comparison of IFI with TTFM | Handa T, Katare RG, Sasaguri S, Sato T. Preliminary experience for the evaluation of the intraoperative graft patency with real color charge-coupled device camera system: an advanced device for simultaneous capturing of color and near-infrared images during coronary artery bypass graft. Interact Cardiovasc Thorac Surg. 2009;9(2):150-154. |
| 10 | Wasuda | US | JACC Cardiovasc Imaging | 2009 | Prospective | Off-pump CABG | 137 (507 grafts) | ICG | 0.625mg | IV | Through a central venous catheter | SPY Novadaq | In off-line IFI analysis, the graft washout was classified based on the number of heartbeats required for indocyanine green washout: fast washout (=<15 beats) and slow washout (>15 beats). | Assessment of graft patency | 379 (75%) grafts were visualized clearly up to the distal anastomosis. | 1% graft revision | 21 grafts with unsatisfactory transit-time flowmetry results demonstrated acceptable patency with IFI. Graft revision was considered unnecessary in these grafts, and 20 grafts (95%) were patent by post-operative X-ray angiography. | None | NA | NA | Comparison of IFI to TTFM and X-ray angiography | Wasuda K, Ako J, Hasegawa T, et al. Intraoperative fluorescence imaging system for on-site assessment of off-pump coronary artery bypass graft. JACC Cardiovasc Imaging. 2009;2(5):604-612. |
| 11 | Singh | Canada | J Thorac Cardiovasc Surg | 2010 | RCT | CABG (on- and off-pump) | 78 (234 grafts), v78 (233 grafts) control | ICG | In-situ grafts on-pump (2.5mg injection into aortic cannula; In-situ grafts off-pump (1.25 mg injection into central venous line); Free grafts distal anastomosis (0.0125 mg direct graft injection), Free grafts proximal anastomosis (1.25 mg injection into central venous line after weaning from cardiopulmonary bypass) | IV, or aortic cannula/graft injection | Injection into aortic cannula or central venous line / direct graft injection before proximal anastomosis construction | SPY Novadaq | NA | Postoperative graft patency | NA | 1.7% graft revision | One-year angiography was performed in 107 patients (imaging, 55 patients/160 grafts; control, 52 patients/152 grafts). The proportion of patients with 1 graft occlusion or more was comparable in the imaging (39.9%) and control (28.9%) groups (relative risk [95% confidence interval], 1.1 [0.6-1.9], P = .82), as were other graft patency end points. | None | NA | NA | IFI and TTFM (imaging group) were compared to standard intraoperative management (control group) | Singh SK, Desai ND, Chikazawa G, et al. The Graft Imaging to Improve Patency (GRIIP) clinical trial results. J Thorac Cardiovasc Surg. 2010;139(2):294-301, 301.e291. |
| 12 | Hatada | Japan | Gen Thorac Cardiovasc Surg | 2011 | Prospective | Isolate CABG (on- and off-pump) | 6 (10 saphenous vein grafts) | ICG | NA | IV | NA | SPY Novadaq | NA | Diagnostic accuracy to determine graft failure | The IFI system demonstrated a satisfactory flow of all grafts, while postoperative X-ray angiography demonstrated that one SVG was 75% stenosed (the others were patent). | NA | NA | None | NA | | The harmonic distortion of the TTFM waveform can provide better diagnostic accuracy for detecting clinically significant grafts than MGF and PI of TTFM and the IFI system. | Hatada A, Okamura Y, Kaneko M, et al. Comparison of the waveforms of transit-time flowmetry and intraoperative fluorescence imaging for assessing coronary artery bypass graft patency. Gen Thorac Cardiovasc Surg. 2011;59(1):14-18. |
| 13 | Kuroyanagi | Japan | Innovations (Phila) | 2012 | Prospective | OPCAB | 159 (435 grafts) | ICG | NA | IV | Into the SVC | NA | NA | Assesment of graft | NA | 2 grafts (0.5%) were revised by ICG fluorescence angiography after TTFM. | NA | None | NA | NA | Comparison of IFI to TTFM and X-ray angiography | Kuroyanagi S, Asai T, Suzuki T. Intraoperative fluorescence imaging after transit-time flow measurement during coronary artery bypass grafting. Innovations (Phila). 2012;7(6):435-440. |
| 14 | Ferguson | US | J Thorac Cardiovasc Surg | 2013 | Prospective | CABG (on- and off-pump) | 167 (359 grafts) | ICG | NA | IV | NA | The near infrared fluorescence (NIRF) system with a complex angiography and perfusion analysis (CAPA) | Fluorescence intensity (CAPA) | Identification of the nature of stenoses in the target vessel | All 359 grafts were widely patent by angiography, and 24% of the arterial and 22% of the saphenous vein grafts showed no regional myocardial perfusion change in response to bypass grafting. In 165 in situ internal mammary artery grafts to the left anterior descending artery (>70%stenosis), 40 had no change in regionalmyocardial perfusion, and 32 of the 40 had competitive flowimaged. | NA | All 359 grafts were widely patent by angiography, and 24% of the arterial and 22% of the saphenous vein grafts showed no regional myocardial perfusion change inresponse to bypass grafting. | None | NA | NA | An important number of angiographically patent bypass grafts demonstrated no change inregional myocardial perfusion, suggesting anatomic, but nonfunctional, stenoses in these target vessel epicardialcoronary arteries | Ferguson TB, Jr., Chen C, Babb JD, Efird JT, Daggubati R, Cahill JM. Fractional flow reserve-guided coronary artery bypass grafting: can intraoperative physiologic imaging guide decision making? J Thorac Cardiovasc Surg. 2013;146(4):824-835.e821. |
| 15 | Yamamoto | Japan | Surg Today | 2015 | Prospective | CABG (on- and off-pump, elective and urgent) | 40 (144 grafts) | ICG | 0.05 mg/kg | IV | Via a central venous catheter | HyperEye Medical System(HEMS) | NA | Visualization of the bypass flow for prediction of graft patency. | Negative predictive value and positive predictive value of HEMS angiography for postoperative graft occlusion were 97.7% and 81.8%, respectively. Those values for TTF were 92.5% and 20.0%, respectively. | NA | Negative predictive value and positive predictive value of HEMS angiography for postoperative graft occlusion were 97.7% and 81.8%, respectively. Those values for TTF were 92.5% and 20.0%, respectively. | None | NA | NA | Compared with TTF | Yamamoto M, Orihashi K, Nishimori H, et al. Efficacy of intraoperative HyperEye Medical System angiography for coronary artery bypass grafting. Surg Today. 2015;45(8):966-972. |
| 16 | Yamamoto | Japan | Surg Today | 2017 | Retrospective | CABG | 69 (177 grafts) | ICG | 0.05 mg/kg | IV | Via a central venous catheter | HEMS | Fluorescence intensity (the increasing rate of ICG intensity, average acceleration value, and time to peak) | Detection of grafts at risk of occlusion. | The quantitative HEMS assessment showed negative and positive predictive values of 100 and 95 % in ITA graft and 85.7 and 86.8 % in SV/RA grafts. | NA | NA | None | NA | NA | | Yamamoto M, Nishimori H, Handa T, et al. Quantitative assessment techniques of HyperEye medical system angiography for coronary artery bypass grafting. Surg Today. 2017;47(2):210-217. |
| 17 | Nakamura | Japan | Innovations (Phila) | 2019 | Retrospective | Robot-assisted minimally invasive direct coronary artery bypass(R-MIDCAB) | 30 | ICG | 2.5mg | IV | Through a central line | Firefly Fluorescence Imaging (Firefly) | NA | Assesment of LITA quality | Success rate, 100% | 7% modifications in surgical procedure | Postoperatic LITA patency rate was 100% | None | NA | NA | | Nakamura Y, Kaneda M, Ito Y, et al. Left Internal Thoracic Artery Graft Assessment by Firefly Fluorescence Imaging for Robot-Assisted Minimally Invasive Direct Coronary Artery Bypass. Innovations (Phila). 2019;14(2):144-150. |

NA, not available or not assessed