Use of Intraoperative Coronary Angiography to Guide Surgical Intervention in Coronary Artery Bypass Graft Surgery

Jaclyn H. Mueller, Kimberly Hollander
Department of Anesthesiology, University of Maryland School of Medicine, Baltimore, MD, USA

ABSTRACT
Following coronary artery bypass graft surgery, graft patency is a major factor contributing to patient morbidity and mortality. There are several modalities available for assessing graft patency intra-op used by both the anesthesiologist and surgeon. However, these modalities have their own advantages and disadvantages which will be summarized in this case report. As illustrated by this case, angiography continues to be the gold standard for coronary anatomy assessment and can be performed easily using a portable digital fluoroscopic system.

Keywords: Cardiothoracic anesthesia, coronary artery bypass surgery, coronary artery disease

INTRODUCTION
Coronary artery bypass graft surgery remains the cornerstone of treatment for coronary artery disease. Graft patency is a major factor contributing to cardiac morbidity and mortality, especially in the early follow-up period. Intraoperative transesophageal echocardiography (TEE) and electrocardiogram (EKG) monitoring that are readily available in the operating room are sensitive for detecting clinically significant graft obstruction but are not specific. When there is high suspicion of bypass graft dysfunction, the ability to perform intraoperative angiography to assess graft patency should be considered to immediately identify obstructions and facilitate their prompt treatment, so the patient may leave with the optimal surgical result. IRB approval and clinical trial registration are not applicable and informed consent was obtained by the patient presented in the following case report.

CASE REPORT
A 51-year-old man with unstable angina was found to have severe single-vessel disease of the left anterior descending (LAD) artery and presented for minimally invasive direct coronary artery bypass (MIDCAB) surgery. Preoperative TEE showed normal biventricular function without valvular disease. Intraoperatively, the DaVinci robot (Intuitive, California USA) was used to dissect the left inferior mammary artery (LIMA) which had excellent flow when transected. The LAD was snared and a shunt was used to facilitate perfusion while the LIMA to LAD anastomosis was performed. ST elevations were noted during snaring of the LAD, but resolved immediately after finishing the LIMA to LAD anastomosis. However, when testing the patency with transit time flowmetry (TTFM) flow probes, they showed poor flow in the LIMA despite normalized ST segments and no regional wall motion.
which is based on the transit time of ultrasonic energy from two transducers in a probe passing through a liquid. While transit time flowmetry is noninvasive, simple, and relatively low cost, its measurements are dependent on a number of physical properties and hemodynamic parameters, including blood pressure, peripheral bed resistance, blood viscosity, and competitive flow, making standardization difficult and compromising diagnostic accuracy.\[2\] TTFM also has varying cut off values in order to determine abnormal flow. Currently most physicians use cutoff values of mean graft flow >20 mL/min and pulsatility index <5 for graft patency. However, most of this data are based on small cohorts and studies with differing cutoff values for predicting graft failure.\[3,4\]

Another modality to assess graft patency includes epicardial ultrasound (ECUS) that is usually performed in conjunction with TTFM. ECUS is best performed on a resting heart and attempts to provide a more anatomical picture of the anastomosis and bypass graft. However, even on a resting heart, it is challenging to maintain stable and optimal contact with the ultrasound probe to assess patency without distorting the image. It is for this reason that ECUS has not gained widespread availability and is not accepted as standard practice.\[5\] Also, in this case, ECUS would not have been feasible during the first part of the MIDCAB procedure since probe placement would be technically improbable on a beating heart.

Intraoperative indocyanine green (ICG) imaging is another imaging technique that can be used intraoperatively to evaluate bypass grafts. Indocyanine green molecules bind to intravascular proteins securing their location in the vascular system. ICG is then stimulated by laser energy and emits a fluorescence light that is captured by a camera as it moves through the graft. The series of images that are captured are then compiled to create an angiographic representation of the vessel. In comparison to conventional angiography, ICG imaging provides high-quality images without the need for radiation or catheters. The limitations of ICG imaging are that it gives a derived image and it gives very little information on competitive flow, distal coronary bed, and transit times. Moreover, each graft requires 3-4 minutes which prolongs operative time.\[6\]

Although multiple modalities exist to assess graft patency intraoperatively, TTFM was used in this case, which highlights one of its most clinically relevant limitations. TTFM provides no anatomic information and cannot locate an obstruction, but rather only report if there is one present.\[7\] In this case, the ability to locate the obstruction distal to the anastomosis allowed the surgeon to effectively...
revise the graft and place a saphenous vein graft to the distal LAD. Thus, the patient was able to leave the operating room with an optimal surgical result.

Angiography continues to be the gold standard for coronary anatomy assessment. However, its routine intraoperative use is hindered by availability and portability, presence of ionizing radiation, time required, and cost. Thus, there is a need for less invasive intraoperative graft assessment modalities such as TTFM, and for many cases, such modalities are sufficient. However, intraoperative coronary angiography should be available in the event of clinically significant graft malfunctions (e.g., obstruction and vasospasm) that are not easily resolved as seen in the case presented. Such imaging could also be applied to other cardiac surgeries such as aortic root repairs where coronaries are reimplanted as well as mitral valve surgery where occlusion to the circumflex artery had been previously described.[8,9]

The availability of hybrid cardiac suites is limited or unavailable at some hospitals. This case shows that angiography using a portable digital fluoroscopic system can be easily performed and provides immediate confirmation of graft patency. In summary, there is utility in intraoperative coronary angiography in selected cases in order to promptly diagnose and guide surgical revision in coronary bypass grafting when other modalities are limited.

Declaration of patient consent
The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Informed consent
The patient’s informed written consent was obtained for publication of this case report.

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Conflicts of interest
There are no conflicts of interest.

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