Correlation of Coronary Angiographic Findings and Hemodynamic Risk During General Anesthesia

Case Study

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Submitted: March 16, 2026
Accepted: April 28, 2026
Published: May 8, 2026

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Research in Health and Medicine: *2026, Volume 6 (Issue 1): 11*

ISSN: 3066-0777

Abstract

Introduction: The World Health Organization Safe Surgery Checklist requires confirmation that relevant imaging is available prior to surgery. In cardiac surgery, review of coronary angiography enhances clinicopathologic correlation and anticipatory management. This case study illustrates the importance of angiographic review to prevent refractory hypotension following anesthetic induction.

Methods: A single-patient case study was conducted involving a 71-year-old male with severe multi-vessel coronary artery disease undergoing beating-heart, pump-assisted coronary artery bypass grafting. Clinical presentation, intraoperative hemodynamics, echocardiographic findings, and vasoactive management were analyzed in the context of preoperative angiographic data.

Results: Following induction of anesthesia, the patient developed severe refractory hypotension (MAP 30 mmHg) and bradycardia (HR 48-55 BPM) despite phenylephrine administration. The diastolic blood pressure became inadequate to perfuse the left anterior descending (LAD) coronary artery, acutely compromising the myocardium. Escalation to epinephrine and norepinephrine provided transient stabilization. Transesophageal echocardiography revealed an acute reduction in left ventricular ejection fraction (LVEF) from 55-60% to 20%. Emergency sternotomy and initiation of cardiopulmonary bypass were required. Postoperative recovery was uneventful.

Conclusions: In high-risk coronary lesions, hypotension may precipitate myocardial failure refractory to vasopressors. Early inotropic support may be preferable to reflexive vasopressor escalation. Lesions involving the LAD coronary artery increase the risk of intraoperative myocardial ischemia. Adequate preoperative coronary angiogram review may have predicted the ischemia-induced low cardiac output state observed in this case. With this knowledge, patient safety and clinical decision-making would likely have improved, and emergent initiation of cardiopulmonary bypass may have been avoided.

Key Words: surgical safety checklist, induction of anesthesia, cardiac anesthesia

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Introduction

United States hospitals have universally adopted the World Health Organization (WHO) Safe Surgery Checklist to help ensure patient safety [1,13]. One item on this list is the requirement to confirm that all relevant images are available in the operating room (OR) prior to starting a case (Figure 1). For cardiac surgical cases, this includes images from the left-heart catheterization, which provides the lead cardiac surgeon a chance to review all relevant coronary blockages with the anesthesia staff. The surgeon's goal of reviewing these images is to enhance the team's firsthand assessment of the severity of their patient's coronary blockages and the degree of clinical significance.

The ability to mentally simulate the future clinical course based on a patient's underlying pathology is a skill known as clinicopathologic correlation [3]. Reviewing images as part of a thorough yet concise pre-case briefing enables providers to anticipate problems and develop contingency plans. The most important future event for the anesthetist is whether ischemia and hemodynamic collapse are likely to occur around the time of induction of anesthesia. A face-to-face review of images prior to the case is the ideal method to achieve this purpose because it is direct, immediate, and interpersonal [4]. This enables the anesthetist to anticipate intraoperative problems and develop contingency plans.

The role of non-technical skills in the surgical arena is ever-increasing. Interdisciplinary collaboration is a complex relational dynamic that depends on effective teamwork and communication [4]. A myocardium- protective anesthetic technique has not been developed, which places even greater emphasis on the preoperative briefing [5]. The anesthesia team can then formulate the appropriate plan to ensure patient safety. A recent cardiac surgical case that developed severe, refractory hypotension after the induction of anesthesia illustrates how knowledge of the coronary angiography images can improve situational awareness and promote the proactive management of hemodynamic problems.

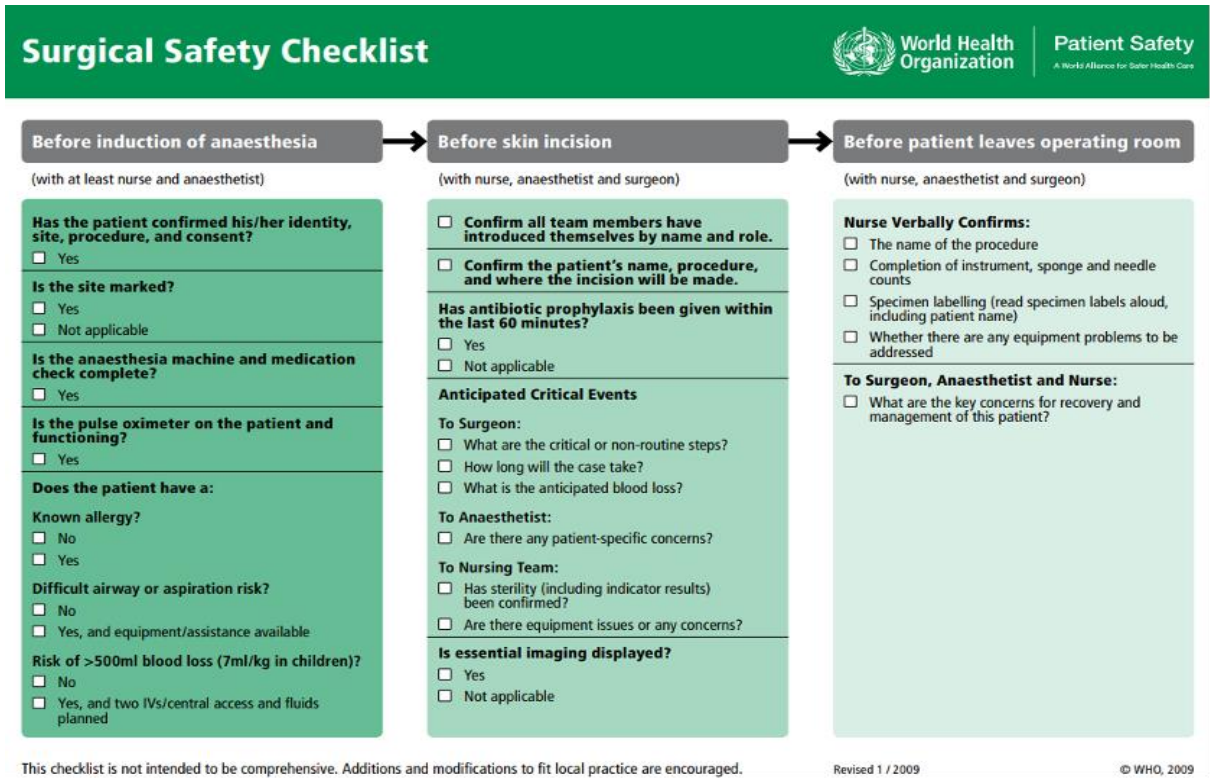

Figure 1. Surgical safety checklist.

Methods

As a retrospective case study, no identifiable patient information is disclosed. Institutional standards for ethical reporting were followed.

Patient Presentation

This case involves a 71-year-old, 90 kg male with severe peripheral vascular disease (PVD) requiring multiple vascular stents, chronic obstructive pulmonary disease (COPD), and multi-vessel coronary artery disease (CAD), who presented with crescendo angina at a rural 300-bed community hospital. The patient was a former smoker (126 pack-years) but did not require supplemental oxygen and had normal pulmonary function values in 2022. Prior echocardiography demonstrated left ventricular ejection fraction (LVEF) of 55% with mild mitral and tricuspid valve regurgitation. An elective heart catheterization one month prior to surgery showed severe diffuse disease (> 90%) in the proximal left anterior descending artery (LAD), a chronic total occlusion of the right coronary artery (RCA) with collateral

circulation, and significant disease (70%) in the circumflex system (Figure 2). The catheterization report revealed a LVEF of 55-60% with normal wall motion.

Surgical Plan

The patient was indicated for 3 to 4-vessel bypass grafts. The surgical plan was beating-heart, pump-assisted coronary bypass grafting x 3: left internal mammary artery (LIMA) to the LAD, right internal mammary artery (RIMA) to the first diagonal, and a saphenous vein graft to the obtuse marginal branch #2. Due to past vascular procedures using a vein graft, there was insufficient venous conduit to bypass the RCA. This vessel was well collateralized and deemed the lowest priority to bypass.

Figure 2. Coronary artery angiography.

Results

Intraoperative Course

The patient arrived in the operating room (OR) with no signs of active myocardial ischemia and a heart rate of 55 beats per minute (bpm). A right radial arterial line had been placed preoperatively, although the waveform was dampened. Ultimately, a left brachial arterial line was placed with a satisfactory tracing. Anesthetic induction was performed with Lidocaine 100mg, Etomidate 10mg, Fentanyl 300mcg, Rocuronium 100mg, and Ketamine 25mg. Intubation with a standard 8.0 endotracheal tube was uncomplicated.

The patient exhibited a brief period of excitation following intubation, characterized by a mean arterial pressure (MAP) of 119 mmHg and a heart rate (HR) of 80 bpm. This was followed by severe hypotension characterized by a systolic blood pressure (SBP) of 50-55 mmHg, MAP of 30 mmHg, and HR of 48-55 bpm. Initially, this hypotension was unresponsive to phenylephrine boluses (total of 200mcg). Epinephrine 30mcg was administered, and an epinephrine infusion was started at 2mcg/min. The patient briefly stabilized (MAP 63-82 mmHg) before severe hypotension reoccurred.

To address persistent hypotension, a norepinephrine infusion of 4 mcg/min was started, with the epinephrine infusion increased to 3 mcg/min to maintain a MAP of 63-70 mmHg. Despite vasoactive support, the continued blood pressure lability prompted an intraoperative transesophageal echocardiogram, which showed a reduced LVEF of 20%. Due to the declining left ventricular function and clinical instability, an emergency sternotomy was performed, and the patient was immediately placed on cardiopulmonary bypass. The procedure was carried out as planned, and the remainder of the case was uneventful. The patient was transferred to the intensive care unit on norepinephrine 4 mcg/min and epinephrine 4 mcg/min. The postoperative course progressed as expected, with discharge to home on postoperative day 6 (Figure 3).

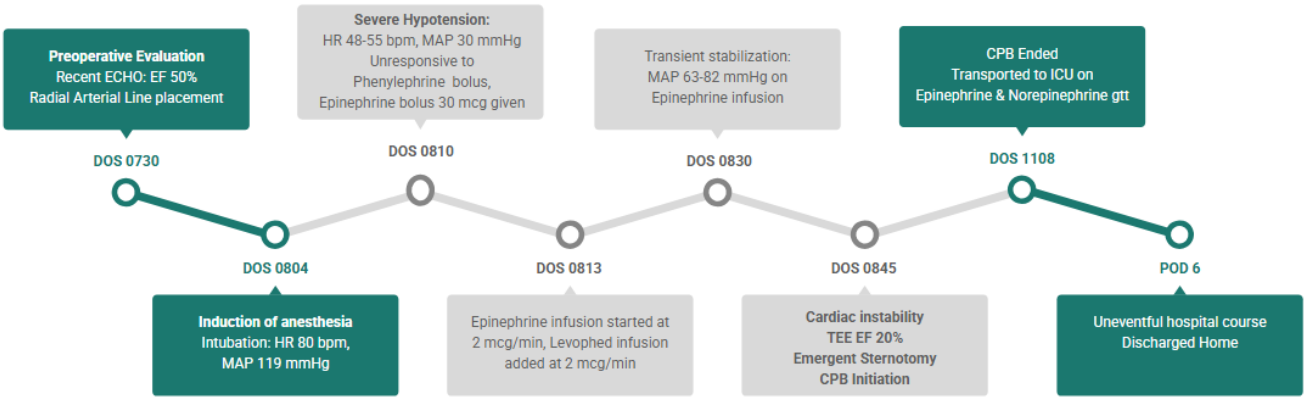

Figure 3. Intraoperative course of events.

Discussion

The anesthetic management of patients with unrevascularized coronary artery disease requires strict attention to the patient's myocardial oxygen supply and demand [5]. Hypotension from systemic vasodilation or hypertension from surgical stress can disturb this balance. Avoiding a disruption in this crucial balance is important for preserving myocardial function. Adverse events may result, such as myocardial infarction, cardiac failure leading to low cardiac output syndrome, arrhythmias, and sudden cardiac arrest [6].

Given the significant risks involved in cardiothoracic surgery, our cardiac surgical team has implemented preoperative briefings to review the coronary angiogram together prior to each case, focusing on the "culprit" lesion. The term culprit refers to the specific atherosclerotic plaque identified on the images that was thought to be responsible for the patient's clinical presentation [2]. The surgeon points out features of the lesion, its severity, location, length, and impact on flow, to provide information that predicts future ischemic events [2]. In this case, the culprit was within the LAD.

Due to extenuating circumstances, the preoperative debriefing held the morning of the case was abbreviated and did not include a review of the angiography with the team. If the coronary angiogram had been discussed in this team's usual fashion, the lesion would have been systematically reviewed, primarily for the severity of its stenosis. Also included in the meeting would have been the proximal location, long length, and how the lesion hindered the speed of contrast flow on coronary cineangiography. Assessments, such as these, can predict a highly significant risk of myocardial ischemia from even brief periods of hypotension.

Indeed, after the patient underwent anesthesia induction, the diastolic pressure likely became inadequate to perfuse the LAD coronary artery, thus acutely compromising the myocardium served by both the LAD and RCA. Vasopressor administration did not reverse the situation, likely because it did not address worsening contractility (LVEF dropped from 50% to 20%) or falling cardiac output. It is common for clinicians (surgeons, ICU nurses, and anesthetists) to miss when a drop in blood pressure is accompanied by a drop in cardiac output [7]. Without invasive monitoring, such as a pulmonary catheter, differentiating the cause of low blood pressure (BP) can be difficult.

The vasopressor choice may temporarily improve blood pressure; however, the problem has not always been resolved. The brief pressor response diverts attention from recognizing that the heart is afterload-sensitive and unable to pump against a higher BP [8]. In this subset of patients, hypotension may recur, prompting repetition of the same flawed 'solution' that previously appeared effective, i.e., increasing the vasopressor. Doing so further reduces the cardiac output, eventually to a point of no return where the only solution is to emergently institute cardiopulmonary bypass, known colloquially as "crashing on pump", which is not ideal. This bailout tactic prolongs the duration of cardiopulmonary bypass and elevates the risk of pump-related morbidity [18,19,20].

Interpretations of coronary angiographic images enable predictions of the patient's future and their past. The patient had a 100% occlusion of the RCA, and it is plausible that this occlusion developed slowly, allowing collateral vessels from the LAD to supply the distal RCA and maintain myocardial viability over time. Once another coronary stenosis compromised the LAD artery, flow through these collateral vessels could have become compromised and turned the RCA circulation into a watershed territory. Watershed territory refers to areas that are stenosed or hypoperfused [14]. It

was because of the wide territory at risk from the culprit lesion that we anticipated a strong susceptibility to even minor transient reductions in flow within the LAD.

As this case illustrates, team review of coronary angiography can provide the anesthetist with a more nuanced understanding of patient risks associated with anesthetic choices and guide strategies to mitigate those risks. Rather than always worrying about hypertension and hypotension equally, taking on a case with a particularly virulent appearing culprit lesion might lead the team to prioritize avoiding hypotension above all else. Acute severe hypertension could cause an ST elevation myocardial infarction. However, many ST elevations noted in the OR have minimal clinical impact [9]. The fact that we are performing cardiopulmonary bypass grafts means the problem will be efficiently addressed by unloading and revascularizing the heart with cardiopulmonary bypass and the planned coronary grafting procedure.

Anesthesia providers are trained to consider the hemodynamic effects on the patient's myocardial oxygen supply and demand. Either hypotension or hypertension in a patient with coronary ischemia undergoing non-cardiac surgery can trigger life-threatening adverse cardiac events. Autonomic-mediated increases in heart rate and blood pressure associated with intubation and surgical stimulation should be controlled with deeper planes of general anesthesia, adrenergic blockade, vasodilators, or a combination thereof. An intraoperative ST elevation myocardial infarction in this setting is a more disastrous event than during cardiac surgery and is associated with a higher mortality rate [10].

On the other hand, the hazard of low cardiac output in the setting of severe coronary artery disease appears to be often overlooked and underappreciated. Myocardial ischemia from this scenario is far worse than ischemia from hypertension. Hypertension might cause ST elevations, but it is not a signal of low cardiac output. Even a prolonged period of severe hypertension during cardiac surgery will not necessarily snowball into hypoperfusion of systemic organs, the kidneys, lungs, and brain, with consequences that may persist for years. Rather than reflexively administering vasopressors, clinicians should consider therapies aimed at increasing cardiac output, such as a fluid bolus and/or inotropic infusion.

An increase in contractility and cardiac output will improve coronary perfusion and thereby interrupt the "hypotension and low cardiac output" state. Studies suggest that a dobutamine infusion is safe in the setting of coronary artery disease (except for those with ST elevations in the OR, concerns about left ventricular outflow tract obstruction, uncontrolled tachyarrhythmias, or systolic BP > 200 mmHg or diastolic BP > 110 mmHg) [11]. Dobutamine has a broader therapeutic window than epinephrine, the inotropic agent used in this case. Epinephrine is known to cause myocardial ischemia out of proportion to its impact on cardiac output [12,15,17].

Conclusions

This case study illustrates how including coronary artery angiogram data in the prebriefing process can improve clinical decision-making. However, as a single case observation, further research is necessary to corroborate these findings. The coronary artery angiogram can serve as a tool in the differential diagnosis of hypotension that occurs after the induction of anesthesia. Oftentimes, a pulmonary artery catheter is not in place prior to induction, thus the anesthesia provider does not have cardiac output or volume status information. Coronary angiogram data can help guide the selection of appropriate vasoactive support.

In summary, reviewing the coronary artery angiogram can provide the anesthesia provider with important information to enhance the safety of cardiac surgery. For patients at high risk for the "hypotension and low cardiac output" state, dobutamine provides a safe option for improving cardiac output and potentially avoiding this deadly syndrome. The more concerning the culprit lesion, the more critical it becomes to avoid hypotension. Maintaining higher arterial pressures may reduce the risk of missing low cardiac output and help prevent end-organ injury. In this case study, dobutamine may have been a better alternative over phenylephrine or epinephrine [15,16].

Conflict of Interest. The authors declare no conflicts of interest.

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