CASE REPORT

# Optimizing outcomes in high-risk patients with low left ventricle ejection fraction undergoing coronary artery bypass grafting: a case report

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*Managing patients with coronary artery disease and low ejection fraction remains a challenge despite medical advancements. Coronary artery bypass grafting has shown benefits for patients with reduced ejection fraction, but it also carries risks, such as post-cardiotomy shock. Pre and intraoperative strategies, like levosimendan preconditioning, on-pump beating-heart technique, comprehensive revascularization, and backup mechanical support, aim to optimize outcomes. Tailored multidisciplinary (Heart-Team) approaches minimize the risks while maximizing outcomes in high-risk patients.*

***Key words:** Coronary artery bypass grafting; Left ventricle ejection fraction, low; on-pump beating heart surgery.*

*El manejo de pacientes con cardiopatía isquémica y fracción de expulsión reducida continúa siendo todo un reto a pesar de los avances médicos. La revascularización miocárdica ha demostrado ser de beneficio para pacientes con fracción de expulsión reducida, sin embargo, no está libre de riesgos, tales como el síndrome de estado de choque post-cardiotomía. Para optimizar resultados, se recomiendan múltiples estrategias prequirúrgicas e intraoperatorias, tales como pre-acondicionamiento con levosimendan, revascularización miocárdica con derivación cardiopulmonar a corazón latiendo, revascularización miocárdica completa, soporte mecánico circulatorio de respaldo. El abordaje individualizado por un equipo multidisciplinario (Heart-Team) reduce significativamente los riesgos, maximizando los resultados en este tipo de pacientes.*

***Palabras clave**: Cirugía de revascularización coronaria; Fracción de expulsión del ventrículo izquierdo, baja; Cirugía en bomba a corazón latiendo.*

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Despite advancements in medical therapies and surgical techniques, managing patients with coronary artery disease (CAD) and low left ventricle ejection fraction (EF) remains a significant challenge. The current treatment options for these patients include intensive medical therapy, coronary artery bypass grafting (CABG), ventricular remodeling, and heart transplantation. In patients undergoing CABG, heart failure (HF) with reduced ejection fraction (HFrEF) is associated with a poor short-term and long-term prognosis, leading to an all-cause mortality rate of up to 7%. Consequently, it becomes a crucial factor in preoperative risk [1-3]. Studies from the 1980s, such as the Veteran Administration Cooperative Study, indicated that patients with reduced EF derive even greater benefits from surgical myocardial revascularization [4]. These findings were further supported by the long-term follow-up of the Surgical Treatment for Ischemic Heart Failure (STICH) trial, demonstrating a significant survival advantage for patients with poor ventricular function who undergo CABG [5].

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Patients with impaired left ventricular function undergoing CABG form a distinct subgroup, with mortality factors that may differ from those associated with traditional risk factors in CABG patients. Consequently, some surgeons may refrain from performing surgery on these patients due to the high risk of post-cardiotomy shock. While myocardial recovery following revascularization may take days to weeks to occur, patients may require high doses of inotropic and vasopressor support due to ongoing cardiogenic and/or metabolic shock, resulting in multiorgan failure and death. However, if patients can be preconditioned with levosimendan prior to surgery or receive appropriate support for early recognition of low cardiac output, excellent outcomes can be expected [6-8]. Yet, an absolute consensus on "the best" approach remains a topic of debate among experts. The use of cardiopulmonary bypass (CPB) and cardioplegic arrest during CABG can contribute to cardiac and systemic complications. Consequently, off-pump CABG has emerged as an alternative technique, particularly in cases of severely calcified ascending aorta. However, transitory hemodynamic instability caused by surgical manipulation, especially in severe coronary disease, may necessitate emergent conversion to on-pump conventional CABG, significantly increasing operative risk [9-11].

High-risk patients, such as those with recent myocardial infarction (MI), HFrEF, or poor hemodynamics, may benefit from an intermediate option that involves continuing to use CPB but eliminating the ischemic component of invasiveness by aboding aortic cross-clamping and maintaining a beating heart throughout the operation [12,13]. This CPB-assisted approach, introduced by Perrault et al. over 20 years ago [14], allows for the maintenance of coronary flow and reduced cardiac preload and afterload. Consequently, it decreases myocardial oxygen demand and provides a constant oxygen supply [15] leading to intraoperative hemodynamic stability without aortic cross-clamping and cardioplegic cardiac arrest. The mortality rate for patients with low LVEF undergoing on-pump beating-heart technique varies from 2 to 8% [9]. This case report aims to summarize and highlight our strategy for current surgical practice in high-risk patients.

## CLINICAL CASE

We present a case of a 43-year-old male without any significant past medical history, who presented with progressively worsening dyspnea over the past 6 months. He also developed orthopnea, paroxysmal nocturnal dyspnea, and occasional effort-related epigastric pain in the 2 weeks prior to hospitalization. The patient underwent several diagnostic tests that revealed severe systolic dysfunction with an LVEF of 26% and multiple segmental contractility defects on echocardiography; coronary angiography revealed multivessel disease; nuclear medicine imaging also showed a reduced ejection fraction of 17% with territories of viable myocardium (**Fig. 1**) (**Fig. 2**). Given his severe symptoms and reduced EF, the patient was considered a high-risk candidate for CABG surgery. To optimize his hemodynamics and myocardial function, he was given levosimendan as a preconditioning agent prior to surgery.

With mechanical circulatory support device in standby in the operating theatre, operation was performed through median sternotomy. Anesthetic management included norepinephrine infusion at 0.05-0.2 mcg/kg/min for mean arterial pressure target above 65 mmHg; and glucose- potassium-insulin solution at an infusion rate of 1 ml/kg/hr. Internal thoracic artery (ITA) and saphenous vein were harvested. CPB was established using ascending aortic cannulation and a two-stage venous cannulation through the right atrium. Heparin was administered and CPB started. The left anterior descending artery was exposed in hemodynamic stabilization, so it was revascularized first with ITA; then the operation was continued with the assisted normothermic beating heart. The distal anastomoses were constructed before the proximal anastomoses followed by the circumflex and right coronary arteries with venous conduits. Regional myocardial coronary targets were achieved with the aid of epicardial stitch and mobilization with a large gauze within it. Regional myocardial immobilization was achieved with a suction stabilizer (Octopus, Medtronic; Guidant Acrobat, Guidant). We did not use the apical suction cardiac positioning device. During anastomoses, target vessel homeostasis was obtained with temporary occlusion of the proximal coronary artery or intracoronary shunts (when suitable) (**Fig. 3**). Distal anastomoses were made with running sutures of 7–0 polypropylene. The proximal anastomoses were created with 6–0 polypropylene sutures under a partial occlusion clamp. After weaning from CPB and decannulation, protamine was given. Due to his hemodynamic conditions and uneventful course, we performed ultrafast-track protocol and continue patient care process in the ICU.

Postoperatively, the patient had an uneventful recovery and was closely monitored for any complications. On the fourth day posterior to surgery the patient was started on guideline-directed medical therapy for heart failure, includ-

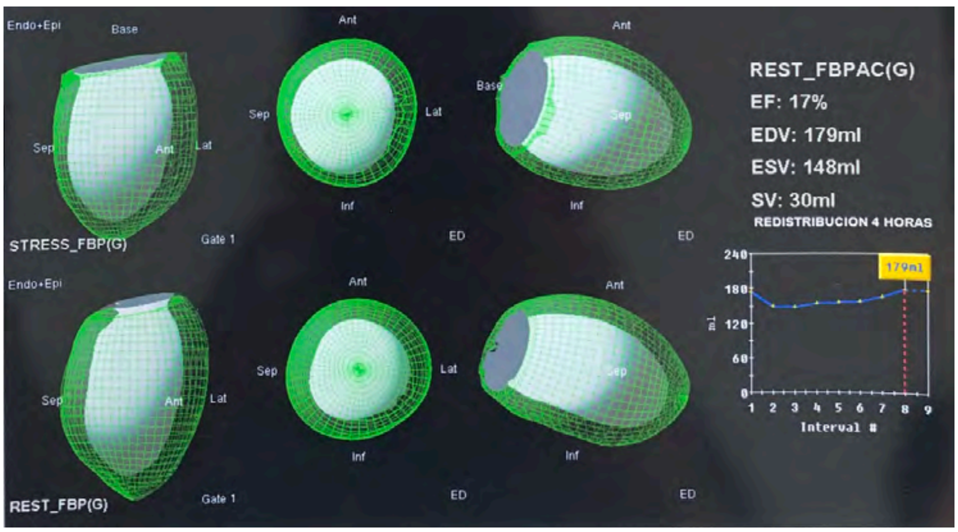


*Figure 1. Nuclear medicine imaging showing a reduced ejection fraction of 17%.*

ing a neprilysin inhibitor, angiotensin receptor blocker, beta-blocker, sodium-glucose co-transporter 2, diuretic and aldosterone antagonist. Symptoms improved significantly, and he was able to be discharged home in stable condition after a few days. He was advised to continue cardiac rehabilitation and to adhere to a heart-healthy lifestyle to optimize his long-term outcomes.

## COMMENT

Patients who exhibit LV dysfunction, particularly those with significant areas of hibernating myocardium, tend to experience substantial improvements in LV function following CABG. Clinical trials conducted on randomized patient populations have highlighted the significant survival advantage observed in individuals with a low LVEF who undergo surgical revascularization [4,5]. It is worth noting that a dysfunctional LV with a low EF is a critical factor associated with higher risks of morbidity and mortality both during and after cardiac surgery [1-3]. At our center, we thoroughly assess patients with ischemic cardiomyopathy to determine their eligibility for CABG and anticipate the potential enhancement of myocardial function. This evaluation considers several factors such as the suitability of coronary arteries for distal anastomosis, the viability of myocardial tissue, the size and function of the left and right ventricles, as well as the patient´s functional status and symptoms. It is essential to emphasize the significance of a multidisciplinary (Heart-Team) approach in our center, where we conduct comprehensive reviews, assessments, and manage patients at every stage of diagnostic tests and treatment.

*Coronary Assessment*

The potential benefits of CABG rely heavily on two key factors: the quality of the coronary targets and the severity of coronary ischemia. For significant improvement to be expected after revascularization, it is crucial that dysfunctional segments of the myocardium correspond to the ischemic territories of the coronary arteries. Generally, target vessels with stenosis exceeding 70%, adequate blood flow, and diameter equal to or larger than 5F angiography catheter are consider suitable for revascularization. The more severe the stenosis and the larger the target vessel and blood flow, the higher the potential for enhanced myocardial function.

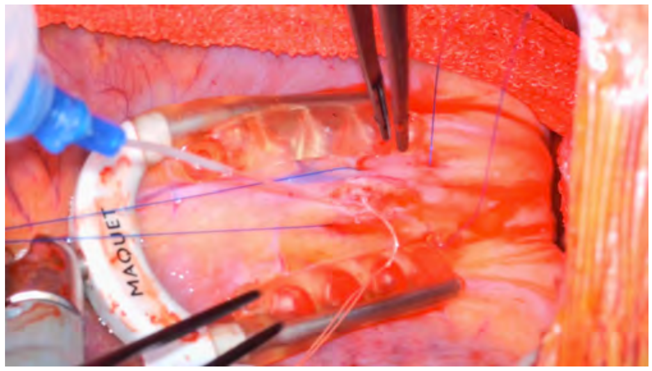


*Figure 3. Mobilization of heart; exposure and stabilization of target vessel with techniques similar to those utilized in off-pump CABG; we can see the epicardial stitch with the gauze within, myocardial regional immobilization with a stabilizer, intracoronary shunt device.*

*Myocardial Viability Assessment [16,17].*

In the context of ischemia, myocardial dysfunction undergoes a progression from stunning to hibernation and eventually leads to scar formation. Stunned and hibernating myocardium are considered viable and have the potential to improve upon revascularization, whereas myocardial scar tissue does not. The viability of myocardium can be assessed either physiologically or anatomically. Physiological assessment involves the use of resting and stress positron emission tomography (PET) with fluorodeoxyglucose, which evaluates both myocardial perfusion and metabolic activity. Normal perfusion indicates viable myocardium, while decreased perfusion with preserved metabolic activity suggests viable myocardium with delayed recovery. However, decreased perfusion along with decreased metabolic activity indicates myocardial scar that would not benefit from revascularization. Anatomical assessment of viability is best accomplished through magnetic resonance imaging (MRI) with delayed gadolinium enhancement. MRI provides the advantage of assessing the thickness of myocardial scar, which typically starts in a subendocardial pattern in ischemic cardiomyopathy. Mid-myocardial or epicardial distribution of scar suggests a different underlying cause than ischemia. Myocardium without scar or with scar limited to less than 25% of the full wall thickness has the greatest potential for improvement, whereas scar exceeding 50% of the myocardial thickness has limited potential for improvement. In cases where MRI is not available, echocardiography can provide information on the thickness of myocardium. While MRI is our preferred modality for viability assessment, it may be challenging to obtain in patients with incompatible implanted devices. In such cases, PET scans can serve as a reasonable alternative. It is important to note that even in the presence of viability, patients with left ventricular end-diastolic diameters greater than 65 mm may have a reduced likelihood of successful myocardial recovery, particularly when coupled with the presence of thinned myocardium.

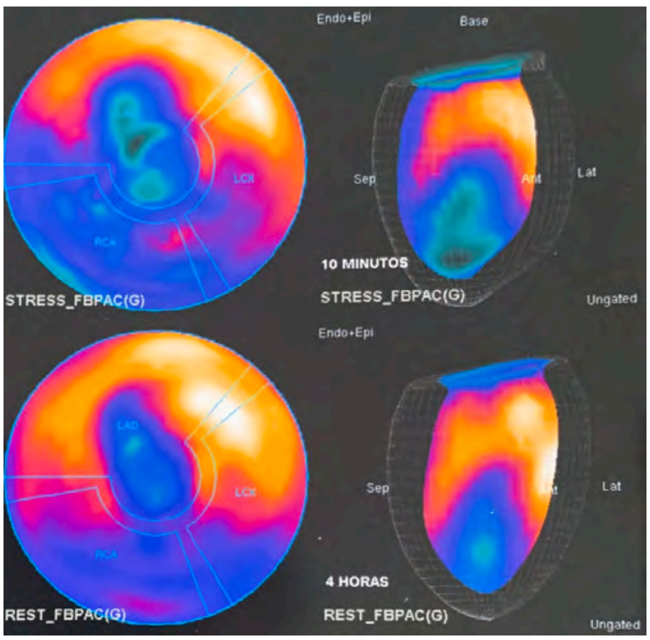


*Figure 2. Nuclear medicine imaging showing viable myocardium.*

***Levosimendan preconditioning***

The efficacy of levosimendan in mitigating risk has been the subject of scrutiny in three recent large-scale randomized trials; namely, LICRON [18], LEVO-CTS [19] and CHEETA [20]. Despite the absence of conclusive evidence indicating a significant decrease in mortality among the levosimendan-treated group, a post hoc analysis of the LEVO-CTS study identified potential benefits exclusively for patients undergoing CABG [6].

The strategic initiation of levosimendan infusion 48 hours prior to surgery is designed to optimize the bioavailability of its active metabolites during a crucial timeframe characterized by intensified myocardial stunning. Specifically, this approach focuses on the initial 24 hours of the immediate postoperative phase, which is known to be particularly critical. By implementing this timing strategy, the prevention of postoperative low cardiac output is achieved, highlighting its positive impact across various stages of preoperative systolic dysfunction. In addition to its sustained hemodynamic effects, levosimendan exhibits an inhibitory effect on intramitochondrial calcium accumulation, a process associated with the ischemia-reperfusion phenomena encountered during extracorporeal circulation. This mechanism confers an additional myocardial protection [6].

Surgical preparation and conduct

We ensure the presence of a backup mechanical circulatory support device such as CardiohelpR ECMO (Maquet Getinge Cardiopulmonary AG, Rastatt, Germany) and/or IMPELLAR (Abiomed Inc., Danvers, MA, USA), as a precautionary measure, ready to be utilized if need arises. Its presence is crucial to address any potential requirements during the course of the surgery [8,21,22]. CABG is performed through a median full-sternotomy approach. We dissect the ITA as a pedicle, considering it the first choice for revascularization of the left AD coronary territory. For suitable cases, saphenous vein grafts and radial arteries are harvested using either open or endoscopic techniques. Our focus lies in achieving comprehensive revascularization across all coronary territories. To establish CPB, we initiate cannulation of the ascending aorta and right atrium after administering systemic heparinization, ensuring an Active Coagulation Time (ACT) of more than 480 seconds. We maintain normothermia without the use of aortic cross-clamp an strive to maintain arterial blood pressure above 50 mmHg. To expose the anterior, lateral, posterior, and inferior walls of the heart, we employ exposure, stabilization, and immobilization techniques similar to those utilized in off-pump CABG procedures [10,11,13,14]. In cases where required, we utilize a $CO_2$ blower/mister device and/or intra-coronary shunts during grafting. Following weaning from CPB, we evaluate the need for mechanical circulatory support if patients exhibit moderate to high doses of two inotropic supports or high doses of a single inotropic support to achieve a cardiac index of 2.2 Lt/min/m2 [8]. In the postoperative period, we prioritize the timely extubation with ultra-fast track protocols, promoting early mobilization whenever feasible.

In conclusion, the decision to proceed with CABG in patients with impaired LV function can be challenging due to the associated risks, including post-cardiotomy shock. To optimize outcomes in high-risk patients, a multidisciplinary approach that includes careful coronary and myocardial viability assessments is essential. Surgical preparation and conduct for CABG in high-risk patients involve comprehensive revascularization, careful hemodynamic management, and the presence of backup mechanical circulatory support devices. The goal is to achieve successful myocardial recovery while minimizing operative risks and complications. At our Heart-Team, we prioritize incorporating the on-pump beating heart revascularization technique to optimize outcomes for high-risk, patients with low ejection fraction undergoing CABG. With this technique we provide a tailored approach aiming to maximize myocardial recovery and minimize the potential risks associated with cardioplegic arrest by performing revascularization on the beating heart with the assistance of cardiopulmonary bypass.

A comprehensive approach that combines careful patient selection, myocardial viability assessment, and the strategic use of adjunctive therapies such as levosimendan further contributes to successful outcomes in high-risk patients undergoing CABG. The choice of CABG technique for patients with low ejection fraction should be based on a collaborative decision-making among the multidisciplinary team that will optimize outcomes and enhance the quality of care provided to this specific patient population.

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