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# Total coronary revascularization via left anterior thoracotomy: a novel approach to achieving comprehensive coronary revascularization

## *Revascularización coronaria total a través de toracotomía anterior izquierda: un nuevo enfoque para lograr una revascularización coronaria completa*

Gustavo A. De La Cerda-Belmont,[*,‡] Arturo Garza-De La Maza,[*,§] María G. Cepeda-Flores,[*,¶] Jorge A. Chávez-De La Mora,[*,‖] Claudia E. González-Zúñiga,[*,‖] Roberto M. Vázquez-González,[*,‡] César A. Morales-Marín,[*,‡] Fabiola Buelna-Gaxiola,[*,§] Gerardo M. Flores-Morín,[*,**] Eliasib Pedroza-Solís[*,‡]

* NOVOCARDIO, Monterrey, Nuevo León, México.
‡ Department of Thoracic and Cardiovascular Surgery, Minimally Invasive Cardiac Surgery.
§ Department of Cardiovascular Intensive Care Unit.
¶ Department of Cardiovascular Anesthesia.
‖ Department of Interventional Cardiology.
** Emergency Department.

### ABSTRACT

Coronary artery bypass grafting (CABG) has been the cornerstone for myocardial revascularization. However, rising demand for less invasive procedures, such as percutaneous coronary intervention (PCI), has challenged its dominance. The emergence of total coronary revascularization via left anterior thoracotomy (TCRAT) presents a groundbreaking alternative. TCRAT achieves complete revascularization through a minimally invasive approach, leveraging left anterior thoracotomy, cardiopulmonary bypass, and peripheral cannulation. Its safety and efficacy mark a transformative shift in coronary artery disease management.

**Keywords:** coronary artery bypass grafting, coronary artery disease, minimally invasive cardiac surgery.

### *RESUMEN*

*La cirugía de bypass de arteria coronaria (CABG) ha sido la piedra angular para la revascularización miocárdica. Sin embargo, la creciente demanda de procedimientos menos invasivos, como la intervención coronaria percutánea (PCI), ha desafiado su dominio. La emergencia de la revascularización coronaria total vía toracotomía anterior izquierda (TCRAT) presenta una alternativa revolucionaria. TCRAT logra una revascularización completa a través de un enfoque mínimamente invasivo, aprovechando la toracotomía anterior izquierda, el bypass cardiopulmonar y la canulación periférica. Su seguridad y eficacia marcan un cambio paradigmático en el manejo de la enfermedad arterial coronaria.*

***Palabras clave:*** *bypass aortocoronario, enfermedad arterial coronaria, cirugía cardiaca mínimamente invasiva.*

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**Correspondence:** Dr. Gustavo Armando De La Cerda Belmont. E-mail: guar20382@hotmail.com

Coronary artery bypass grafting surgery (CABG) has been a cornerstone in treating coronary artery disease for over half a century.[1] Despite significant advances in coronary artery disease management, especially in percutaneous interventions and perioperative care, the core techniques of CABG have undergone minimal evolution. Notably, the use of the left internal mammary artery (LIMA) to revascularize the left anterior descending artery (LAD) marks a pivotal advancement in CABG.[1] Despite its unchanged nature, CABG remains the gold standard for myocardial revascularization, particularly for patients with complex coronary artery pathology,[2-6] with a sternotomy approach being the predominant choice globally.[7-9] However, there has been a substantial surge in demand for percutaneous coronary intervention (PCI) and less invasive procedures over the last two decades due to patient attractiveness.[6,10] The preference for PCI over CABG is attributed to perceptions of invasiveness and patients' short- and long-term preferences.[11] Despite evidence favoring CABG, its growth has stagnated, while PCI procedures have tripled and continue to rise.[5,6] Robotic endoscopic CABG and minimally invasive cardiac surgery (MICS) CABG have been introduced to reduce invasiveness, yet their adoption remains limited due to technical complexities and infrastructure requirements.[5,7,9,12-15] Offering complete revascularization through minimally invasive techniques remains challenging despite their effectiveness, highlighting the ongoing need for advancements in surgical approaches.[5,12,16,17]

Until 2019, no technique systematically addressed the challenge of complete revascularization while preserving key surgical principles and wide applicability for most patients. Babliak et al. proposed a new operative approach called "total coronary revascularization via left anterior thoracotomy (TCRAT)" in 2019.[18] Based on established cardiac surgery concepts and insights from minimally invasive cardiac surgery, this technique utilizes a small left anterior thoracotomy for revascularization in multivessel coronary diseases. TCRAT represents a promising advancement in achieving comprehensive coronary revascularization through minimally invasive means. We describe how we are applying this technique in our center.

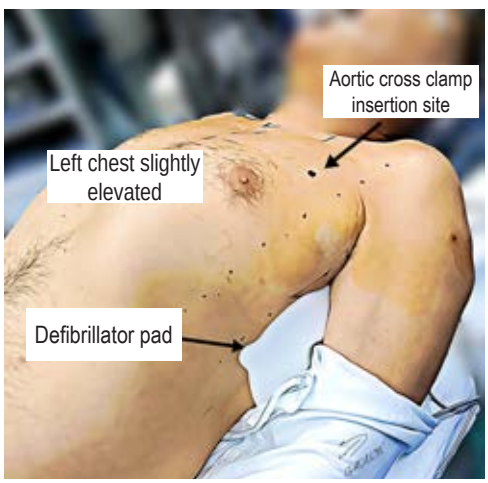


Figure 1: Supine patient, mild elevation of the left chest. Notice the colocation of the defibrillator pad prior to anesthetic induction.

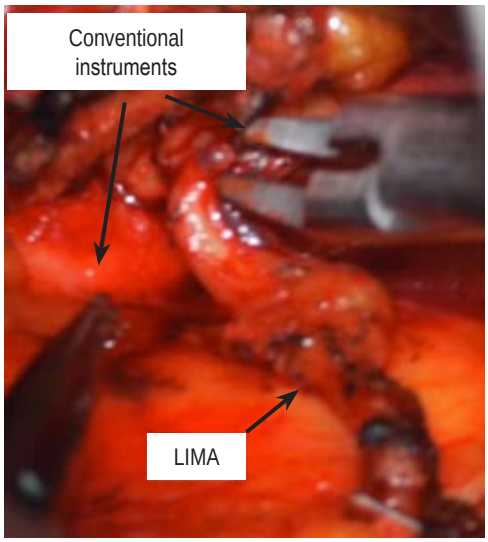


Figure 2: Surgeon's view of the left internal mammary artery; harvesting is accomplished with long conventional instruments.

## Preoperative evaluation

Thorough preoperative planning is essential for ensuring the success of surgeries, especially in minimally invasive cardiac surgery. Identifying potential complications ahead of time allows for proactive intervention, minimizing obstacles to the patient's recovery. Specific preoperative conditions such as chronic lung diseases, cerebrovascular diseases, peripheral artery disease, chest wall abnormalities, lung irradiation, and prior cardiac and/or lung surgeries warrant particular attention. Standard preoperative assessments for these cases involve various diagnostic procedures including electrocardiogram, chest X-Ray, complete blood laboratory tests, echocardiogram, and cardiac catheterization, mirroring those performed in cases requiring full sternotomy. However, it is important to note that there may be variations in preoperative investigations for standards CABG. The significance of computed tomography (CT) in the preoperative assessment of minimally invasive procedures cannot be underestimated.[19-21] CT scans provide invaluable insight into the patient´s anatomy, facilitating the safe execution of surgeries. Detailed information about the lungs, airway, chest wall, mediastinum, heart, major blood vessels, and peripheral vascular anatomy is obtained through

CT scans. Notably, CT findings related to peripheral artery disease are of particular importance, as they can influence the chosen surgical approach, especially in peripheral cannulation (transaxillary or transfemoral), and must be carefully considered during the planning phase.

## Surgical technique[18,22-24]

Patients are positioned supine with the left chest slightly elevated to optimize exposure of LIMA and the heart *(Figure 1)*. The saphenous vein is harvested using a disposable endoscopic retractor and a bipolar radiofrequency vessel sealing system (Vasoview Hemopro, Getinge, Sweden), through a 2.5 cm incision made at the medial surface of the knee.

TCRAT is conducted via a left mini-thoracotomy, which entails a 5 to 8-cm skin incision positioned on the fourth intercostal space, obviating the necessity for rib resection. A small thoracic retractor is introduced through the mini-thoracotomy, facilitating the identification, clipping, and sectioning of LIMA. Before clipping LIMA, 8,000 units of heparin are administered intravenously. Concurrently, access

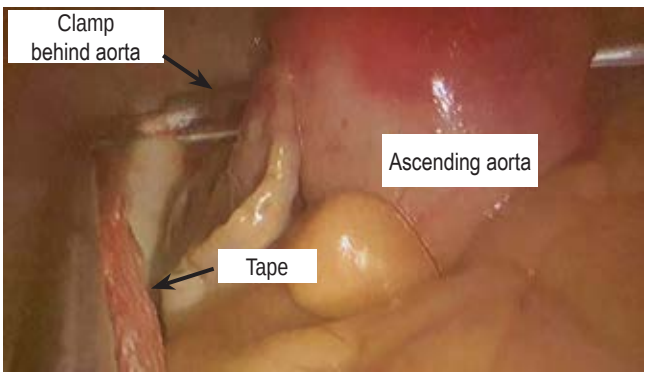


Figure 3: Ascending aorta encircled with tape.

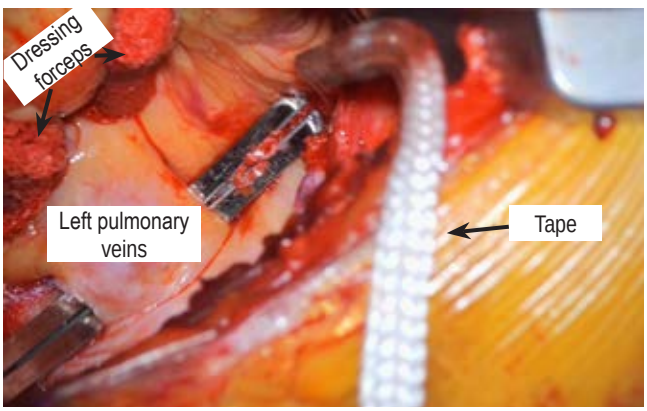


Figure 4: Left pulmonary veins encircled with tape.

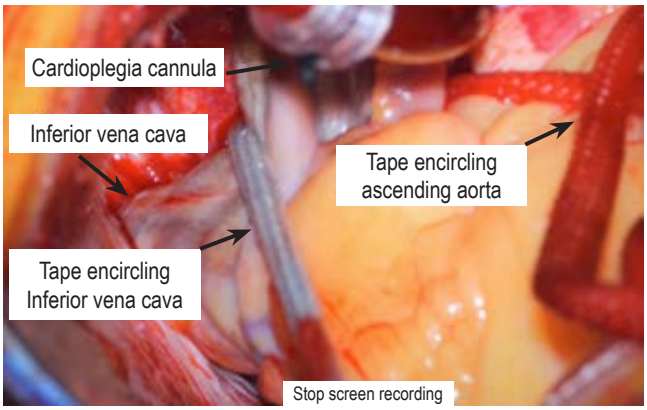


Figure 5: Inferior vena cava encircled with tape.

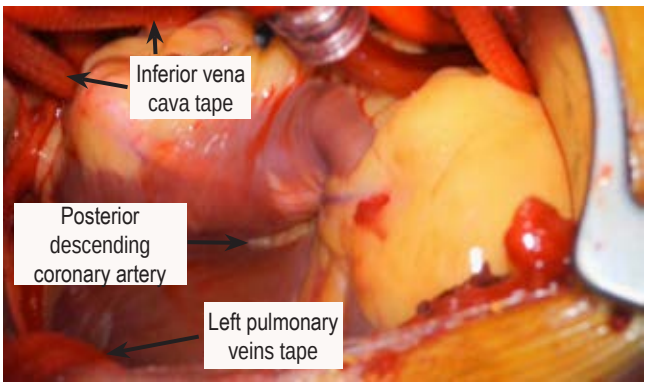


Figure 6: Surgeon's view of the right coronary territory exposure maneuver, notice the feasible access to the inferior surface of the heart.

to the femoral vessels is attained through a 1 cm inguinal incision, and femoral venous and arterial cannulation is accomplished utilizing dedicated cannulae. The placement of these cannulae is always guided by transesophageal echocardiography and in some instances, fluoroscopy. In cases where indicated, access to the axillary artery is achieved through a 2 cm subclavian incision and cannulated using an 8 mm vascular graft.

LIMA harvesting is conducted under direct surgical visualization using long conventional instruments and a specialized internal mammary artery (IMA) retractor (Delacroix-Chevalier, MIDAccess IMA Retractor) *(Figure 2)*. Upon completion of LIMA harvesting and cannulation, heparinization is adjusted to 300 units per kilogram, and cardiopulmonary bypass is initiated employing vacuum-assisted drainage.

The pericardium is longitudinally opened from the apex to the ascending aorta and widely to the sides, with careful attention to avoid injury to the phrenic nerve. The ascending aorta is dissected and freed from the pulmonary arteries,

encircled with tape *(Figure 3)*, and subsequently maneuvered toward the thoracic incision to facilitate the insertion of the cardioplegia cannula. A transthoracic aortic clamp is introduced through the left second intercostal space, between the midclavicular and anterior axillary lines. Under direct vision, the aorta is cross-clamped, and antegrade cardioplegia is administered to achieve cardiac arrest.

Following cardiac arrest, cessation of cardioplegia infusion, and once complete decompression of the heart are achieved, the heart is mobilized with dressing forceps, and left pulmonary veins *(Figure 4)* as well as inferior vena cava *(Figure 5)* are encircled with tapes.

To achieve optimal exposure for coronary artery bypass grafting, specific maneuvers are employed to rotate the heart effectively. These maneuvers are orchestrated to facilitate surgical access to different coronary territories. A detailed description is as follows:

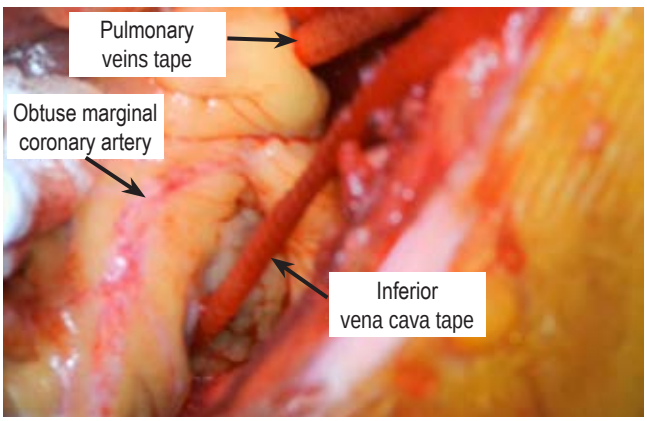


Figure 7: Surgeon's view of circumflex coronary territory exposure maneuver, notice the feasible access of the lateral surface of the heart and exposure of obtuse marginal coronary artery.

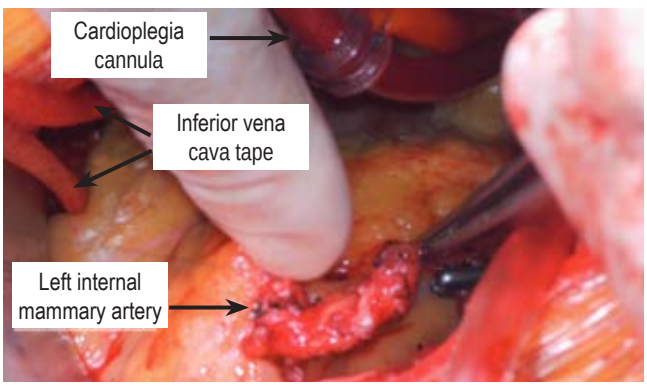


Figure 8: Surgeon's view of the left anterior descending coronary territory exposure maneuver, notice anastomosis being tied without the aid of any special instrument.

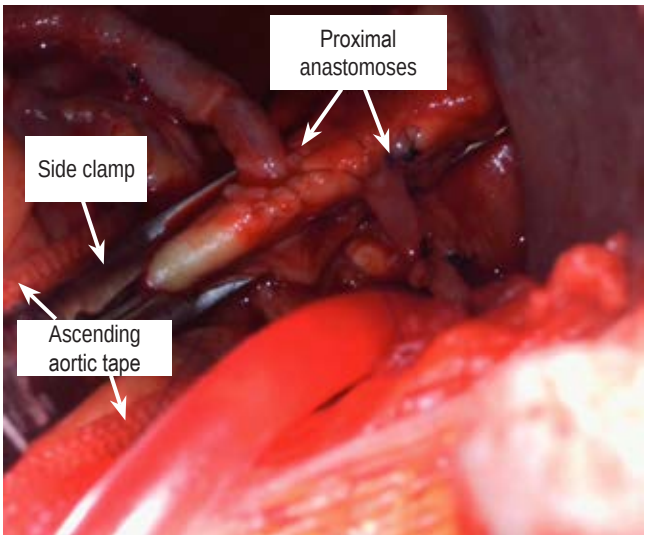


Figure 9: Surgeon's view of proximal anastomosis maneuver using a conventional aortic side clamp.

### Right coronary territory exposure:

1. The left pulmonary vein tape is moved under the heart and towards the inferior vena cava.
2. Simultaneously, traction is applied to both the left pulmonary veins and inferior vena cava tapes in a downward direction.
3. This maneuver induces a rotation of the heart, enabling the exposure of the posterior descending artery up to the right coronary artery *(Figure 6)*.

### Circumflex territory exposure:

1. Initially, the inferior vena cava tape is shifted under the heart towards the left pulmonary veins.
2. Subsequently, traction is applied simultaneously upwards on both the left pulmonary veins and inferior vena cava tapes.
3. This maneuver induces a rotation of the heart, enabling the exposure of the lateral wall for access to the circumflex territory *(Figure 7)*.

### Left anterior descending territory exposure:

1. To access the left anterior descending territory, a simpler maneuver is executed.
2. Traction is applied downwards on both the left pulmonary veins tape and the inferior vena cava tape *(Figure 8)*.

Once the desired anastomosis is completed, traction is discontinued, allowing the heart to return to its original

position. Anastomoses are performed using standard coronary instruments and the standard anastomotic technique of running sutures. The average distance from the skin to coronary anastomoses ranges from 6 to 8 cm. Proximal vein anastomoses to the aorta are facilitated using a side clamp while pulling downward on the ascending aorta tape *(Figure 9)*. These meticulous traction and rotation maneuvers ensure adequate and stable exposure of any coronary target, irrespective of ventricular localization; this configuration is outlined in *Figure 10 and 11*.

## COMMENT

In Mexico, the field of minimally invasive cardiac surgery has yet to witness complete revascularization through surgical means, with only a handful of previous reports detailing incomplete revascularization procedures.[25-27] However, the introduction of the TCRAT technique marks a significant leap forward. Proposed by Babliak et al. in 2019,[18] this pioneering method integrates insights from minimally invasive cardiac surgery and adheres to established cardiac surgery principles, offering a promising avenue for achieving comprehensive coronary revascularization while minimizing the invasiveness associated with traditional approaches.

The TCRAT technique, characterized by precise maneuvers, ensures adequate and stable exposure of any coronary target identified preoperatively by the heart team for revascularization. Regardless of ventricular localization, this approach enables complete anatomical revascularization with unparalleled dexterity, ensuring optimal graft placement and functional outcomes for every patient.

The advent of TCRAT heralds a new era in the management of coronary artery disease in Mexico, presenting patients with a viable alternative to traditional surgical methods while maintaining the highest standards of safety and efficacy. As the first manuscript documenting such an experience in Mexico, TCRAT not only broadens the horizons of cardiac surgeons but also lays the groundwork for future innovations in minimally invasive cardiac surgery. Furthermore, its reproducible technique ensures that this groundbreaking approach can be embraced and enhanced by any cardiac surgical team, solidifying its status as a transformative milestone in cardiovascular care.

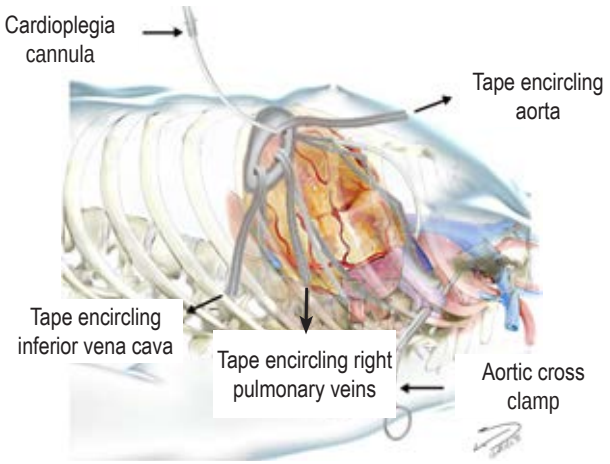


Figure 11: Schematic drawing of tapes that encircle heart structures for maneuvers employed to rotate the heart.

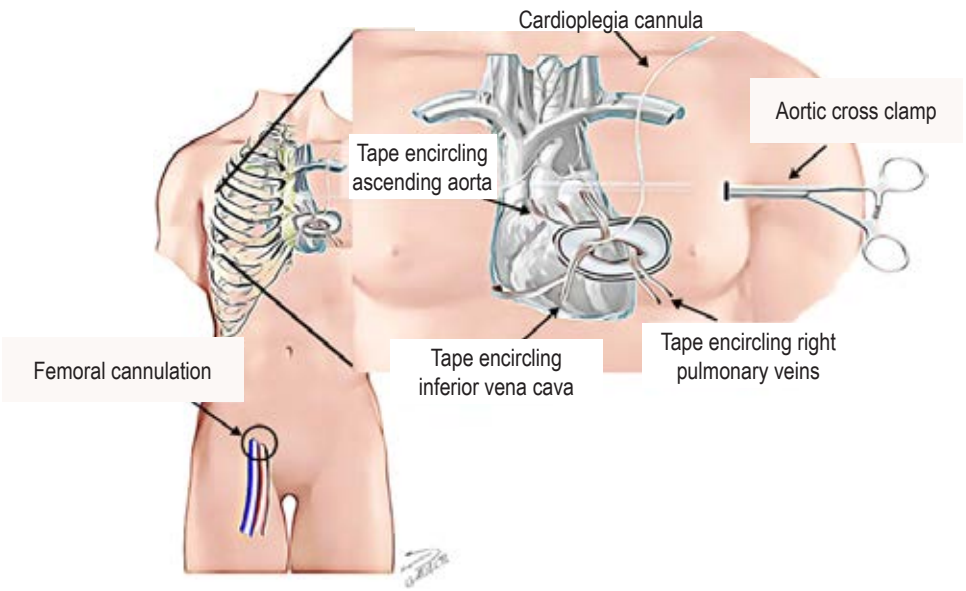


Figure 10:

Schematic drawing of intraoperative setup for total coronary revascularization via left anterior thoracotomy. Notice skin incision through the fourth intercostal space.

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