

# Minimally Invasive Coronary Artery Bypass Grafting

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Limited access, off-pump coronary artery bypass grafting for revascularization of all the various coronary arteries is an acceptable alternative to standard on-pump coronary bypass grafting through sternotomy. A variety of small, targeted incisions are used to approach various coronary locations. Technical advances in conduit harvesting, stabilization, cardiac positioning devices, and anastomotic connectors have made these procedures more standardized and replicable. This has resulted in reduced morbidity as a consequence of less invasive approaches. These efforts have paved the way for the ultimate goal of same day surgical coronary revascularization.

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The idea of grafting the left internal mammary artery (LIMA) to the left anterior descending artery (LAD) via thoracotomy without the aid of cardiopulmonary bypass (CPB) was first explored by Kolessov in 1967.<sup>1</sup> Unsatisfactory results and the emergence of CPB and cardioplegia, which allowed for a motionless and bloodless field, resulted in little enthusiasm for Kolessov's idea. Over the last two decades, with the emergence of percutaneous procedures, surgeons have found new enthusiasm for developing strategies for surgical revascularization avoiding the deleterious effects of CPB and median sternotomy.

In November 1994, at the international workshop on arterial conduits for myocardial revascularization held in Rome, Italy, Dr. V.A. Subramanian reported his group's early experience in LAD grafting via minithoracotomy without CPB. This procedure rapidly became popular, and the first large multicenter trial was reported at the American Heart Association meeting in November 1995.<sup>2</sup> In the 12 years since that report, minimally invasive direct coronary artery bypass (MIDCAB), though not adopted across the board, has been pursued by some who have standardized the procedure. Technical advances in stabilization and robotic assisted internal mammary artery (IMA) harvesting have made this procedure more adoptable. Also, the advent of drug eluting stents has generated enthusiasm for hybrid revascularization in patients with multivessel disease. In this approach, a variety of small targeted incisions are used to approach various coro-

nary artery targets (Fig. 1). In this article, we share our institution's experience of MIDCAB over the last 13 years.

## Anterior MIDCAB

The initial approach used for limited access coronary artery revascularization was an anterior exposure of the heart for grafting to the mid-distal LAD with an in situ LIMA conduit. This still remains the most common application and approach for MIDCAB procedure.

## Surgical Technique

### Patient Positioning

Patients are placed in the anterolateral decubitus position with a 20 to 30° tilt with a roll underneath the left scapula. This positioning is used because with the Thorlift IMA retractor (U.S. Surgical, Norwalk, CT), it creates a better visual tunnel needed for exposure.

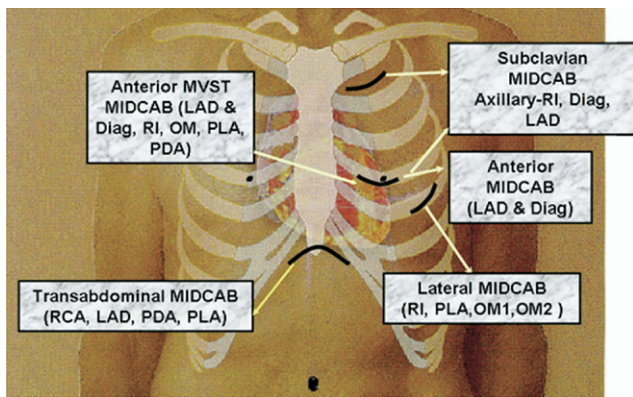
### Incision

The initial approach used was an 8 cm incision placed directly over the anterior aspect of the fourth costal cartilage medial to the nipple. Part of the fourth costal cartilage is excised by bone rongeur leaving the perichondrium intact. Alternatively, the entire costal cartilage can be removed by starting the excision laterally at the costochondral junction and disarticulating the medial end from the sternochondral junction. This incision, with rare exception, has not been used for the last 8 years. The reasons for abandoning this approach were twofold. First, it led to difficulty in harvesting an adequate length of the LIMA. Second, postoperative pain was greater due to removal of the costal cartilage. Currently, we use a submammary incision over the fourth intercostal

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**Figure 1** Various MIDCAB incisions with target vessels. (Color version of figure is available online at <http://www.semthorcardiovascsurg.com>.)

space, with two-thirds of the incision medial and one-third of the incision lateral to the nipple. The length and exact position of the incision depends on the site of the distal target. When the IMA is dissected by robotic assistance, the incision is guided by thoracoscopic examination of the target vessel.

### Internal Mammary Artery Harvesting

After identifying the IMA at the medial end of the incision, the Thorlift (U.S. Surgical) LIMA retractor (Fig. 2) is used to expose the IMA. Mobilization of the IMA is performed from a lateral approach (essentially a mirror image of the technique commonly used via median sternotomy). First, an incision is made in the endothoracic fascia on the lateral aspect of the left internal mammary vein (IMV), and then the IMA is dissected in a pedicle fashion (or more recently in a skeletonized fashion) using the fascia to retract the IMA. The left IMV is routinely divided at the origin of the innominate vein. Two distinct medial pericardial branches of the IMA lateral to the phrenic nerve are routinely divided. The distal IMA is then harvested by reversing the retractor. Isolation of a sizable length of the IMA is an essential component of the MIDCAB operation because it

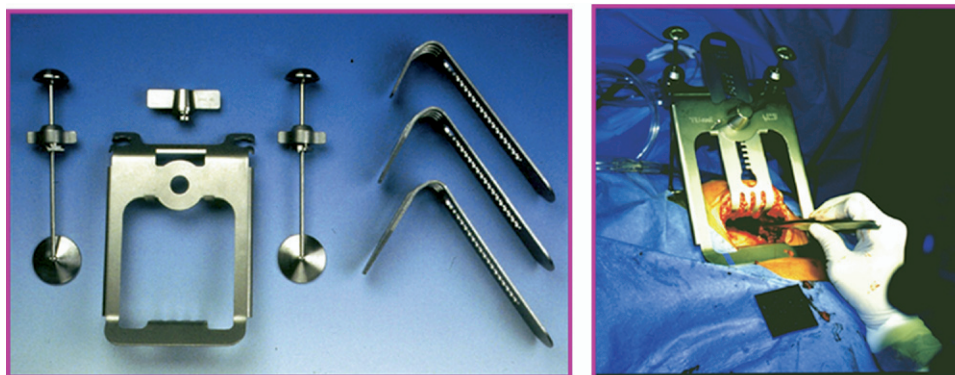
1. avoids kinking that occurs at the chest wall takedown site when a short IMA is harvested;

2. allows a tension free anastomosis, avoiding graft avulsion;
3. reaches the LAD in a large transverse heart or in patients with COPD with large residual lung volumes;
4. avoids the need to extend the LIMA with other conduits;
5. reaches the distal third of the LIMA in cases with in-stent restenosis;
6. allows sequential grafting to a large diagonal artery.

In the last 6 years, we have used robotic assistance to harvest the IMA for anterior MIDCAB in over 90% of our cases. Efforts have been made to harvest the IMA with conventional video assisted thoracoscopic instruments, but this technique is limited by lack of precision due to a fulcrum effect of the instruments at entry into the thoracic cage and a limited range of motion of the instruments. Introduction of robotic-assisted endowrist in the Da Vinci system (Intuitive Surgical, Sunnyvale, CA) has allowed harvesting the entire length of the IMA endoscopically.<sup>3,4</sup> An advantage of this approach is that robotic indexing allows surgeons to maintain a comfortable and ergonomic arm position at the console while performing IMA dissection. While operating from the master console, the surgeon experiences no discomfort or fatigue caused by instrument torque, a common occurrence with manual videoscopic IMA harvesting. The controller software also eliminates the fulcrum effect of reversing instrument direction. This digital manipulation restores the natural hand motions of the open harvesting technique. These advantages have the effect of shortening the learning curve of totally endoscopic LIMA harvesting.<sup>5</sup> Also, the incision for the subsequent MIDCAB can be directed after examining the target vessel, resulting in a very small atraumatic incision requiring only soft tissue retraction.<sup>6</sup>

### Exposure of Left Anterior Descending Artery and Diagonal Artery

The chest incision is retracted with a CTS retractor (Cardio Thoracic Systems; Maquet Cardiovascular, San Jose, CA), although we occasionally use the low-profile MIDCAB retractors (Genzyme or Estech Corporation, Danville, CA). The pericardium is incised about 1 finger breadth lateral to the IMA pedicle and



**Figure 2** Thorlift (U.S. Surgical) retractor for direct IMA harvesting in anterior MIDCAB. (Color version of figure is available online at <http://www.semthorcardiovascsurg.com>.)

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