**Intramyocardial LAD; Relevant Morphological/Anatomical Features and**

**Stepwise Technique for Optimal Surgical Exposure**

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**Abstract**

Exposure of the embedded intra mural left anterior descending (LAD) coronary artery remains quite challenging especially for inexperienced surgeons. The main focus of this short review is thus to summarize both the relevant morphological characteristics and the already illustrated techniques for surgical exposure in English literature. We then propose a step by step rational and reproducible approach to successfully expose the intramural LAD artery for bypass and successfully tackle avoidable difficulties.

Keywords: Left anterior descending; Surgical exposure; Coronary arteries

**Introduction**

Coronary arteries in humans usually have an epicardial course and may be easily identified. However, it is not uncommon that the artery passes intramyocardially, through variable depth and length through the epicardium and the underlying myocardium, thereby making it difficult for detection. Myocardial bridging refers to a coronary artery, which is covered by a myocardial bundle and is considered to be an inborn abnormality. This condition is more frequently encounted in the LAD [1]. It is well known that the LAD is the most important artery for coronary revascularization procedure. It is predominantly grafted by left internal mammary artery, what is considered as a gold standard of coronary bypass surgery. Identification of the embedded LAD remains a challenge for young surgeons and different techniques have been proposed for the exposure of the intramural LAD. We here describe the different techniques published, the morphological aspect of myocardial bridges and finally our proposed approach for the exposition of the embedded LAD.

**Morphological and anatomical relevant data**

The true prevalence of myocardial bridging in human species is not exactly known. The reported values differ significantly according to the techniques used to identify the embedded vessel, the predetermined cut off value of the thickness of the bridging muscle, the cause of death of the cardiac specimen studied, the underlying pathology (HCOM, cardiac transplant recipient) and the population studied [2].

The tunneled intramuscular course can be of variable depth and length with a spectrum of presentations that extends from easily found sub epicardial localization to an intracavity vessel.

The LAD has the highest overall incidence and reported as high as 72% (57% concerning the mid LAD and 15% concerning the distal LAD) [3].

The bridged segment is of variable length as reported by Apostolaskis et al. [4] and usually varies between 10 mm to 30 mm. The depth is also reported to be variable from few tenth of mm to the intra cavity form.

Autopsy series reveal that superficial bridges originate mostly from bundles of the right ventricle that cross the LAD at an angle of 90° or less along their course towards the apex of the left ventricle. These superficial fibers usually don't interfere with the position of the LAD. Inversely, deep bridges usually deviate the LAD toward the right ventricle and this can be explained by the fact that both ventricles are quite thin at the level of the interventricular groove.

Ferreira et al. [5] reported the existence of a longitudinal bundle arising from the apex of the right ventricle and anchoring on the interventricular septum crosses the LAD mostly obliquely or helically. This layout can be responsible for the systolic distortion and delayed diastolic opening of the artery. According to Azorides [6], this phenomenon can be responsible for recurrent episodes of ischemia and even sudden death.

As confirmed by Polacek [7], it is important to note that the great cardiac vein maintains a sub epicardial route and thus can be used as a major landmark in finding the intramural LAD. The proximal LAD is usually found to the left of the pulmonary root. The diagonal branches on the other hand, may also be intramural and go deep beneath the great cardiac vein.

The bridged LAD is typically free from atherosclerosis and has reduced medio-intimal thickness. However, it is commonly accepted that the LAD before the bridged segment, is usually concerned by atherosclerosis development. Thus, exposition of the intramural LAD is frequently required during bypass surgery.

Preoperative imaging can reasonably predict an intramural course and the "milking" of the LAD is considered to be pathognomonic. Subepicardial arteries normally have a serpentine course on the angiography with discrete systolic compression.

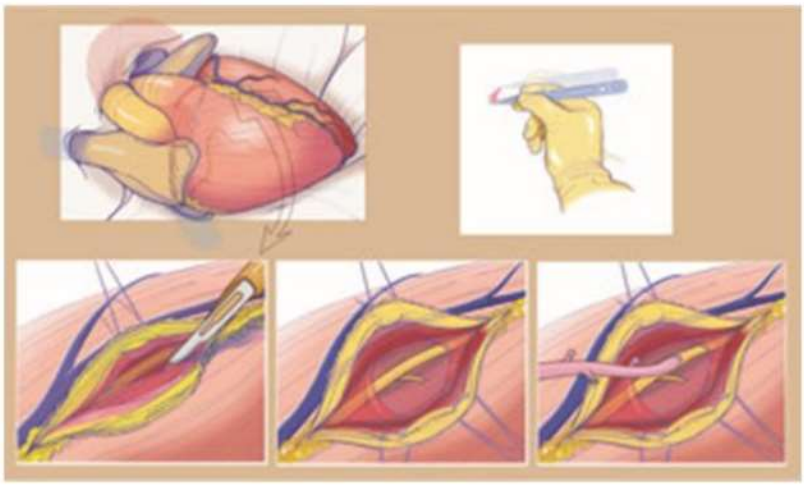

**Figure 1**: Exposure of the IMLAD: 1) Stay suture on both side of the epicardial trench, shaving of superficial tissue with No. 15 blade. 2) Exposure of the target spot on the IMLAD. 3) Anastomosis completed and graft lying in the groove.

Any proximal right-angle change of its course in the lateral oblique view is highly suggestive of the artery diving in the septum and having an intramyocardial course. If the artery exits at right angle from its deep location, dep or intracavity LAD should be suspected (Figure 1 and Figure 2).

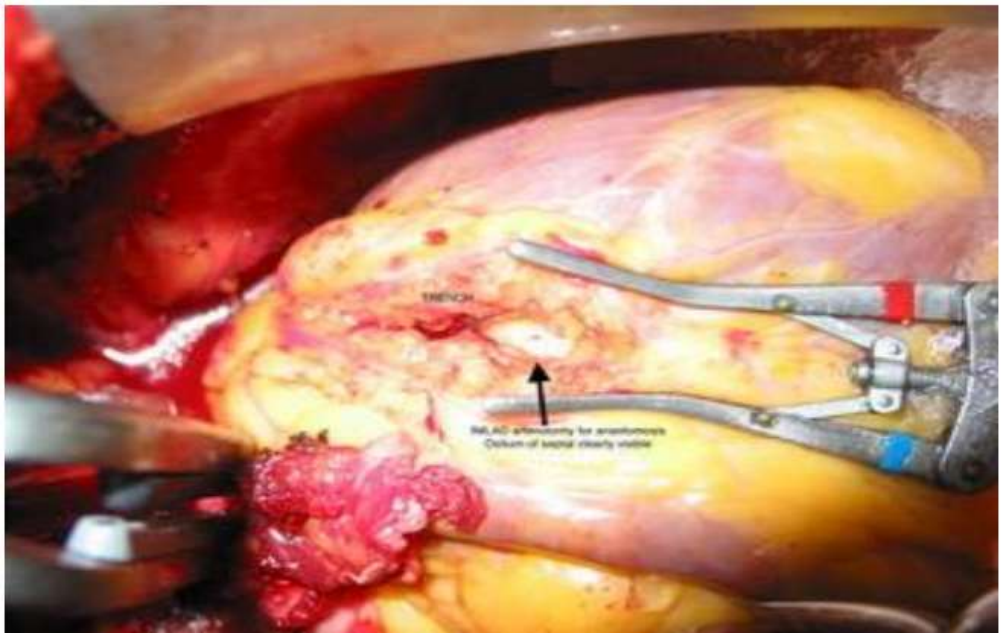

**Figure 2:** Surgical view of IMLAD.

**Exposure of LAD**

Myocardial bridging may represent a technical challenge during coronary arterial bypass because surgical exposure of the intramural LAD may be difficult. Dissection can cause injury to sepal branches, diagonals, coronary veins and right ventricle leading to prolonged cross-clamp times and hemostasis can be difficult to achieve. Right ventricle injury causes additional problems of introduction of air, difficulty in exposure due to absence of bloodless field, postoperative bleeding, and obstruction of LAD and branches during closure of the ventriculotomy. Preoperative investigation of the outer surface of the heart and definition of the main landmarks such as arterial and venous branches is the key to success in locating the LAD. Previous reports have described methods to localize the intramyocardial LAD and Ochsner [8] proposed how to deal with right ventricle injury during exposure of the embedded LAD.

One of the first techniques used to locate the LAD has been the retrograde passage of a fine atraumatic vascular probe inserted through a distal arteriotomy. The distal part of LAD, near to the apex, is almost always superficial and easily exposed. By palpation, the artery is located then opened by longitudinal incision over the intraluminal probe tip [9]. After completing anastomosis on the target spot, the distal arteriotomy is closed. However, this technique has few drawbacks such as intimal damage due to vulnerable stenotic segments and it requires closure of the distal arteriotomy, which can be responsible for stenosis.

The use of a US probe has also been proposed. This technique can only be applied in off-pump CABG and has limited use in proximally occluded or severely stenotic arteries [10]. However, we discourage this retrograde catheterization of the vessel with the hope of feeling the probe to localize the LAD as it may be quite challenging to experience such a feeling when the arterial course is very deep.

Some teams have made use of intraoperative cineangiography [11] to locate the IMLAD. However, this requires the need for a hybrid operating theater, has limited use in patients with kidney failure and can only be used on-pump patients [12].

The bold direct dissection of the interventricular sulcus is performed by many experienced surgeons. Direct palpation of the proximal artery may help localizing the proximal segment but unfortunately the plaque-free intramyocardial segment will not be detected. Retrograde or anterograde tracing of the LAD by dissecting with Pott's scissors the tissue (muscle and fat) above the artery is part of the classic armamentarium. The LAD is identified from its distal epicardial segment (usually near the apex) or from a diagonal branch. This technique has also been used to treat symptomatic milking in patients with otherwise non stenotic coronaries [13]. When the apical part of LAD is not visualized, the artery can be located by tracing the first diagonal artery in the same manner. Penetration of the right ventricular chamber and injury to the LAD itself or diagonal arteries are the main drawbacks of the latter technique. Of note, venous injuries of the great cardiac vein or afferents may also occur. To tackle the problem of diffuse bleeding from the trench, glue can be used. Marsupialization of the dissected LAD via fine running stitch of the edges of the so created groove may avoid constriction of the graft and warrants hemostasis [14].

Our team has been using a technique very similar to the one described by Oz [15] and his team but independently developed for the proper detection of the deeply embedded LAD. Our approach does not require any special equipment and relies mostly on two useful landmarks; the great cardiac vein and the location of the very proximal LAD at the left of the pulmonary root.Any epicardial groove to the right of the GCV is noted and is usually the target site where dissection should proceed. The first step is therefore the opening of the epicardium and underneath fat with a blade and then progressively going deeper with the low-power cautery .The artery may be detected close to the myocardium or seen through a thin fibro-fatty or muscular layer. If the contact with the myocardium is gained but the artery remains undetected, the rest of the dissection is best safely done after cardioplegic arrest. After cross-clamping and anterograde cardioplegia has been delivered, we proceed with exposure of the anterior intraventricular sulcus; a pad is placed under the LV to allow exposure and 6/0 stay sutures are placed on both sides of the deep epicardial trench. A self-retaining or eyelid tissue retractor may enhance exposure. An elastic tape on a blunt needle can alternatively be placed transversally, encompassing the great cardiac vein, and interventricular fat layer surrounding anterior septal myocardium (including the LAD) is an adjunct to enhance exposure [15]. Under direct visualization of the myocardium the scalpel with a No.15 blade is used to shave the superficially bridging myocardium (Figure 1). This careful shaving is carried out cautiously from medial (at the right of the GCV) then proceeds to the lateral side as required avoiding entry of the RV chamber. This usually allows the detection the underlying LAD, which is seen beneath a thin layer of muscle. At this point, the target spot is located and dissection is completed longitudinally especially toward the proximal end to facilitate a smooth entry of the graft (usually ITA) towards the anastomotic site. (Figure 2) The anastomosis is performed taking care of the relative fragility of the intra mural segment. Should the RV being entered during dissection; this implies a more extensive mobilization of the LAD to render its course superficial. This allows direct closure of the RV with U mattress stitches passed from the RV free wall to the septum. These maneuvers can jeopardy septal or diagonal branches. It is of utmost importance to avoid kinking or squeezing of the LAD.

**Conclusion**

In this article we underline the fact that detection of IMLAD remains quite challenging for young surgeons. Different techniques have been proposed to identify and expose the IMLAD for bypass surgery and each of them has their own drawbacks.

We here describe our technique to locate the intramyocardially located LAD and how to tackle right ventriculotomy. This technique is based on knowledge of the morphology of the Muscle Bridge and reliable landmarks. It involves a few simple steps that in our experience have been easily reproducible and teachable. The proposed approach does not require any special equipment.

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