

## Indirect Myocardial Revascularization Great Therapeutic Potential If Understanding the Mechanisms

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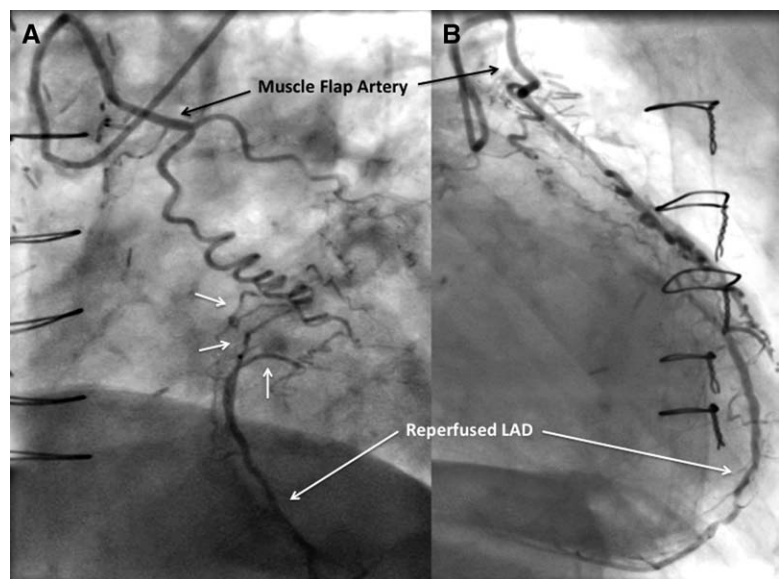
Strategies for indirect myocardial revascularization in end stage ischemic coronary artery disease have been described and are still developing, including transmyocardial laser revascularization, ischemic preconditioning, low-energy shock wave therapy, or epicardial transplantation of latissimus dorsi muscle flap.<sup>1-4</sup> All of them are intended to induce angiogenesis and generate neocollaterals to improve regional myocardial perfusion. The latter has been performed in some patients in whom no direct revascularization of the target vessel was possible because of diffuse calcification, small vessel disease, or in patients with multiple stents implanted in a single vessels, leaving no room for bypass anastomosis. We report a successful reperfusion of a formerly occluded left anterior descending coronary artery (LAD) in a patient in whom a free latissimus dorsi muscle flap had been transplanted onto the ischemic anterior epicardial area because of massive LAD calcification and occlusion in December 1995.

A 55-year-old male underwent coronary artery bypass grafting for double vessel disease in December 1995 with a venous bypass graft to the right coronary artery. At this time,

an additional bypass graft to the occluded LAD was planned. However, the LAD was completely and heavily calcified. Because of the proximal occlusion of the LAD and his diffuse, advanced calcification up to the apex, no direct revascularization was feasible. Therefore, a free latissimus dorsi muscle flap had been transplanted onto the ischemic anterior epicardial area. The arterial perfusion of the muscle was achieved by implantation of the supplying artery directly in the ascending aorta and the venous blood drainage into the right atrium.

After an uncomplicated postoperative course, the patient was discharged, did well in his daily life, and had returned to our cardiologists for routine follow-ups every 2 to 3 years.

More than 16 years later, in April 2012, the patient was rereferred to our center with angina Canadian Cardiovascular Society class II. The coronary angiogram revealed an occluded venous graft to the right coronary artery. In addition, an open arterial inflow to the muscle flap was identified from which multiple neocollaterals evolved, supplying the anterior wall of the left ventricle via the native, formerly occluded LAD (online-only Data Supplement Movies I and II and Figure 1)



**Figure 1.** Coronary angiogram 16 years postsurgery reveals a perfused LAD by neo vessels (arrows) arising from the muscle flap artery anastomosed to the ascending aorta.

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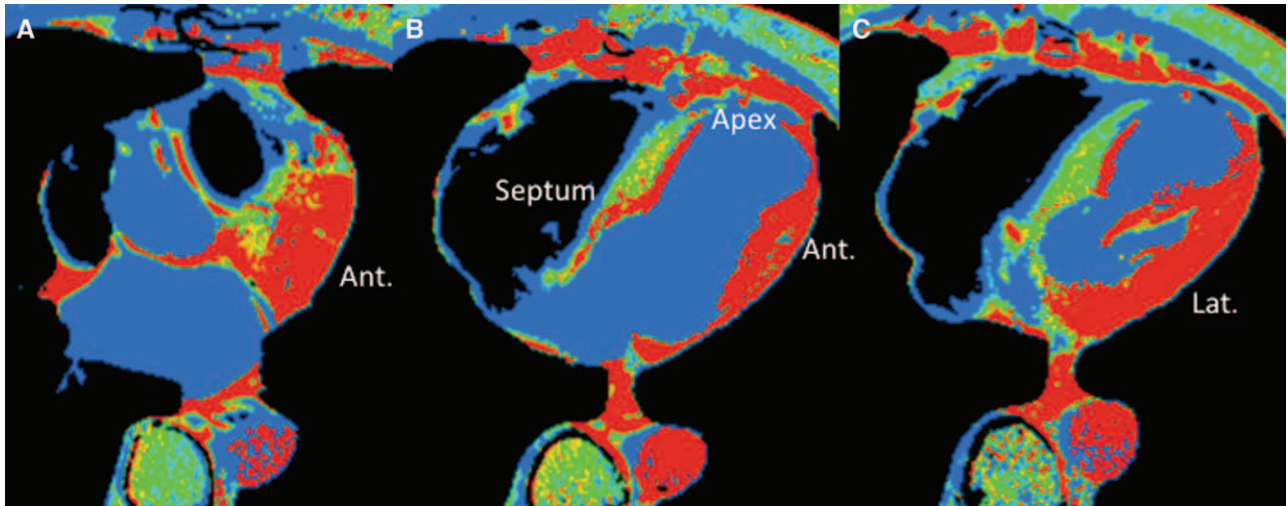
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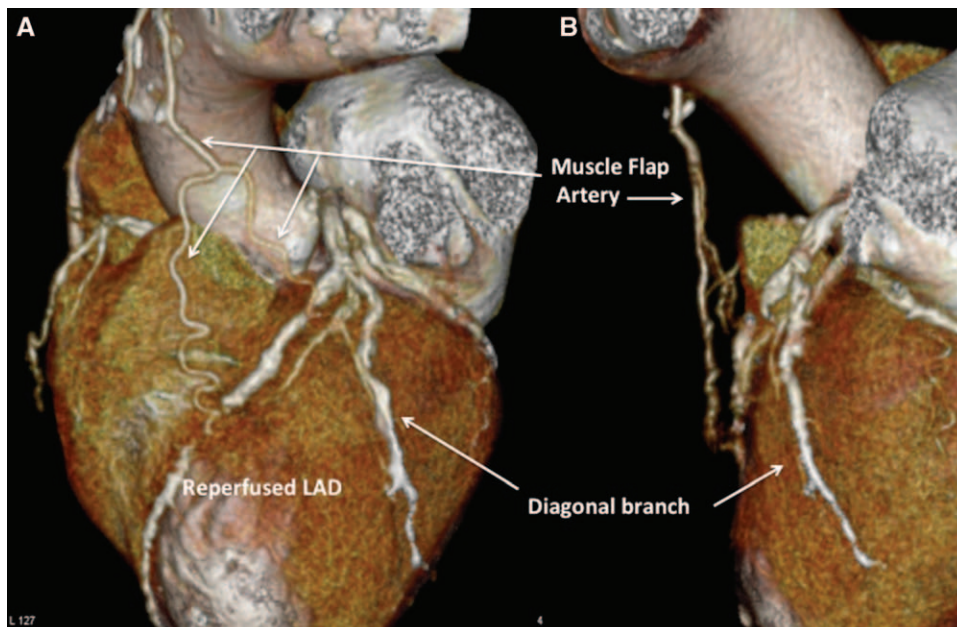
**Figure 2.** Myocardial perfusion measurement using a 256-row multislice computed tomography (Philips Brilliance iCT) is semiquantitatively depicted in colors, where red indicates strong perfusion, green-yellow indicates moderate perfusion, and blue depicts regions of low perfusion. As shown in **A** and **B**, the anterior wall supplied by the left anterior descending coronary artery is well perfused, whereas the septum is only moderately perfused. The apical (postinfarction) region is low perfused (**C**). Lat indicates lateral; and Ant, anterior.

A computed tomography perfusion study (256-row multislice Philips Brilliance iCT) showed excellent perfusion of the anterior and lateral wall (Figure 2A and 2B), whereas the septum perfusion was diminished (Figure 2B). The apex had been infarcted back in 1995 showing an aneurysmatic dilatation and calcification. Three-dimensional reconstruction of the heart shows 2 main branches coming off the muscle flap, the bigger one connecting to the native LAD via multiple collaterals or neovessels (Figure 3).

The patient was advised to take dual antiplatelet therapy, and no further coronary intervention was performed. The patient is now doing well in New York Heart Association class II and Canadian Cardiovascular Society class II with an estimated ejection fraction of 44%. Considering the initial clinical stage Canadian Cardiovascular Society class IV when the procedure was done in 1995, the latissimus dorsi muscle

wrapped around the heart 16 years ago represents an excellent long-term result, demonstrating direct neovascularization to the formerly occluded LAD.

The incidence of CAD is increasing and the affected patients are getting older, with increased comorbidities. This may also be reflected by advanced calcification of the coronary vessels. The interesting observation made in the present patient is that, despite advanced calcification of the epicardial conduit vessels, there is obviously a tissue and vascular response to perfusion and inflammation caused by the positioning of a bleeding muscle flap on the epicardial surface, which eventually resulted in formation of new vessels finding their way to an occluded LAD. The question arises as to the potential underlying mechanisms, because their understanding could help to find new reliable treatment strategies of indirect revascularization procedures.



**Figure 3.** Three-dimensional reconstruction of the muscle flap artery debranching into 2 separate supply vessels (**arrows, A**). Note the massive calcification of the formerly occluded left anterior descending coronary artery (LAD, **A**) and the diagonal branch (**B**), as well as the calcified apical aneurysm (**A**).

In fact, angiogenesis has been successfully induced by direct epicardial low-energy shock wave therapy in rat ischemic heart failure and was associated with increased levels of vascular and placental endothelial growth factor.<sup>3</sup> Moreover, Landau et al<sup>2</sup> demonstrated new epicardial small-vessel growth after application of basic fibroblast growth factor in hypertrophic rabbit hearts.

In conclusion, indirect revascularization using a muscle flap is not a standard therapy for coronary patients, in particular because of the lack of reliability. However, the course of the patient presented shows the potential of indirect revascularization strategies intended to induce neovascularization. Although the detailed pathways of neovascularization observed here remain unclear, the present report suggests that a targeted and directed induction of angiogenesis would benefit many patients with advanced ischemic heart disease.

## Disclosures

None.

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