Surgical Unroofing of Hemodynamically Significant Left Anterior Descending Myocardial Bridges

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Background. **Left anterior descending artery myocardial bridges (MBs) range from clinically insignificant incidental angiographic findings to a potential cause of sudden cardiac death. Within this spectrum, a group of patients with isolated, symptomatic, and hemodynamically significant MBs despite maximally tolerated medical therapy exist for whom the optimal treatment is controversial. We evaluated supraarterial myotomy, or surgical unroofing, of the left anterior descending MBs as an isolated procedure in these patients.**

Methods. **In 50 adult patients, we prospectively evaluated baseline clinical characteristics, risk factors, and medications for coronary artery disease, relevant diagnostic data (stress echocardiography, computed tomography angiography, stress coronary angiogram with dobutamine challenge for measurement of diastolic fractional flow reserve, and intravascular ultrasonography), and anginal symptoms using the Seattle Angina Questionnaire. These patients then underwent surgical unroofing of their left anterior descending artery MBs followed by readministration of the Seattle Angina Questionnaire at 6.6-month (range, 2 to 13) follow-up after surgery.**

Results. **Dramatic improvements were noted in physical limitation due to angina (52.0 versus 87.1, $p < 0.001$), anginal stability (29.6 versus 66.4, $p < 0.001$), anginal frequency (52.1 versus 84.7, $p < 0.001$), treatment satisfaction (76.1 versus 93.9, $p < 0.001$), and quality of life (25.0 versus 78.9, $p < 0.001$), all five dimensions of the Seattle Angina Questionnaire. There were no major complications or deaths.**

Conclusions. **Surgical unroofing of carefully selected patients with MBs can be performed safely as an independent procedure with significant improvement in symptoms postoperatively. It is the optimal treatment for isolated, symptomatic, and hemodynamically significant MBs resistant to maximally tolerated medical therapy.**

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Myocardium that courses external to an intramyocardial left anterior descending coronary artery (LAD), a tunneled artery, is termed a myocardial bridge (MB). The first description of MB appeared nearly 300 years ago [1]. More recently, MBs have been documented in 40% to 80% of autopsy series and in 1.5% to 16% of invasive angiographic series [2]. The condition is congenital. It can be isolated or associated with other congenital cardiac anomalies. In some cases, the finding of an MB has been incidental, and the patient is asymptomatic. In other cases, angina, both typical and atypical, is noted. In a few episodes of sudden cardiac death, the only abnormality detected was an MB [3, 4]. The postulated pathophysiology is one of myocardial ischemia brought about by systolic compression of the intramyocardial coronary artery by the MB, resulting in delayed relaxation of the vessel and leading to impaired diastolic coronary perfusion.

The diagnostic evaluation and treatment of patients with symptomatic MBs varies considerably owing to the growing awareness and understanding of the disease process. A characteristic angiographic finding, the "milking effect," in conjunction with appropriate symptoms determined the diagnosis in the past [5]. We propose that a more stringent and objective evaluation include a stress echocardiogram, a coronary computed tomography (CT) angiogram, and an invasive coronary angiogram with intravascular ultrasnography (IVUS) and dobutamine challenge for calculation of diastolic fractional flow reserve (dFFR) to evaluate the anatomic characteristics of an MB and its hemodynamic significance.

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Abbreviations and Acronyms

CABG = coronary artery bypass graft surgery
CAD = coronary artery disease
CT = computed tomography
dFFR = diastolic fractional flow reserve
IVUS = intravascular ultrasonography
LAD = left anterior descending artery
MB = myocardial bridge
PCI = percutaneous coronary intervention
SAQ = Seattle Angina Questionnaire

Medical management consists of beta-blockers to reduce compression of the artery by the muscular band and slow the heart rate, thereby increasing the diastolic period [6]. Calcium-channel blockers with negative chronotropic effect and nitrates (when significant endothelial dysfunction is present within the MB, as determined by intracoronary acetylcholine administration) are supplements or alternatives. For patients whose medical management is insufficient, percutaneous coronary intervention (PCI) has been associated with an unacceptably high rate of adverse events related to stent fracture and in-stent restenosis [7, 8].

The surgical treatment of LAD MBs can offer more definitive therapy. Coronary artery bypass graft surgery (CABG) distal to the diseased segment, by both venous and arterial conduits, has been performed, as well as supraarterial myotomy or unroofing. Graft failure rates among patients treated with CABG are high, likely related to competitive flow, indicating CABG as an unfavorable strategy [9]. Good results with unroofing have been reported for more than 35 years [10, 11]; however, some uncertainty relating to the safe conduct of the operation, including injury to the coronary artery or inadvertent entry into a ventricular chamber, has led to a slow adoption of this technique. Here, we describe the surgical technique in a select group of patients, as well as their preoperative evaluation and symptomatic outcomes.

Patients and Methods

Study Population

We evaluated 50 adult patients between August 2011 and November 2015, with isolated, symptomatic, and hemodynamically significant LAD MBs resistant to maximally tolerated medical management. Patients whose symptoms remained life limiting or intolerable were offered surgical unroofing of their MB. Each patient with severe anginal symptoms underwent a systematic and thorough objective evaluation (Fig 1). The possible diagnosis of an MB was initially raised by the presence of septal buckling with apical sparing on stress echocardiography [12]. In the majority of cases, a coronary CT angiogram was also obtained to document the presence of LAD MB and to evaluate its anatomic characteristics. Medical therapy was then instituted, and escalated if needed. If symptoms persisted despite maximal medical therapy tolerated by the patient, and surgical unroofing was being considered, invasive testing was performed.

All 50 patients underwent invasive angiography utilizing IVUS (Atlantis SR Pro2 40-MHz mechanical transducer ultrasound catheter; Boston Scientific, Marlborough, MA) to measure systolic arterial compression (defined as the change in vessel area during the cardiac cycle divided by vessel area during diastole), MB thickness (defined by the maximal thickness of the echolucent half-moon sign, or halo), the length of the MB (measured from the first proximal appearance of the echolucent halo to its distal end), and the maximal plaque burden (measured as the difference between vessel and lumen areas divided by vessel area with the largest plaque burden) upstream from the MB entrance (Fig 2A, B). After IVUS, we tested the hemodynamic significance of the MB by performing dFFR (diastolic Pd/Pa, the fraction of diastolic coronary artery pressure divided by diastolic aortic pressure) and Doppler flow velocity using a Combowire (Volcano, San Diego, CA) in the LAD. Both measurements were obtained proximal to, within, and distal to the MB at rest and during stress, which was induced by incremental intravenous infusions of as much as 50 $\mu g \cdot kg^{-1} \cdot min^{-1}$ dobutamine (Fig 3) [12, 13]. A dFFR of 0.76 or less was considered to be hemodynamically significant [14].

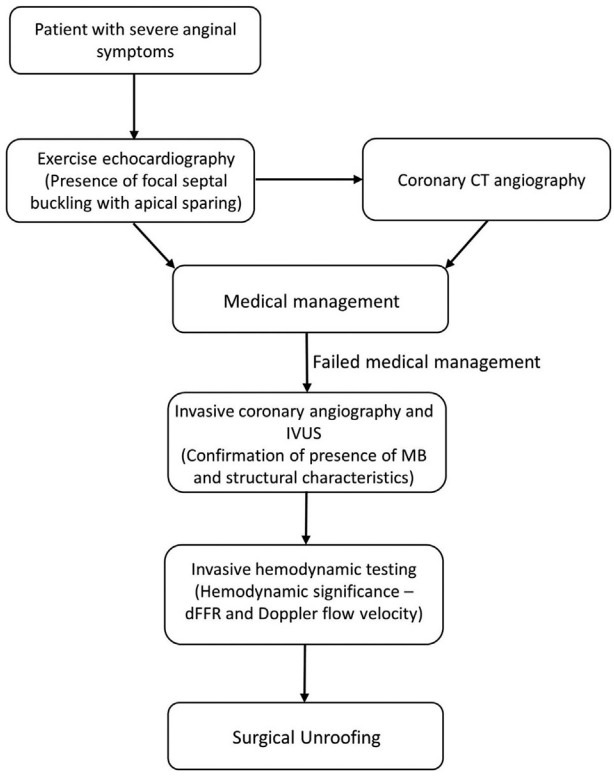

Fig 1. Schematic representation of the detailed evaluation performed for diagnosing a hemodynamically significant myocardial bridge (MB) suitable for surgical unroofing. (CT = computed tomography; dFFR = diastolic fractional flow reserve; IVUS = intravascular ultrasonography.)