Case report

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Left internal mammary artery graft disfunction diagnosed by transthoracic Doppler echocardiography. A report of two cases.

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Abstract

Transthoracic Doppler echocardiography (TDE) is a non-invasive and easy reproducible method to assess the left internal mammary artery (LIMA) graft patency after coronary artery bypass graft surgery (CABG). LIMA graft dysfunction is rare, its rate being 10% at 10 to 15 years after revascularization. The most common cause of graft dysfunction is the competitive flow with the native coronary artery, when the stenosis of the bypassed vessels is not severe. We present two cases of LIMA graft dysfunction diagnosed by TDE and confirmed by angiography, with two particular pulsed-wave color Doppler flow signals.

Keywords: color Doppler ultrasound, left internal mammary artery, coronary artery bypass

Introduction

The left internal mammary artery (LIMA) is considered to provide an excellent long-term patency rate, and its bypass procedure to the left anterior descending (LAD) coronary artery improves long-term survival after coronary artery bypass grafting (CABG) surgery [1]. The rate of the mammary artery graft dysfunction is about 10% at 10 to 15 years after revascularization [2]. However, a number of problems have continued to be associated with LIMA grafts, including inadequate perfusion during or after CABG [1] and distal narrowing because of competitive flow from the native coronary arteries [3]. Moderately narrowed bypassed coronary artery is the most critical factor affecting bypass dysfunction after CABG [4]. Hashimoto et al [5] showed that when the stenosis in the recipient artery is narrowed by less than 60% the occlusion rate of the LIMA graft is high. Cardiac catheterization remains the reference standard for graft patency, but its invasive nature limits its routine use. Lately, transthoracic Doppler echocardiography (TDE) of LIMA has been used as a noninvasive and easily reproducible method to assess graft patency [6,7]. We present two cases of LIMA graft dysfunction due to competitive flow from the native LAD, with two particular pulsed-wave color Doppler flow signals, early and totally reversal systolic flow.

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Cases report

Case 1

A 38 year old male, with inferior myocardial infarction and percutaneous coronary artery intervention (PTCA) with a stent on the right coronary artery (RCA) in 2003, diffuse in-stent restenosis and CABG with LIMA to LAD in 2004, without intraoperative RCA visualization, presented after 7 years for new angina at moderate effort. Stress test was submaximal, being stopped for angina without ST-segment changes. Echocardiography examination revealed non-dilated left ventricle, inferior wall akinesis, and 58% ejection fraction (EF). TDE in the 3rd left intercostals space (fig 1) showed Doppler signal of LIMA with early systolic flow reversal of 163 ms and velocity of 30 cm/s, the ratio of peak diastolic (PDV)

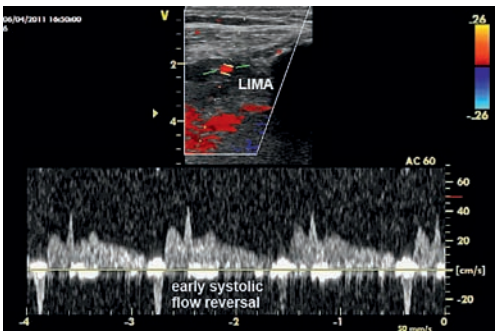


Fig 1. Pulsed-wave color Doppler flow of LIMA, with early systolic flow reversal, scan from the 3rd left intercostal space window

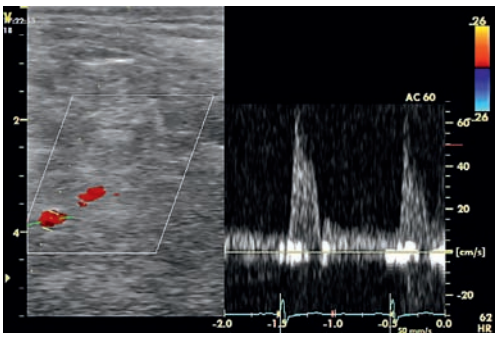


Fig 3. Pulsed- wave color Doppler flow of LIMA from the supraclavicular window, with a PDV/ PSV= 0.28 and a DF=37%

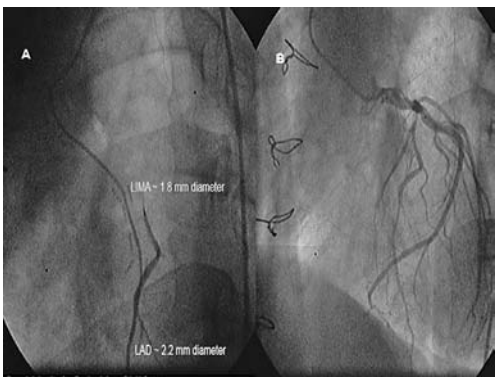


Fig 2. A) Angiographic aspect of the degenerated but still patent LIMA, with a smaller diameter than that of the native LAD; B) Angiographic aspect of LAD at current presentation

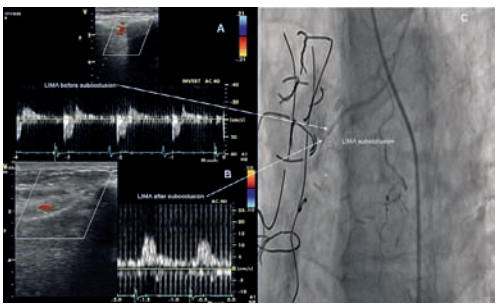


Fig 4. Correlation of the pulsed- wave color Doppler flow of LIMA A) from the 3rd left intercostal space window before the subocclusion site; B) immediately after the subocclusion site; C) the angiographic aspect

to systolic (PSV) velocity of 1.18 and a diastolic fraction (DF) of 67%. At angiography the LIMA graft (fig 2A) was patent, still functional, but degenerated, with a small diameter of 1.8 mm and competitive flow from LAD, which was without significant stenosis (fig 2B) and a greater diameter than the LIMA graft (2.2 mm), the RCA having the same aspect as preoperatively. The early systolic flow reversal in LIMA graft at TDE is the result of the competitive flow with LAD. The greater diameter of LAD compared with the LIMA graft and the competitive flow LIMA-LAD, suggested that probably the LAD stenosis was not severe enough preoperatively, so the LIMA graft had started to degenerate.

Due to the fact that the new angina was probably due to the myocardial ischemia in the RCA territory, which has the same aspect as preoperatively, the patient was treated conservatively.

Case 2

A 75 year old man presented to the emergency room with acute coronary syndrome (ACS) with ST segment elevation in inferior leads. He was a smoker and had a medical history of dislipidemia, hypertension and type 2 diabetes mellitus. Seven years ago he had underwent a CABG with LIMA to LAD for unstable angina; at that time his coronary arteries were described as being aneurismally dilated, but only LAD had a thigh stenosis (70%) in the first segment. At current presentation transthoracic echocardiography showed a non-dilated left ventricle, hipokinesis of the basal interventricular septum and inferior wall, with a normal EF of 60%.TDE of LIMA from the supraclavicular and left intercostals windows was performed. From the supraclavicular window (fig 3) the PDV/PSV ratio was 0.28 and the DF was 37%; in the 3rd left intercostals space window (fig 4A) a systolic flow reversal of 192 ms with a velocity of 27 cm/s and a DF of 10% was detected. One intercostals space below there was a hardly detectable flow in LIMA graft, with very small PSV (15 cm/s) and PDV (6 cm/s) (fig 4B), a ratio PDV/PSV of 0.4 and a DF of 10%. Taking into consideration the above mentioned pulsed-wave Doppler signal in LIMA, a severe LIMA body graft stenosis was

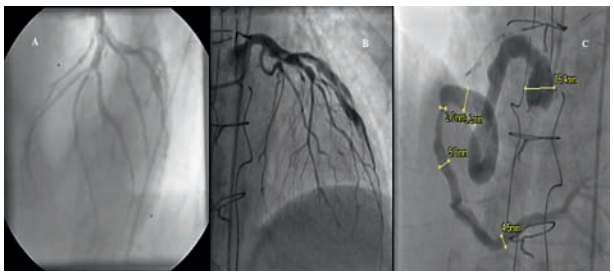


Fig 5. Angiographic aspect of the LAD A) before CABG; B) at current presentation; C) Angiographic aspect of the RCA, with its relative stenosis of 50%, with a patent lumen of 2.7 mm, responsible for the acute coronary syndrome

suspected. At coronary angiography our assumption was confirmed; the LIMA graft (fig 4C) had a medium body subocclusion with no flow on LAD, which had the same stenosis as preoperatively (fig 5A and B) and a bifurcation aneurysm (maximum diameter of 7 mm). The aneurysms in the circumflex artery and RCA were greater than preoperatively, with maximum diameters of 8 mm and 16 mm respectively. We considered that the ACS was due to a relative stenosis of 50% (patent lumen of 2.7 mm) of the RCA (fig 5C) with impossible percutaneous access due to the very tortuous anatomy, without any possible percutaneous intervention for LIMA and we decided to continue with medical treatment.

Discussion

In recent years non-invasive detection of coronary artery bypass graft flow has been carried out by some investigators using the TDE technique [6-8]. LIMA is the conduit of choice to LAD and is associated with longer patency than venous grafts [9]. Late occlusion of the LIMA graft is rare and its pathological basis is unknown; the most likely hypothesis to explain its late closure is the flow competition between the bypass and the native artery [4,10]. The flow in LIMA graft is laminar with a modulated proximal systolic component and a large distal diastolic component matched to the coronary circulation [4]. A predominantly high native coronary flow will impair this important diastolic phase, which has been shown to be absent in failed grafts [11]. The terms "string sign" or "distal thread phenomenon" is used synonymously and represent a physiological adaptation to reduced flow. They are assumed to be an angiographic feature caused by competitive flow from the native artery, but Dincer et al [12] has shown it to be reversible with the abolition of the native coronary flow. Kitamura et al [13] demonstrated the anatomical patency of the string-like LIMA graft by temporary occlusion of the recipient LAD coronary artery with a percutaneous transluminal coronary angioplasty balloon. However, the influence of the competitive flow on the features of LIMA remains controversial because these string-like phenomena do not always occur with patients who demonstrate strong competitive flow from the native coronary artery. LIMA graft lesions are most commonly located at the distal anastomosis site [14], opposite to our case 2 where LIMA subocclusion was in the graft body. In assessing the LIMA graft patency TDE has an excellent specificity (~95%), but a slightly reduced sensitivity (79%) [15]. It must be remembered that the LIMA graft ratio PDV/ PSV changes from 0.6 proximally to 1.4 distally [16]; accordingly, the PDV/ PSV ratios must be interpreted in relation to the LIMA interrogation site. Several reports have shown that a decrease in PDV/PSV <0.5 or 0.6 is a powerful predictive parameter of LIMA graft stenosis [5,14,17]. In the study by Mizukami et al [18] mean PDV/ PSV <0.57 predicted graft stenosis with 88% sensitivity, 91% specificity, and 91% accuracy. Another pulsed wave color-Doppler derived parameter is the diastolic fraction, which is computed as the ratio of the diastolic time velocity integral and the total velocity time integral. A DF under 50% seems to be the best indicator for significant graft stenosis, with 89% sensitivity and 94% specificity [15]. Flow dynamics of the LIMA graft in no-flow conditions, evaluated by Doppler guide wire, demonstrated to and fro signals with systolic flow reversal and diastolic anterograde flow in the distal portion of angiographically no-flow patent LIMAs at baseline rest conditions [19]. Madaric et al [20] demonstrated that the LIMA flow characteristics are affected by the site of the occlusion or stenosis. Flow competition with LAD affects essentially the distal LIMA flow as shown by the development of systolic flow reversal [14]. In our Case 1 patient the LIMA graft was still functional, in a course of degeneration, so the systolic reversal flow was viewable only in the early systole. In the Case 2 patient, due to complete systolic flow reversal and an almost absent diastolic flow, with the ratio PDV/PSV <0.5 and the DF< 50%, graft dysfunction was suspected. It seems that LIMA graft subocclusion was totally asymptomatic, without any electrocardiographic or echocardiographic signs, which means that its flow was not significant and necessary for myocardial perfusion. Because the current angiographic aspect of the LAD was quite the same as preoperatively the LIMA graft subocclusion was interpreted as being due to competitive flow from LAD. Comparing the two above mentioned cases in terms of color- Doppler flow signals, we could say that Case 1 with early systolic floe reversal represents the first stage of the degenerative process of the LIMA graft, while Case 2 with totally

systolic flow reversal represents an already degenerated LIMA graft, with the body graft subocclusion, both due to competitive flow from LAD. The particularity of the two presented cases is that even if both LIMA grafts were bypassed on LAD for 7 years and were both dysfunctional, one of them is still functional, while the other one is almost occluded. We might suppose that in the Case 1 LAD stenosis was much more severe or the atherosclerosis progressed more rapidly than in the Case 2 LAD.

In conclusion it seems that chronic competitive flow plays a major role in the process of late arterial graft closure and this should be taken into account when a decision about revascularization is considered. Even if coronary angiography is the gold standard to assess graft patency after CABG, transthoracic color-duplex ultrasound could be a useful non-invasive technique for the postoperative follow-up of the LIMA graft, as was shown in the above mentioned cases.

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