

Steal of Blood Flow from the Vertebral Artery to the Internal Thoracic Artery Anastomosed to the Coronary Artery

Jose Sebastião de Abreu^{1,2,3}, Nayara Lima Pimentel⁴, Jordana Magalhães Siqueira⁴, Carlos Newton Diógenes Pinheiro⁵, Teresa Cristina Pinheiro Diógenes³, José Nogueira Paes Junior³

Instituto do Coração SP - Universidade de São Paulo¹, São Paulo, SP; Universidade Estadual do Ceará²; Prontocárdio e Clínicárdio³; Faculdade de Medicina da Universidade Federal do Ceará⁴; Hospital Geral de Fortaleza⁵, Fortaleza, CE - Brazil

Introduction

The left vertebral and internal thoracic arteries are branches of the left subclavian artery which, under physiological conditions, exhibit antegrade flow direction.

On Doppler evaluation, the internal thoracic artery (ITA) flow shows a predominance of systolic component, but when anastomosed to the left coronary arteries, the prevalence of the diastolic component is usual. This predominance can become exacerbated and a situation that increases oxygen consumption by the myocardium can occur, such as what happens during dobutamine stress echocardiography, when the systolic component can be suppressed and the diastolic becomes the only component of the cardiac cycle. The two-dimensional and Doppler imaging allows anatomical assessment of arteries and the verification of normal and pathological flow patterns. Thus, the flow direction reversal of an artery can be compatible with steal of blood flow and an exacerbation of the diastolic component of the anastomosed internal thoracic artery (AITA) at Doppler may indicate good functional status of the vessel¹⁻³.

Occlusion of the left subclavian artery determines impairment of blood supply to the left arm, but the steal of blood flow from the left vertebral artery may improve limb perfusion. When the subclavian artery occlusion occurs in cases with ITA anastomosed to the left coronary arteries, the direction of the post-stenotic flow in symptomatic patients is variable and can be reverse in the vertebral and internal thoracic arteries⁴, have no reverse component⁵, be reverse only in ITA⁶ or, as in our patient, show preferential reverse flow from the left vertebral artery to the ITA.

Case report

A 47-year-old female had had stable angina for approximately three years and increasing angina for the last

three months. She reported decreased strength to elevate the left upper limb. She was hypertensive, dyslipidemic and a smoker. She used calcium antagonists, nitrates, aspirin and statin. Ten years before, she had undergone myocardial revascularization with saphenous vein graft to the right coronary artery and from the internal thoracic artery (ITA) to the anterior descending coronary artery (ADA).

On physical examination she had normal pulmonary auscultation, regular heart rhythm and fourth heart sound, cervical murmur to the left (++/4+), pulse in the left arm not palpable without edema. Blood pressure in the right upper limb was 130 x 80 mmHg.

The electrocardiogram showed mild ventricular repolarization alteration in the anterolateral wall. She underwent cardiac catheterization, which showed occlusion of the saphenous vein graft, severe stenosis (> 80%) in left main coronary artery (LMCA), of ADA, circumflex (Cx), and diagonal (Dg) artery and left subclavian artery (LSA) occlusion; it was not possible to perform proper assessment of the ITA-ADA conduit (Figure 1A and 1B).

The echocardiogram showed mild left ventricular hypertrophy and normal basal segmental contraction. The two-dimensional image and Doppler of the anastomosed ITA (AITA), viewed in supraclavicular level, showed good patency of the conduit through Doppler spectrum with exuberant percentage of diastolic component (84%) at rest, well above the commonly found one (Figure 1C and 1D). The vertebral arteries showed normal anatomy and flow velocity; however, the flow was retrograde in the left vertebral artery (LVA) and showed normal antegrade pattern in the right (Figure 1E and 1F).

The attending physician considered that the left coronary system was partially protected by the AITA and the patient was submitted to stenting in the LMCA and Cx and angioplasty in the Dg, with consequent cessation of anginal symptoms.

Six months after the percutaneous intervention, she underwent dobutamine stress echocardiography, reaching a maximum heart rate (220 - age) with uneventful outcome and negative result for myocardial ischemia. At peak stress, the flow in the AITA became exclusively diastolic, with coronary flow reserve index of 1.8 (Figure 2A and 2B), indicating good functional status^{1,3}, while the LVA remained entirely with retrograde flow (Figure 2C and 2D).

Four months after the stress echocardiography, the patient underwent a new intervention for stent implantation in the LSA. A subsequent angiogram showed calibrous and

Keywords

Mammary Arteries; Echocardiography, Stress; Angioplasty, Balloon, Coronary; Stents.

Mailing Address: Jose Sebastião de Abreu •

Rua Dr. José Lourenço, 500/700, Meireles. Postal Code 60115-280, Fortaleza, CE - Brazil

E-mail: jsabreu@cardiol.br, jsabreu10@yahoo.com.br

Article received on 11/10/12, revised on 12/04/12, accepted on 3/25/13.

DOI: 10.5935/abc.20130216

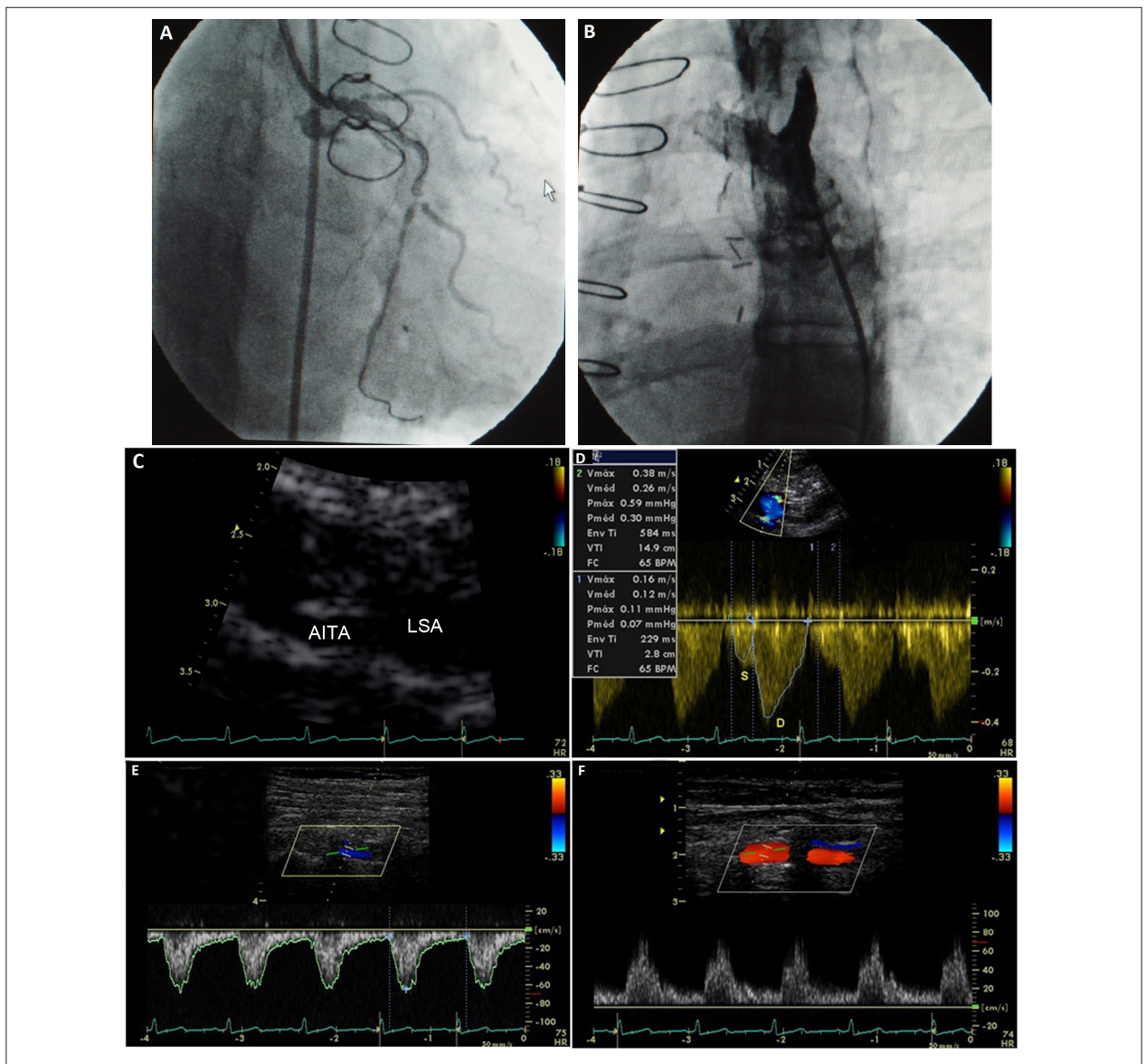


Figure 1 - Angiography showing stenosis > 80% in the left main coronary artery, left anterior descending artery, circumflex and diagonal arteries (1A), and left subclavian artery (LSA) with occlusion (1B). Supraclavicular recording of two-dimensional image of the anastomosed internal thoracic artery (AITA) emerging from the post-stenotic region of LSA (1C). AITA Doppler imaging showing marked diastolic component (1D), abnormal left vertebral artery with retrograde spectrum (1D) and normal antegrade spectrum in the right artery (1F).

fully patent ITA-ADA conduit (Figure 2E and 2F). In a new Doppler assessment, it was observed that the LVA had started to show normal antegrade flow. The AITA flow at rest showed a decrease in the diastolic component, but it remained predominantly (58%) within the range expected for AITA with adequate patency (Figure 2G and 2H).

The pulse in the left arm became palpable.

Discussion

During LSA occlusion in revascularized patients with AITA, distinct variations may occur in flow direction distal

to the stenotic LSA. In the study by Omeish et al⁴, it was observed that a patient admitted with acute pulmonary edema had, at the hemodynamic study, reverse flow in AITA and LVA, and that after stenting in the occluded LSA, the directions of these flows normalized and became antegrade, concomitant to a successful clinical outcome.

On the other hand, in the study by Alcocer et al⁵, it was observed that antegrade flow to AITA was compromised, as in this patient with angina pectoris there was no "compensatory" steal of blood flow to the region distal to the LSA stenosis. Vecera et al⁶ showed, by Doppler assessment, AITA with reverse flow and the hemodynamic study confirmed the

Case Report

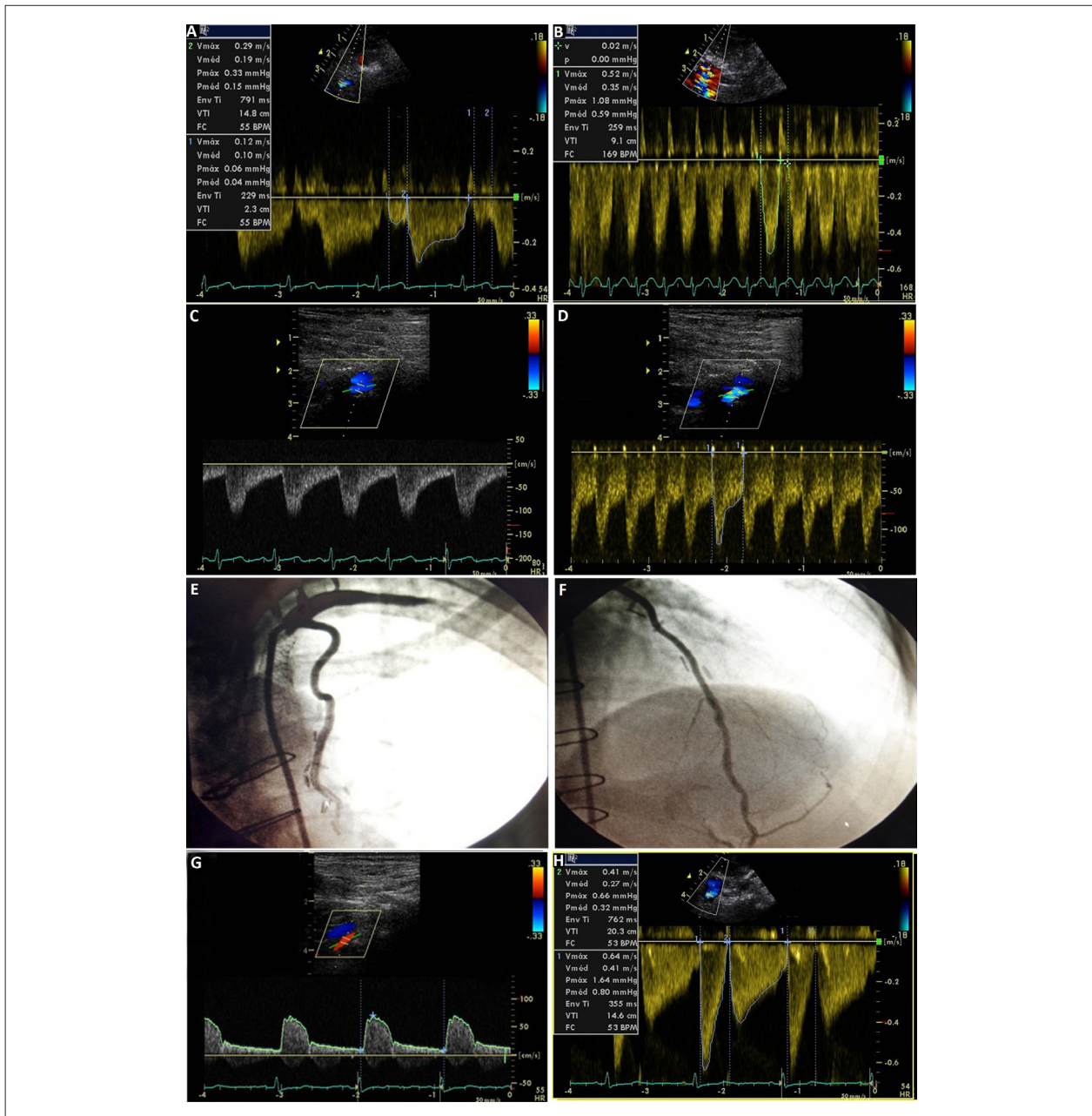


Figure 2 – AITA with diastolic predominance at baseline (2A) and 100% diastolic at the end of dobutamine stress echocardiogram (2B). Doppler spectrum of the left vertebral artery (LVA) maintained retrograde (abnormal) at baseline (2C) and during stress (2D). Angiographic view of stent in LSA (2E) and calibrous AITA emerging from the LSA (2F). Subsequent Doppler assessment showing normalization of LVA blood flow direction (2G) and decreased prevalence of diastolic component in the AITA (2H).

suspected LSA occlusion. After LSA angioplasty, the AITA flow showed normal antegrade pattern.

The case reported herein is the first to show that, in the presence of LSA occlusion, the steal of blood flow in the LVA can help to increase the antegrade flow of the AITA without stenosis and to demonstrate that, the role of two-dimensional Doppler image was crucial.

The hemodynamic study diagnosed the LSA occlusion, as well as severe stenoses of the coronary arteries,

but showed limitations in the assessment of the AITA. The two-dimensional Doppler image was of great importance to demonstrate that the diastolic component in the AITA was more pronounced than usual, which suggested to the attending physician that the left coronary system was partially protected by this AITA, favoring the decision of performing a percutaneous intervention through stenting in severely compromised coronary arteries, including the left main coronary artery.

After the interventional therapy, the patient asymptomatic evolution and the fact that the dobutamine-stress echocardiogram was negative for myocardial ischemia corroborated the appropriateness of the interventions. The AITA Doppler assessment showed good functional status of this conduit as, during stress, it was observed that the flow became 100% diastolic with a coronary flow reserve index of 1.8. The two-dimensional Doppler study performed immediately after stent implantation in LSA showed that the flow direction in the LVA had normalized (anterograde) and that changes had occurred in the AITA flow, which demonstrated increased systolic component, while still remaining anterograde and with diastolic predominance (58%), which is the Doppler standard usually found in patent AITA³.

We emphasize that stress echocardiography, which has such widespread use in the evaluation of myocardial ischemia, is an important tool for the assessment of coronary flow reserve through the graft.

Conclusion

In the presence of LSA occlusion, it was inferred that the steal of blood flow from the LVA contributed to the increase in blood supply to the AITA. The two-dimensional Doppler image was essential to demonstrate that the AITA was patent and had good functional status, favoring the

decision to perform percutaneous intervention for severe stenosis of the LMCA and branches of a partially protected left coronary system.

Author contributions

Conception and design of the research: Abreu JS; Acquisition of data, Analysis and interpretation of the data, Writing of the manuscript and Critical revision of the manuscript for intellectual content: Abreu JS, Pimentel NL, Siqueira JM, Diógenes TCP, Paes Junior JN; Performing procedure (examination): Abreu JS, Pinheiro CND, Paes Junior JN.

Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

Sources of Funding

There were no external funding sources for this study.

Study Association

This study is not associated with any post-graduation program.

References

1. Abreu JS, Diógenes TC, Morais JM, Barreto JE, Lobo Fo. JG, Paes Jr JN. Avaliação da patência da mamária interna enxertada pelo ecodoppler com e sem uso de dobutamina. *Arq Bras Cardiol.* 1997;69 (supl 1):119.
2. Arruda A, Campos Filho O, Ribeiro E, Petrizzo A, Andrade JL, Carvalho AC, et al. Avaliação da anastomose de artéria torácica interna esquerda com artéria interventricular anterior pela ecodoppler cardiografia. *Arq Bras Cardiol.* 1997;69(6):413-9.
3. Abreu JS, Diógenes TC, Abreu AL, Barreto JE, Morais JM, Abreu ME, et al. Artéria torácica interna enxertada: patência e estado funcional em repouso e após dobutamina. *Arq Bras Cardiol.* 2008;90(1):37-45.
4. Omeish AF, Ghanma IM, Alamlh RI. Successful stenting of total left subclavian artery occlusion post-coronary artery bypass graft surgery using dual left vertebral artery and left internal mammary artery protection. *J Invasive Cardiol.* 2011;23(6):E132-6.
5. Alcocer A, Castillo C, Rivera-Capello JM, González V, Meaney E. Anterograde flow compromise of a patent left internal mammary artery graft from a proximal subclavian artery stenosis. Myocardial ischemia not driven by the coronary-subclavian steal syndrome mechanism. *Arch Cardiol Mex.* 2012;82(2):135-8.
6. Vecera J, Vojtisek P, Varvarovský I, Lojík M, Másová K, Kvasnicka J. Non-invasive diagnosis of coronary-subclavian steal: role of the Doppler ultrasound. *Eur J Echocardiogr.* 2010;11(9):E34.