Review Article

My Approach to Coronary Flow Assessment With Transthoracic Echocardiography

José Maria Del Castillo,[1] *Issam Shehadeh*[1,2]
Escola de Ecografia de Pernambuco,[1] *Recife, PE – Brazil*
Cardiovision,[2] *Esteio, RS – Brazil*

Abstract

The assessment of coronary flow reserve is an extremely important step in stress echocardiography, both within and outside the context of coronary artery disease. For some, it is seen as an impossible parameter; for others, it is essential. In any case, everything begins with the proper visualization of the coronary arteries at rest. In this article, we will address theoretical and practical concepts for incorporating coronary flow study into the routine of the echocardiographer.

Introduction

The study of coronary flow by echocardiography is still considered, by many authors, a utopia. Practically speaking, we learn that coronary assessment is limited to the visualization of their ostia, often only through transesophageal study. However, identification of the flow in the Left Anterior Descending artery (LAD) at rest, in the mid-distal third, is possible in more than 90% of patients.[1] The incorporation of Coronary Flow Reserve (CFR) assessment into stress echocardiography adds important diagnostic and prognostic information.[2] Furthermore, coronary flow patterns, even at rest, can be very useful in diagnosing not only Coronary Artery Disease (CAD) but also other diseases.

Pathophysiology of Coronary Flow

Coronary flow is biphasic, due to changes in resistance that the myocardial vascular system undergoes during the cardiac cycle. Coronary flow (Q) is regulated by the relationship between perfusion pressure (P) and the resistance offered by extramural arteries (R1), intramural arterioles R2), and compression of subendocardial arterioles caused by ventricular contraction on the blood inside the left ventricle. Since these resistances are lower during diastole, coronary flow is predominantly diastolic in the left coronary artery and more balanced in the right coronary artery, where subendocardial compression is less (Central Illustration).

Keywords

Coronary Artery Disease; Doppler Ultrasonography; Ecocardiografia sob Estresse.

Mailling Address: Issam Shehadeh •
ECOPE. Rua Solidônio Leite, 200. Postal code: 51111-130. Recife, PE – Brazil
E-mail: issam05@gmail.com
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Thus, two components of coronary flow can be distinguished: capacitance flow, which depends on the ventricular wall decompression of the left ventricle and the dilation of intramural arterioles (vascular tone), and conductance flow, which depends on the resistance to blood passage through the arteriolar-capillary system (vascular resistance). The more compliant the vascular bed, the greater the acceleration of conductance flow; and the lower the resistance to flow passage, the faster the deceleration of the conductance component (Figure 1).

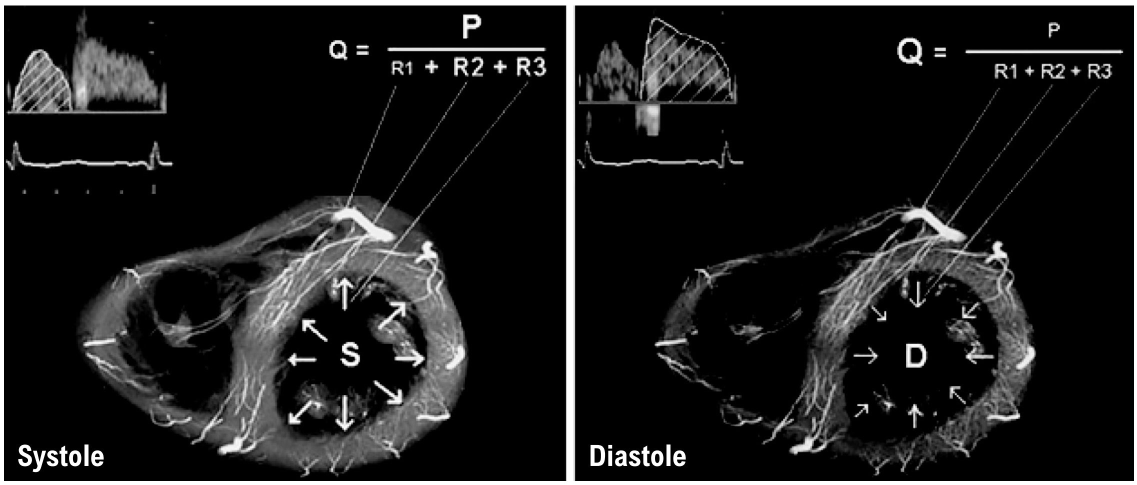
Coronary flow supplies oxygen to the myocardium according to demand. When oxygen demand increases – for example, during exercise – the coronary arteries increase flow through vasodilation, which leads to increased velocity, especially in epicardial and intramural arteries. The difference in velocity between the resting state and hyperemia (caused by the increased oxygen supply to the myocardium) allows estimation of the so-called CFR. The methods used to measure it, either through hemodynamic study or by obtaining coronary flow via ultrasound, are physical exercise or pharmacologically induced vasodilation (dipyridamole, adenosine, papaverine).

Absence of a specific preset

Undoubtedly, the main limitation for the study of coronary flow is the absence of a specific preset. Some equipment already provides it by default. However, additional adjustments are often required. Since the coronary artery in the mid-distal third is a very subtle structure and the flow is of low velocity, in general, the following adjustments should be made to color and pulsed Doppler:

Color Doppler	Pulsed Doppler
Frequency in the range of 2.5 to 2.9 MHz	Frequency in the range of 2.5 to 2.9 MHz
PRF around 20 cm/s	Velocity scale around 50 cm/s
High gain	Reduced low-velocity filter
High persistence	Sample volume between 2 to 4 mm
High low-velocity filter	Low PRF deactivated
High frame rate	Side-by-side" layout
Sample volume about 1 mm	
Low tissue prioritization	

Central Illustration: My Approach to Coronary Flow Assessment With Transthoracic Echocardiography



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Coronary flow (Q) is regulated by the relationship between perfusion pressure (P) and the resistance offered by the extramural arteries (R1), intramural arterioles (R2), and the compression exerted on the subendocardial arterioles caused by ventricular contraction on the blood inside the LV (R3). Since these resistances are lower during diastole, coronary flow is predominantly diastolic for the left coronary artery and balanced for the right coronary artery, where subendocardial compression is less pronounced

Although there are variations in these parameters among different devices, this is generally the conceptual approach. It is not mandatory to use a pediatric transducer, since current adult transducers operate across a wide frequency range. If available, the use of a higher-frequency transducer may facilitate coronary visualization.

Technique

Left Anterior Descending artery in the mid-distal third

The key point for visualizing the LAD is to identify the anterior interventricular groove. For this purpose, two approaches can be used:

1. Modified short-axis view

Starting from the parasternal short-axis view, approximately at the level of the papillary muscles, one should attempt to visualize the anterior interventricular groove, at the transition between the RV and LV, in the subepicardial region of the junction between the anteroseptal and anterior walls, where the mid portion of the LAD passes. Once the flow – predominantly diastolic —has been detected, the transducer can be slowly rotated clockwise to better align the ultrasound beam with the anterior interventricular groove, thereby allowing detection of larger segments of the artery.

2. Modified parasternal long-axis view

From the traditional parasternal long-axis view, the transducer is slid one or two intercostal spaces lower. Next, the ultrasound beam is angled anteriorly, pointing the transducer toward the patient's left shoulder. This maneuver is crucial to remove part of the right ventricle from the image and expose the interventricular groove. If any portion of the right ventricle remains visible in this view, the transducer should be rotated clockwise until this chamber disappears. The resulting image will be a transitional view between the parasternal long-axis and the short-axis. The interventricular groove will then be exposed. Its location is quite superficial in the patient's chest, which increases the success rate for visualizing the LAD compared with other coronary arteries.

After this step, color Doppler should be activated. The LAD is visualized as a small tubular, pulsatile structure, with upward flow (red) and predominantly diastolic. If a circular structure with the same characteristics is identified, the transducer should be subtly rotated clockwise to open the vessel longitudinally (Video 1). It is extremely important, when studying coronary flow, to activate electrocardiographic monitoring.

It is often possible to perform a sweep of the LAD over a wide extension, both proximally and distally, which allows the study of flow at different points. It is not uncommon to find areas of aliasing on color Doppler, which may correspond to a stenotic segment.

On pulsed Doppler, a biphasic flow is identified, with a predominant diastolic component and a trapezoidal appearance. Diastolic velocity is usually approximately twice the systolic velocity. Some authors, instead of evaluating only velocities, study the Velocity–Time Integral (VTI). From a practical standpoint, velocity analysis appears much simpler and faster, especially when used during stress echocardiography.

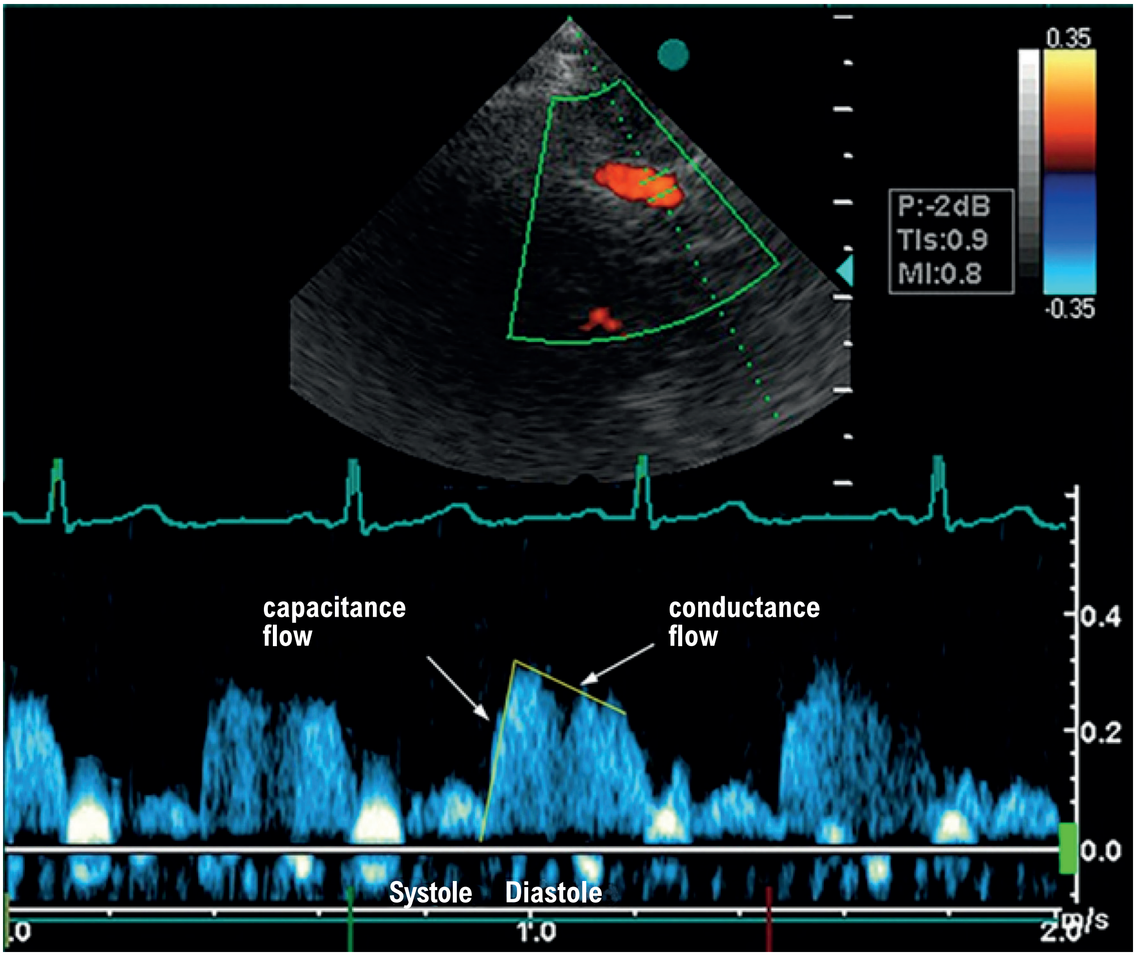


Figure 1 – *Transthoracic Doppler of coronary flow showing a normal systo-diastolic pattern.*

Posterior Descending Branch of the Right Coronary Artery

The success rate for visualizing the Posterior Descending branch (PD) is between 60% and 70%.[3] The view used is the modified apical two-chamber. From this plane, the transducer is rotated slightly counterclockwise and the ultrasound beam is directed posteriorly. This produces a transitional view between the two-chamber and three-chamber planes. Along the inferior wall, one should look for a pulsatile, diastolic, upward (red) flow. This flow can be visualized both at the basal level and more apically along the inferior wall. Therefore, it is important to carefully scan the wall in search of this vessel (Video 2). The pulsed Doppler characteristics are similar to those of the LAD, as previously described.

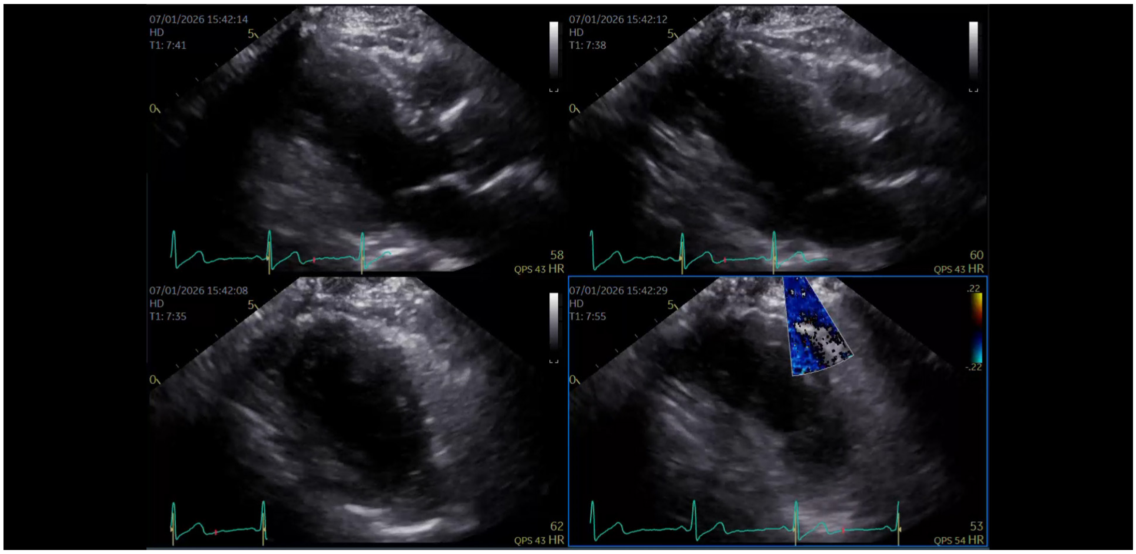
Marginal Branch of the Circumflex Artery

Among the three coronary arteries, this is technically the most difficult to study, with feasibility below 60%.[4] The examination begins from the apical four-chamber view, rotating the transducer slightly clockwise to adequately expose the lateral wall. A practical tip is to keep the right ventricle widely open on the screen. Then, the ultrasound beam is directed posteriorly, as if studying the coronary sinus. The lateral wall should remain well exposed, even if the image appears out of plane (Video 3). It should be emphasized that these views are specific for studying the coronary arteries and not the left ventricle, which may initially seem unusual.

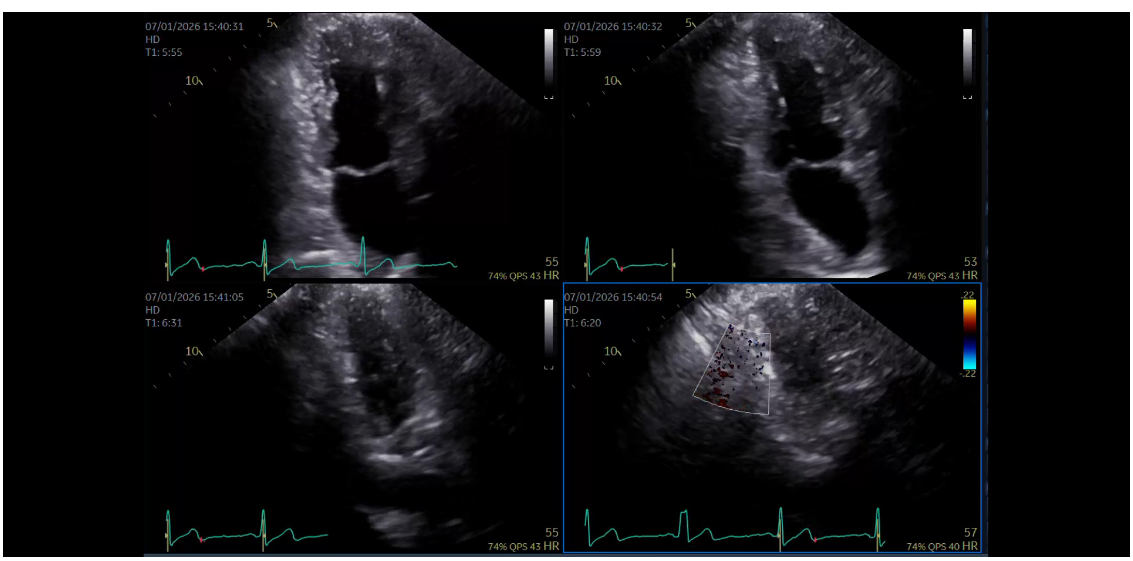
Color Doppler will demonstrate one or more small vessels in the lateral wall, pulsatile, upward (red), and diastolic. Again, it is important to highlight that the study should always be performed with electrocardiographic monitoring. The pulsed Doppler characteristics are similar to those of the other coronary arteries, as previously described.

Pitfalls

During coronary flow assessment, some structures may mimic the LAD. A vessel commonly found in a similar topographic location is the internal thoracic artery. However, its Doppler flow pattern is distinct: predominantly systolic and with higher velocity. Small pericardial effusions

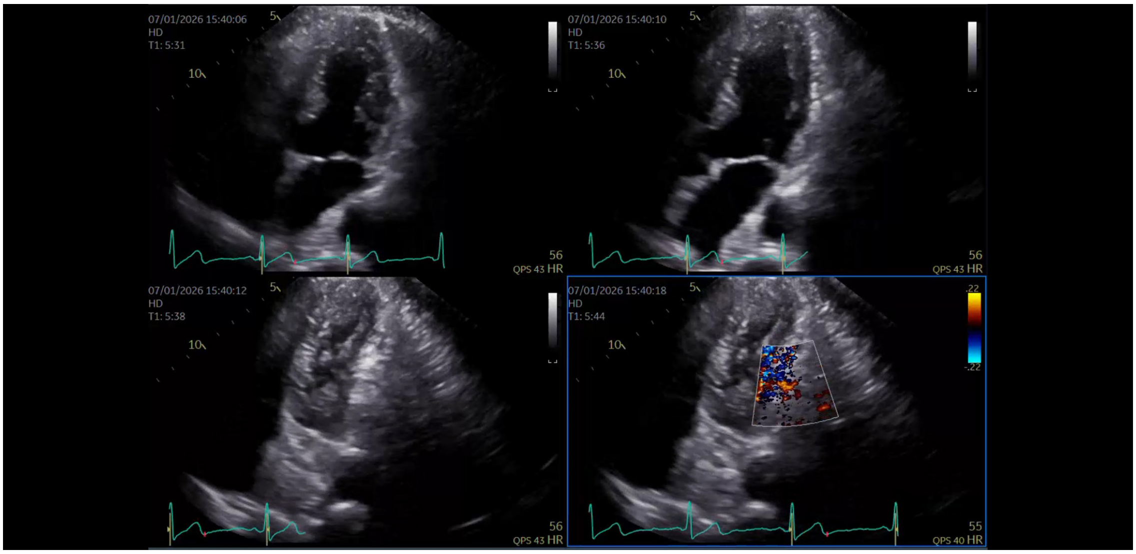


Video 1 – *Step-by-step visualization of the LAD. 1.Low parasternal view. 2. Direct the ultrasound beam toward the patient's left shoulder. 3. Clockwise rotation to remove the RV from the image and identify the interventricular sulcus. 4. Color Doppler demonstrating a small vessel with diastolic flow.*
Link: http://abcimaging.org/supplementary-material/2026/3901/2026-0006_video_01.mp4



Video 2 – *Step-by-step visualization of the PDA. 1. Standard two-chamber view. 2. Intermediate view between the two- and three-chamber views. 3. Posteriorly direct the ultrasound beam. 4. Color Doppler demonstrating a small vessel with diastolic flow in the inferior wall.*
Link: http://abcimaging.org/supplementary-material/2026/3901/2026-0006_video_02.mp4

may present with a flow resembling that seen on color Doppler; however, pulsed Doppler does not reveal the predominant diastolic pattern. In certain situations, a blue (downward) flow may be identified in the interventricular groove, in contrast to the usual red flow. This may indicate LAD occlusion with retrograde flow or the presence of a septal branch of the LAD itself. The PD flow may be confused with the inflow tract of the right ventricle. Nevertheless, the pulsed Doppler pattern is quite different from the characteristic coronary flow.



Video 3 – *Step-by-step visualization of the Mg. 1. Standard four-chamber view. 2. Counterclockwise rotation to "open" the RV. 3. Posteriorly direct the ultrasound beam. 4. Color Doppler demonstrating small vessels with diastolic flow in the lateral wall.*
Link: http://abcimaging.org/supplementary-material/2026/3901/2026-0006_video_03.mp4

Clinical Applications

Rest

In general, the diastolic velocity of coronary flow is below 40 cm/s. Obviously, this velocity is influenced by several factors. Hyperkinesia, tachycardia, hypertension, and anemia, for example, may increase it even in the absence of stenosis. The systolic component usually does not exceed 60% of the diastolic velocity.

According to a recent study by Cortigiani et al.,[5] in patients with chronic coronary syndromes and preserved left ventricular ejection fraction, a resting coronary flow velocity in the LAD equal to or greater than 32 cm/s was independently associated with worse survival.[5] The combination of this resting velocity with a reduced CFR represented the scenario with the poorest prognosis.

In coronary artery disease, the simple identification of a patent distal LAD flow in a patient with wall motion abnormalities in the same territory adds important clinical information. It is not uncommon to directly visualize points of turbulent, high-velocity flow on Doppler. Some authors suggest a cutoff above 80 cm/s, while others propose above 1 m/s, for the detection of significant obstruction.[6,7]

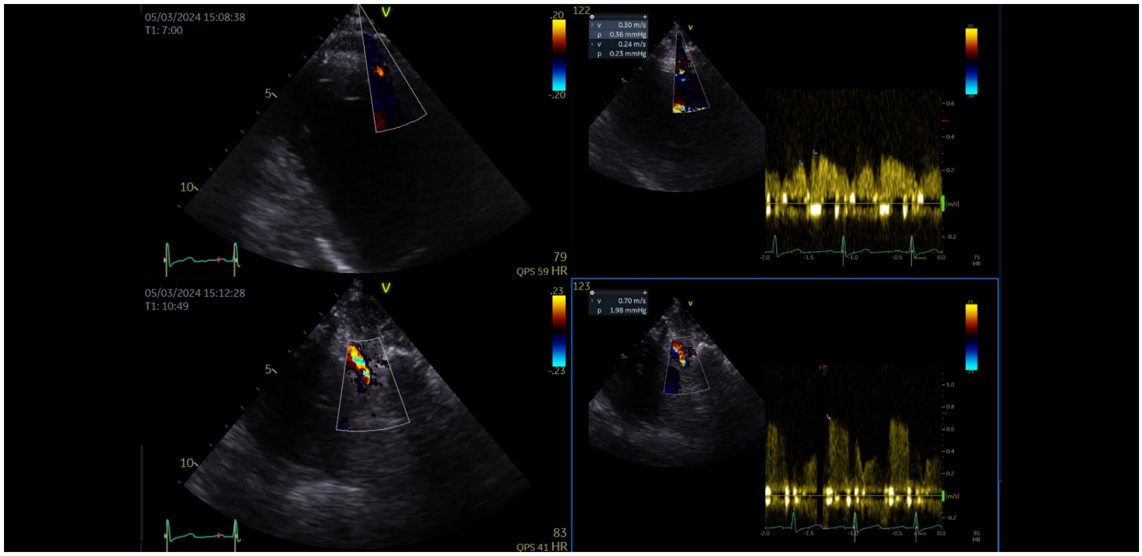
The identification of a "velocity jump" is an interesting parameter that raises the possibility of significant LAD stenosis. This occurs when the diastolic velocity doubles in different regions of the vessel under study (for example, proximal vs. distal). In addition, an increase in the systolic component of coronary flow velocity is another relevant finding. A diastolic-to-systolic velocity ratio below 1.5 shows a sensitivity of 81.8% and a specificity of 85.7% for the diagnosis of coronary stenosis[7] (Video 4).

The coronary flow pattern with rapid diastolic deceleration, often accompanied by reversed systolic flow, is a strong indicator of the no-reflow phenomenon in patients with acute coronary syndrome undergoing percutaneous coronary intervention. Its pathophysiology lies in damage to the coronary microcirculation, such as endothelial injury and distal embolization, which prevent adequate filling of the vascular bed, increase distal pressure, and accelerate flow deceleration. Studies have shown that the deceleration timeis significantly shorter in these patients (152 ± 109 ms) compared with those without the phenomenon (395 ± 128 ms), indicating severe impairment of myocardial perfusion.[8]

Similarly, in patients with hypertrophic cardiomyopathy, coronary Doppler also reveals an atypical flow pattern, characterized by reduction, absence, or inversion of systolic flow.[9] (Figure 2). This similarity to the pattern observed in no-reflow is attributed to the abnormal increase in intramyocardial pressure during systole, which results in compression of the small intramural vessels and elevation of coronary resistance. In addition, the detection of flow in the septal communicating arteries represents another relevant pattern, being a common finding and particularly prevalent in apical and mixed morphologies,[10] conferring significant auxiliary value in the differential diagnosis of conditions that may mimic apical hypertrophic cardiomyopathy (Video 5).

Coronary Flow Reserve

The incorporation of multiple parameters, in addition to wall motion assessment, transforms stress echocardiography into a powerful and highly versatile clinical tool.[11] Beyond enhancing its diagnostic power, it also provides relevant and non-redundant prognostic information.[12] Several publications have demonstrated the importance of CFR evaluation in different clinical scenarios,[13-15] and the European Society of Cardiology has recommended its routine use since the 2008 stress echocardiography guidelines.[16,17]



Video 4 – *Identification of pathological LAD flow at rest and velocity step-up. 1. Laminar flow in the mid-distal segment of the LAD. 2. PW Doppler recording showing a diastolic velocity of 30 cm/s and systolic velocity of 24 cm/s, with a ratio of 1.25 (suggestive of stenosis). 3. Turbulent LAD flow when scanning the vessel more proximally. 4. PW Doppler recording showing a velocity of 70 cm/s (2.3-fold increase). Coronary angiography revealed a significant lesion in the left main coronary artery and proximal LAD.*
Link: http://abcimaging.org/supplementary-material/2026/3901/2026-0006_video_04.mp4

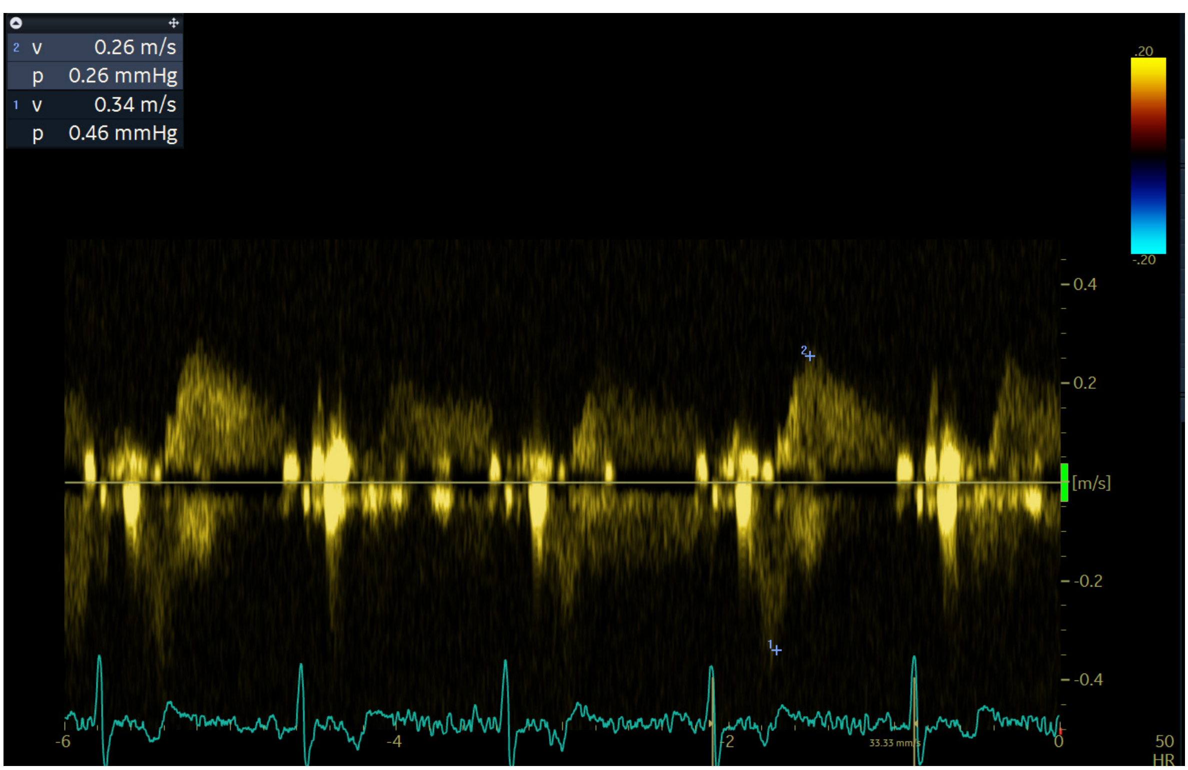
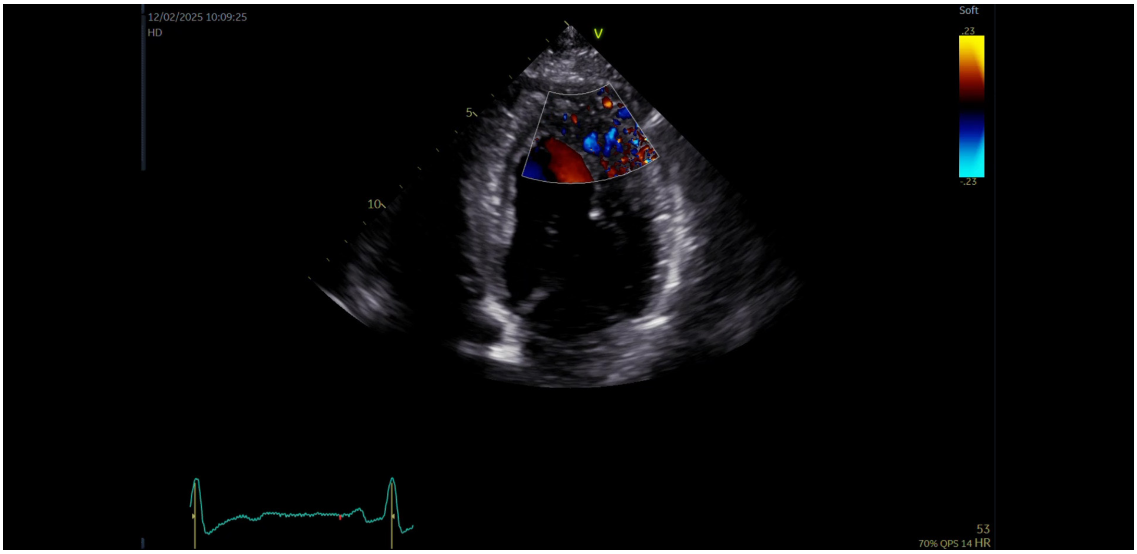


Figure 2 – *LAD flow in a patient with HCM. Inversion of the systolic component is observed*



Video 5 – *Flow in apical communicating branches (blue) in a patient with apical hypertrophic cardiomyopathy. Link: http://abcimaging.org/supplementary-material/2026/3901/2026-0006_video_05.mp4*

The addition of coronary flow assessment to stress echocardiography, after adequate training, does not significantly increase the examination time. Its interpretation takes only a few seconds and is based on the ratio between coronary velocity during stress and at rest. The discriminatory value of 2.0 separates normal from pathological. All stress modalities allow CFR evaluation. The success rate is highest in studies with vasodilators (above 90%), followed by dobutamine (around 80%) and bicycle exercise (about 70%).[18]

Methodology with vasodilator

After acquiring all the baseline images, the diastolic velocity of the distal LAD is recorded as far as possible. Without removing the transducer from the patient's chest, and maintaining continuous visualization of the coronary artery at the same point and angle, dipyridamole is administered at a dose of 0.84 mg/kg over four minutes. The maximum velocity is then recorded up to one minute after the end of the infusion (fifth minute of the test). Under normal conditions, the LAD velocity doubles within a few minutes after the start of the test.

Methodology with dobutamine

Unlike the dipyridamole protocol, in which the LAD is continuously monitored, in the dobutamine test the LAD velocity is measured at rest and again after an increment of 50 beats compared with baseline heart rate and/or when 75% of the predicted maximum heart rate is reached, which usually occurs during the high-dose stages of the drug.[19]

zMethodology with supine bicycle exercise

The evaluation of CFR during exercise is more challenging. As workload increases, trunk movement and hyperventilation impair the acoustic window and make visualization of the LAD more difficult.

For less experienced operators, we recommend a strategy similar to the dipyridamole protocol: locate the LAD at rest with color Doppler and ensure its continuous visualization in the imaging sector from the beginning of the test. This approach favors velocity measurement always at the same point and with the same angulation. However, the main limitation of this strategy is the loss of two-dimensional recordings at low workload, which are particularly useful in studies performed with a cycle ergometer.

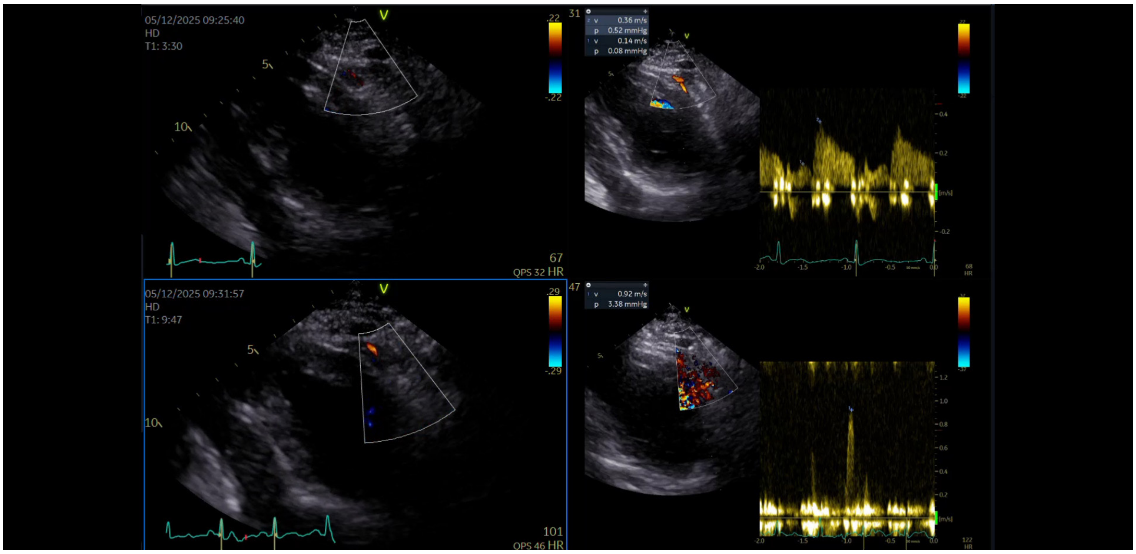
Another approach, technically more demanding, is to begin LAD monitoring during exercise immediately after acquiring two-dimensional images at low workload, ensuring that velocity is measured at the same point and with the same angulation used at rest (Video 6).

In healthy individuals, coronary velocity doubles already in the early stages of exercise (up to 75 watts). The same concepts applied in the dobutamine protocol regarding heart rate are used for CFR evaluation if this doubling does not occur promptly.

It is worth noting that, although CFR assessment in the LAD is the most commonly used, it can also be performed in the other coronary arteries; however, the success rate tends to be lower.

Conclusion

Coronary flow assessment by echocardiography is no longer a utopia and has already become a reality capable of transforming echocardiography laboratories. At rest or under stress, with vasodilators or during exercise, the possibilities are broad and the information obtained is highly relevant. It is possible to detect significant coronary obstructions at rest and anticipate stress-echo results even before ischemia appears.



Video 6 – *LAD CFR during exercise. 1. Flow at rest. 2. Diastolic velocity of 36 cm/s. 3. Flow during exercise (75 W). 4. Diastolic velocity of 92 cm/s. CFR of 2.55 (normal > 2).*
Link: http://abcimaging.org/supplementary-material/2026/3901/2026-0006_video_06.mp4

Identifying higher risk in patients with normal segmental wall motion but reduced CFR has a direct clinical impact. Echocardiography, therefore, should not be regarded as a mere adjunct, but rather as the main player.

Author Contributions

Conception and design of the research, writing of the manuscript and critical revision of the manuscript for intellectual content: Del Castillo JM, Shehadeh I.

Potential Conflict of Interest

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

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Study Association

This study is not associated with any thesis or dissertation work.

Ethics Approval and Consent to Participate

This article does not contain any studies with human participants or animals performed by any of the authors.

Use of Artificial Intelligence

The authors did not use any artificial intelligence tools in the development of this work.

Availability of Research Data

The underlying content of the research text is contained within the manuscript.

References

1. Zagatina A, Zhuravskaya N, Caprnda M, Shiwani HA, Gazdikova K, Rodrigo L, et al. Should we Routinely Assess Coronary Artery Doppler in Daily Echocardiography Practice? Acta Cardiol. 2022;77(7):573-9. doi: 10.1080/00015385.2021.1973771.
2. Ciampi Q, Zagatina A, Cortigiani L, Gaibazzi N, Daros CB, Zhuravskaya N, et al. Functional, Anatomical, and Prognostic Correlates of Coronary Flow Velocity Reserve During Stress Echocardiography. J Am Coll Cardiol. 2019;74(18):2278-91. doi: 10.1016/j.jacc.2019.08.1046.
3. Rigo F, Murer B, Ossena G, Favaretto E. Transthoracic Echocardiographic Imaging of Coronary Arteries: Tips, Traps, and Pitfalls. Cardiovasc Ultrasound. 2008;6:7. doi: 10.1186/1476-7120-6-7.
4. Vegsundvåg J, Holte E, Wiseth R, Hegbom K, Hole T. Transthoracic Echocardiography for Imaging of the Different Coronary Artery Segments: A Feasibility Study. Cardiovasc Ultrasound. 2009;7:58. doi: 10.1186/1476-7120-7-58.
5. Cortigiani L, Gaibazzi N, Ciampi Q, Rigo F, Rodríguez-Zanella H, Wierzbowska-Drabik K, et al. High Resting Coronary Flow Velocity by Echocardiography Is Associated with Worse Survival in Patients with Chronic Coronary Syndromes. J Am Heart Assoc. 2024;13(4):e031270. doi: 10.1161/JAHA.123.031270.
6. Rigo F, Picano E. Coronary Flow Reserve. In: Picano E, editor. Stress Echocardiography. Cham: Springer; 2015. doi:10.1007/978-3-319-20958-6_9.

7. Lowenstein J. Padrões de Fluxo Coronariano Normal e Determinação da Reserva Coronariana pelo Ecodopplertranstorácico. In: Mathias W Jr, Tsutsui JM, editors. Ecocardiografia. Barueri: Manole; 2012, p. 109-29.

8. Youn HJ, Foster E. Demonstration of Coronary Artery Flow Using Transthoracic Doppler Echocardiography. J Am Soc Echocardiogr. 2004;17(2):178-85. doi: 10.1016/j.echo.2003.08.017.

9. Ferreiro DE, Cianciulli TF, Saccheri MC, Lax JA, Celano L, Beck MA, et al. Assessment of Coronary Flow with Transthoracic Color Doppler Echocardiography in Patients with Hypertrophic Cardiomyopathy. Echocardiography. 2013;30(10):1156-63. doi: 10.1111/echo.12242.

10. Sousa CG, Castillo JMD, Mazzarollo C, Albuquerque ES, Sena ADM, Brindeiro D Filho, et al. Comparative Analysis of the Coronary Arteries Flow Pattern in Secondary Myocardial Hypertrophies and by Sarcomeric Mutation. Arq Bras Cardiol: Imagem Cardiovasc. 2021;34(1):eabc131. doi: 10.47593/2675-312X/20213401eabc131.

11. Picano E, Ciampi Q, Wierzbowska-Drabik K, Urluescu ML, Morrone D, Carpeggiani C. The New Clinical Standard of Integrated Quadruple Stress Echocardiography with ABCD Protocol. Cardiovasc Ultrasound. 2018;16(1):22. doi: 10.1186/s12947-018-0141-z.

12. Ciampi Q, Zagatina A, Cortigiani L, Wierzbowska-Drabik K, Kasprzak JD, Haberka M, et al. Prognostic Value of Stress Echocardiography Assessed by the ABCDE Protocol. Eur Heart J. 2021;42(37):3869-78. doi: 10.1093/eurheartj/ehab493.

13. Lowenstein JA, Caniggia C, Rousse G, Amor M, Sánchez ME, Alasia D, et al. Coronary Flow Velocity Reserve during Pharmacologic Stress Echocardiography with Normal Contractility Adds Important Prognostic Value in Diabetic and Nondiabetic Patients. J Am Soc Echocardiogr. 2014;27(10):1113-9. doi: 10.1016/j.echo.2014.05.009.

14. Cortigiani L, Gaibazzi N, Ciampi Q, Tuttolomondo D, Navacchi R, Bovenzi F, et al. Prognostic Significance of Coronary Flow Velocity Reserve in Patients with Peripheral Arterial Disease. Int J Cardiovasc Imaging. 2025;41(7):1287-95. doi: 10.1007/s10554-025-03411-z.

15. Ciampi Q, Olivotto I, Gardini C, Mori F, Peteiro J, Monserrat L, et al. Prognostic Role of Stress Echocardiography in Hypertrophic Cardiomyopathy: The International Stress Echo Registry. Int J Cardiol. 2016;219:331-8. doi: 10.1016/j.ijcard.2016.06.044.

16. Sicari R, Nihoyannopoulos P, Evangelista A, Kasprzak J, Lancellotti P, Poldermans D, et al. Stress Echocardiography Expert Consensus Statement: European Association of Echocardiography (EAE) (A Registered Branch of the ESC). Eur J Echocardiogr. 2008;9(4):415-37. doi: 10.1093/ejechocard/jen175.

17. Picano E, Pierard L, Peteiro J, Djordjevic-Dikic A, Sade LE, Cortigiani L, et al. The Clinical Use of Stress Echocardiography in Chronic Coronary Syndromes and Beyond Coronary Artery Disease: A Clinical Consensus Statement from the European Association of Cardiovascular Imaging of the ESC. Eur Heart J Cardiovasc Imaging. 2024;25(2):e65-e90. doi: 10.1093/ehjci/jead250.

18. Rigo F, Picano E. Step D for Doppler-Based Coronary Flow Velocity Reserve in Stress Echocardiography. In: Picano E, editors. Stress Echocardiography. Cham: Springer; 2023. p. 55-77. doi: 10.1007/978-3-031-31062-1_4.

19. Forte EH, Rousse MG, Lowenstein JA. Target Heart Rate to Determine the Normal Value of Coronary Flow Reserve during Dobutamine Stress Echocardiography. Cardiovasc Ultrasound. 2011;9:10. doi: 10.1186/1476-7120-9-10.