Bristol Publishers

Case Reports and Case Series in Cardiology Journal

Case Series | Open Access | Volume: 2 Issue: 1 (January-March 2026) Pages: 30-35

ISSN: 3107-6416 (Online) | DOI: doi.org/10.64874/crcscj.v2i1.2026.023

Diagnostics of Significant Coronary Artery Stenosis in Asymptomatic Patients Based on Transthoracic Echocardiography Data

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Received: 03 March 2026; **Revised:** 05 April 2026; **Accepted:** 09 April 2026; **Published:** 10 April 2026

Academic Editor: Dr. Zahid Khan

Abstract

Background: Up to 50% of patients with myocardial ischemia may remain asymptomatic until the occurrence of an acute coronary event. Identification of high-risk individuals without clinical manifestations remains a diagnostic challenge. Assessment of coronary artery flow during routine transthoracic echocardiography may provide additional information in patients with silent ischemia. Coronary artery ultrasound is rarely used in routine clinical practice, primarily due to technical challenges, operator dependency, and the availability of more established imaging modalities like CT angiography and invasive coronary angiography, although coronary ultrasound is non-invasive and free of radiation, making it much more patient-friendly and potentially advantageous. However, the following cases will highlight situations where coronary ultrasound provides crucial, timely insights that can influence diagnosis and management, demonstrating its potential value beyond standard use.

Case Presentation: We present a series of three asymptomatic male patients aged 37-44 years with cardiovascular risk factors who underwent transthoracic echocardiography with coronary artery flow assessment. None of the patients reported chest pain, dyspnea, or exercise intolerance, and no ischemic electrocardiographic changes were observed during stress testing. Coronary artery screening revealed persistently increased diastolic flow velocities in the proximal segments of the left anterior descending artery. Subsequent stress echocardiography demonstrated extensive inducible ischemia in all cases. Coronary angiography confirmed significant coronary artery stenoses, predominantly affecting the proximal and mid segments of the left anterior descending artery. All patients underwent effective surgical treatment.

Conclusion: Determination of coronary flow velocity during routine transthoracic echocardiography may serve as a valuable adjunctive diagnostic instrument for finding substantial coronary artery disease in asymptomatic patients with cardiovascular risk factors.

Keywords: Silent ischemia; Coronary artery disease; Coronary flow velocity; Stress echocardiography; Transthoracic echo coronary Doppler

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Introduction

Silent myocardial ischemia is a well-recognized clinical entity associated with unfavorable cardiovascular outcomes. A considerable number of individuals with significant coronary artery disease (CAD) may remain asymptomatic, delaying diagnosis and treatment. Conventional stress testing may fail to identify ischemia in the absence of symptoms or electrocardiogram changes. Advances in transthoracic echocardiographic techniques have made it possible to non-invasively visualize and evaluate coronary artery flow, particularly in the anterior descending branch of the left coronary artery. Transthoracic Doppler echocardiography enables assessment of coronary flow velocity, providing functional information on coronary artery stenosis in real-world clinical practice [1-3]. Coronary flow velocity reserve and resting coronary flow velocity have been shown to correlate with invasive fractional flow reserve and reflect the hemodynamic importance of coronary artery disease [4]. Increased coronary flow velocity at rest may indicate hemodynamically significant stenosis and has been consistently associated with impaired coronary flow reserve and adverse clinical outcomes across different patient populations, including elderly individuals [5-10]. This case series highlights the diagnostic value of coronary artery flow assessment during routine echocardiography in asymptomatic patients with CAD risk factors.

Methods:

Transthoracic echocardiography was performed using Vivid 7 Dimension (GE Healthcare, USA; Liestal, Switzerland) with an M4S transducer and Vivid E9 (GE Healthcare, USA; Horten, Norway) with an M5S transducer. Both systems employed multifrequency phased-array probes with second harmonic imaging and the manufacturer's "Coronary" preset.

In addition to standard echocardiography, left coronary artery flow was assessed using color Doppler imaging. Examinations were performed in the supine or left lateral decubitus position using standard and modified parasternal, apical, and subcostal views. The ultrasound beam was aligned as parallel as possible to coronary blood flow.

When abnormal flow was suspected, the transducer was positioned at the site of maximal disturbance for quantitative analysis. Coronary flow velocity was measured using pulsed-wave Doppler with a 2-3.0 mm sample volume placed at the region of greatest turbulence. Angle correction was not applied. The Nyquist limit was initially set at 0.22 m/s and adjusted up to 0.46 m/s for optimal visualization. The highest recorded flow velocities were used for analysis. A persistent diastolic coronary flow velocity ≥0.70 m/s was considered indicative of significant coronary artery stenosis. Stress echocardiography was performed using a semi-supine bicycle ergometer with stepwise workload increments of 25 W until standard termination criteria were reached, under continuous electrocardiographic and blood pressure monitoring.

Cases Presentation

Each patient included in this report signed a written informed consent form allowing the publication of their clinical data and related images.

Case 1:

A 37-year-old physically active male smoker with arterial hypertension and hypercholesterolemia (5.9 mmol/L) reported no cardiovascular symptoms. Carotid ultrasound showed no pathological changes. Standard echocardiographic parameters, including left ventricular ejection fraction, wall thickness, left ventricular mass, and diastolic function, were within normal reference ranges. Coronary artery flow assessment demonstrated elevated velocities of 1.1 m/s (Figure 1) and 0.98 m/s in the proximal and mid-left anterior descending artery (LAD), respectively. Stress echocardiography (SE) had not been performed previously, as no clear indication was present; current guidelines do not recommend SE for asymptomatic patients without a high risk of coronary artery disease (CAD). During the test, the patient remained asymptomatic, with a heart rate reaching 100 bpm at a workload of 50 W, and no significant ECG changes were observed. SE revealed inducible ischemia in the apical, septal, anterior, and lateral segments.

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Coronary angiography confirmed 90% stenoses of the proximal and mid-LAD. The patient underwent successful stenting of the proximal and mid-LAD, with repeat stenting performed one year later as indicated.

Since then, the patient has been followed annually for seven years. Stress tests are negative, and he reports no chest pain or dyspnea. He maintains regular physical activity and guideline-directed therapy, including antiplatelet therapy, high-dose statin, ezetimibe, an angiotensin receptor blocker, and a beta-blocker.

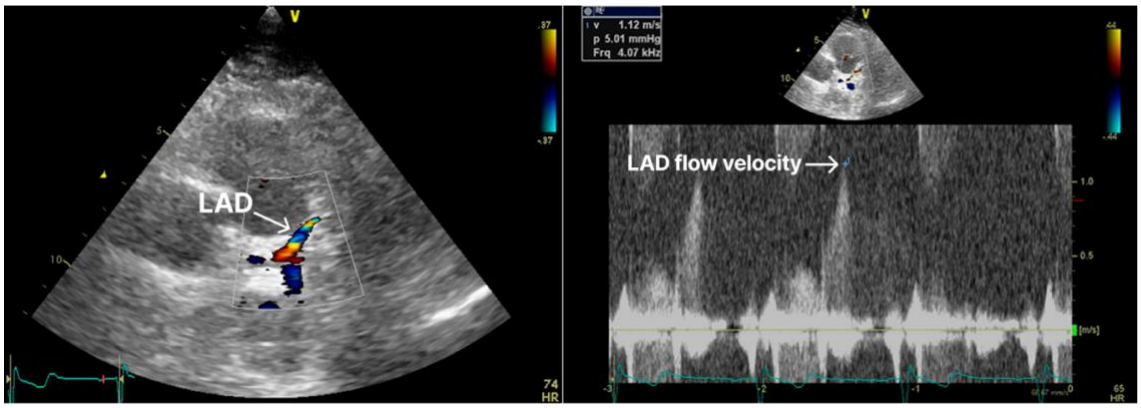

Figure 1: Transthoracic Doppler echocardiography of the left anterior descending artery in Case 1: Color Doppler imaging demonstrates the left anterior descending artery (LAD) in the proximal segment. Pulsed-wave Doppler recording shows increased resting diastolic coronary flow velocity, consistent with hemodynamically significant LAD stenosis.

Case 2:

A 39-year-old male smoker with mild arterial hypertension and hypercholesterolemia (total cholesterol 5.9 mmol/L) underwent echocardiography as part of cardiovascular risk assessment. The patient reported no chest pain or dyspnea during daily or sport activities. All conventional echocardiographic parameters, such as left ventricular ejection fraction, wall thickness, left ventricular mass, and diastolic function, were within normal limits. Assessment of coronary artery flow revealed a focal increase in diastolic velocity to 0.70 m/s in the proximal left anterior descending artery (LAD). Stress echocardiography was subsequently performed following echocardiography with coronary flow velocity assessment. The test was terminated at a workload of 50 W when a heart rate of 96 bpm was reached due to extensive inducible ischemia involving the apical, septal, anterior, and lateral walls. Coronary angiography performed one month later demonstrated 70-80% proximal and 80% mid-LAD stenosis, 90% stenosis of the first marginal branch (OM1), and occlusion of the proximal right coronary artery (RCA), which was not amenable to stenting. The patient underwent successful stenting of the proximal marginal branch and LAD. Since then, the patient has been followed annually for 10 years. Stress testing remains positive in the RCA territory without progression. He continues long-term therapy with antihypertensives, statins, and beta-blockers, engages in regular physical activity, and reports no chest pain or dyspnea.

Case 3:

A 44-year-old non-smoking male with moderate arterial hypertension and total cholesterol of 5.0 mmol/L underwent echocardiographic evaluation. Carotid ultrasound revealed increased intima-media thickness. Standard echocardiographic parameters, including left ventricular ejection fraction, left ventricular mass, and diastolic function, were within normal reference ranges, while mild increases in wall thickness were observed (interventricular septum up to 10 mm, posterior wall up to 11 mm; relative wall thickness 0.37). Coronary artery screening identified a localized turbulent flow zone in the proximal LAD with a peak diastolic velocity of 0.9-0.98 m/s (Figure 2).

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Stress echocardiography demonstrated ischemic changes similar to those observed in Case 1, achieved at a heart rate of 122 bpm during a workload of 50 W. Coronary angiography revealed 80-90% proximal LAD stenosis, and the patient was successfully stented. One year later, a follow-up stress test remained positive, prompting coronary artery bypass grafting (CABG). After surgery, the patient experienced two episodes of paroxysmal atrial fibrillation, but subsequent stress tests indicated a low-risk profile. At present, ten years after initial presentation, the patient continues guideline-directed therapy with antihypertensives, statins, ezetimibe, beta-blockers, and oral anticoagulants, maintains regular physical activity, and reports no chest pain or dyspnea.

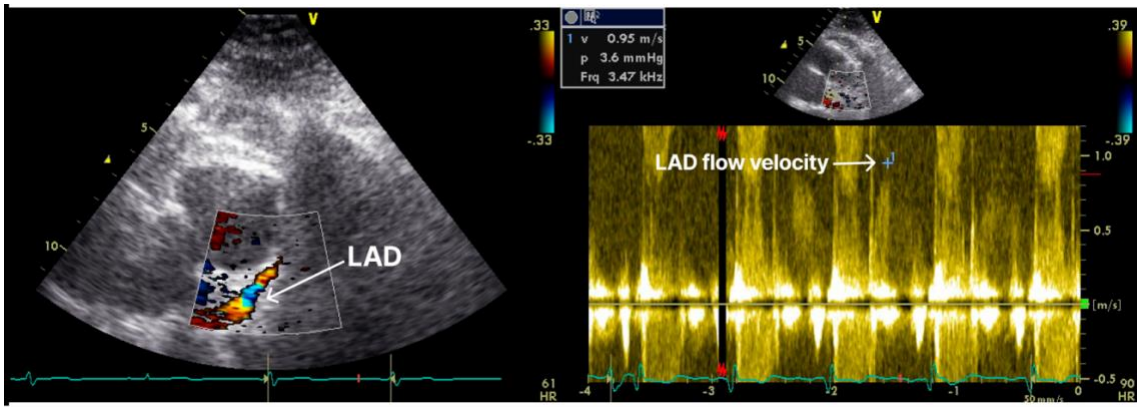

Figure 2: Increased coronary flow velocity in the proximal left anterior descending artery in Case 3: Color Doppler visualization of the left anterior descending artery (LAD) demonstrates turbulent flow. Pulsed-wave Doppler shows elevated resting diastolic flow velocity, suggesting significant proximal LAD stenosis later confirmed by coronary angiography.

Table 1: Clinical characteristics, coronary flow velocity, angiographic findings, and treatment of the study patients.

Patient	Age (years)	Risk Factors	Resting LAD Velocity (m/s)	Coronary Angiography Findings	Treatment
1	37	Smoking, arterial hypertension, hypercholesterolemia (5.9 mmol/L)	1.10 (proximal), 0.98 (mid)	90% stenosis of proximal and mid-LAD; PCI performed	No therapy at presentation; after diagnosis: antiplatelet therapy, high-dose statin, ezetimibe, angiotensin receptor blocker, beta-blocker
2	39	Smoking, mild arterial hypertension, hypercholesterolemia (5.9 mmol/L)	0.70 (proximal)	70-80% proximal LAD, 80% mid-LAD stenosis; 90% marginal branch stenosis; proximal RCA occlusion; revascularization performed	No therapy at presentation; after diagnosis: antiplatelet therapy, high-dose statin, ACE inhibitor, beta-blocker
3	44	Arterial hypertension, hypercholesterolemia (5.0 mmol/L)	0.90-0.98 (proximal)	80-90% proximal LAD stenosis; revascularization performed	No therapy at presentation; after diagnosis: beta-blocker, statin plus ezetimibe, angiotensin receptor blocker, calcium channel blocker, and NOAC (due to paroxysmal atrial fibrillation after CABG)

Diagnostics: In all cases, high coronary artery flow velocity in the proximal LAD during transthoracic echocardiography was associated with significant angiographic stenosis and extensive inducible ischemia on stress echocardiography.

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Discussion

Coronary artery stenosis leads to an increase in coronary flow velocity due to fundamental hemodynamic principles. As the vessel lumen narrows, the same volume of blood must pass through a smaller cross-sectional area, resulting in an acceleration of flow velocity (according to the principle of conservation of mass and the continuity equation). Additionally, significant stenosis creates a pressure gradient across the narrowed segment, further contributing to increased flow velocity, particularly distal to the lesion. On Doppler echocardiography, this manifests as elevated diastolic coronary flow velocities, which may indicate hemodynamically significant obstruction.

Beyond the assessment of absolute coronary flow velocity (CFV), evaluation of coronary flow velocity reserve (CFVR) provides additional functional insight into coronary circulation. Previous studies have demonstrated that CFVR remains independently correlated with exercise duration, achieved workload, and abnormal findings on exercise stress echocardiography, with a CFVR value < 2.3 identified as the optimal cutoff for predicting abnormal SE results [11]. Moreover, increased resting CFV has been associated with worse survival in patients with both ischemic and non-ischemic heart failure with reduced ejection fraction [12]. Also CFVR assessment in the LAD enhances the risk stratification capabilities of stress echocardiography beyond conventional parameters such as stress-induced regional wall motion abnormalities and left ventricular ejection fraction [13]. An abnormal CFVR measured by transthoracic Doppler echocardiography has been shown to provide incremental diagnostic value when combined with clinical data and dobutamine stress echocardiography variables in detecting significant LAD stenosis [14]. These findings further support the role of coronary flow assessment as a sensitive and functionally meaningful marker of coronary artery disease. Thus, integration of coronary flow parameters may complement established echocardiographic predictors and improve prognostic evaluation.

This case series illustrates the potential clinical value of coronary artery flow assessment during routine transthoracic echocardiography in patients exhibiting cardiovascular risk factors in the absence of clinical symptoms. This study has several limitations. It represents a single-center experience with a small sample size, and all assessments were operator-dependent. Additionally, all patients included in this series had cardiovascular risk factors, which may limit the generalizability of the findings to broader populations.

Despite the absence of symptoms and electrocardiogram changes, all patients demonstrated markedly increased coronary flow velocities, which correlated with significant obstructive coronary artery disease on coronary angiography. None of the patients had a clear indication for stress echocardiography prior to coronary flow assessment. Early identification of such patients may allow timely intervention and prevention of adverse cardiac events.

It remains uncertain whether this represents silent LAD stenosis with a potentially benign prognosis in untreated patients. However, data from prospective pilot studies suggest that high diastolic velocity in the LAD (greater than 0.7 m/s) may represent an unfavorable prognostic marker [5,8,9]. Given that the initial clinical manifestation of coronary artery disease is often myocardial infarction or cardiac death, incorporating coronary artery flow assessment into standard echocardiographic protocols may improve both diagnostic accuracy and risk stratification in selected populations.

Conclusions

Evaluation of coronary flow velocity during routine transthoracic echocardiography can provide additional clinically relevant diagnostic information and facilitate early detection of significant coronary artery disease in asymptomatic patients with cardiovascular risk factors. Since coronary artery ultrasound is a non-invasive, inexpensive, and effective method for detecting significant coronary stenoses, even in asymptomatic patients, we recommend incorporating this assessment routinely as part of standard echocardiography whenever technically feasible. In cases where blood flow velocity exceeds 0.7 m/s, further evaluation with stress echocardiography is warranted to determine the clinical significance of the stenosis and to guide optimal patient management.

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Abbreviations: AH: Arterial hypertension; **CAD:** Coronary artery disease; **CA:** Coronary angiography; **LAD:** Left anterior descending artery; **SE:** Stress echocardiography; **CFV:** Coronary flow velocity; **CFVR:** Coronary flow velocity reserve

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