

Impact of heart rate related left bundle branch block on instantaneous fractional flow reserve in aged patients

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Interpretation of coronary physiology with fractional flow reserve (FFR) assumes stable relationships between flow, demand, and resistance, but conduction abnormalities such as left bundle branch block (LBBB) can disrupt myocardial activation, perfusion, and pressure-derived ischemic indices especially in aged patients.^[1] Heart rate related LBBB is a transient, rate-dependent conduction delay that induces ventricular dyssynchrony and impairs regional perfusion, potentially altering instantaneous FFR (iFFR) accuracy, particularly in the left anterior descending artery or the left circumflex artery disease.^[2] Because the physiological impact of heart rate related LBBB is unknown, we investigated its influence on iFFR in aged patients with intermediate stenoses in the left coronary artery.

We conducted an observational study of consecutive patients evaluated for unstable angina at Padova South Hospitals, Monselice, Italy from October 2023 to August 2025. Eligible patients had symptom onset within three months, underwent elective coronary angiography, had mild-intermediate (40%–70%) left anterior descending artery or left circumflex artery stenosis by quantitative coronary angiography (QCA), preserved left ventricular ejection fraction ($\geq 55\%$), and no significant valvular disease. The experimental group consisted of patients with documented heart rate related LBBB, defined as a typical LBBB pattern appearing only at higher heart rates and resolving at lower rates; controls had no history of heart rate related LBBB.

Exclusion criteria included permanent LBBB, prior percutaneous coronary intervention or coronary artery bypass grafting, acute coronary syndromes, and significant valvular disease. All patients provided informed consent, and

institutional approval was obtained. Coronary angiograms were analyzed by two blinded investigators, with stenosis severity quantified by QCA. The iFFR was measured using a pressure sensor guidewire after equalization. In heart rate related LBBB patients, FFR was recorded during normal conduction and during tachycardia-induced LBBB; Δ FFR represented the difference between these values. Controls underwent a single iFFR measurement. Angiographic-functional discordance was defined as $\text{FFR} \leq 0.80$ in lesions with $\text{QCA} \leq 50\%$.

Clinical characteristics, risk factors, comorbidities, and laboratory data were extracted from medical records. Continuous and categorical variables were compared using the Student's *t*-test and the Pearson's chi-squared test or the Fisher's exact probability test. Predictors of Δ FFR were identified through multivariable linear regression including heart rate related LBBB, heart rate, their interaction, and clinical confounders. Analyses were performed using R statistical software 4.3.2 (R Foundation for Statistical Computing, Vienna, Austria) and SPSS 20.0 (SPSS Inc., Armonk, New York, USA), with significance set at *P*-value < 0.05 .

Seventy-nine patients with intermediate left coronary stenoses were enrolled, including 41 patients with heart rate related LBBB and 38 controls (mean age: 79.5 ± 4.3 years, males/females: 48/31). No differences in demographics, risk factors, or QCA stenosis were observed among the two groups. Patients with heart rate related LBBB developed conduction delay at a mean heart rate of 88 ± 8 beats/min and showed significantly lower iFFR than controls (0.75 ± 0.06 vs. 0.84 ± 0.05 , $P < 0.001$). The iFFR declined by -0.08 ± 0.03 from baseline, and 46.7% exhibited angiographic-functional discordance. Heart rate related LBBB independently

predicted a greater Δ FFR reduction, and higher heart rate further amplified this effect, with a significant heart rate $\times$ heart rate related LBBB interaction. QCA stenosis showed no

significant association with Δ FFR. The final model explained 48% of Δ FFR variability, without evidence of multicollinearity (Table 1 & Figure 1).

Table 1 Multivariate linear regression analysis for Δ fractional flow reserve.

	β coefficient	95% CI	P-value
LBBB, yes vs. no	−0.045	−0.072 to −0.018	0.001
Heart rate, per 10 beats/min $\uparrow$	−0.012	−0.020 to −0.004	0.004
LBBB $\times$ Heart rate	−0.008	−0.014 to −0.002	0.009
QCA, %	−0.001	−0.002 to 0.000	0.08
Low-density lipoprotein cholesterol, per 10 mg/dL $\uparrow$	0.002	−0.001 to 0.006	0.24
Type 2 diabetes mellitus	−0.010	−0.035 to 0.015	0.42

LBBB: left bundle branch block; QCA: quantitative coronary angiography.

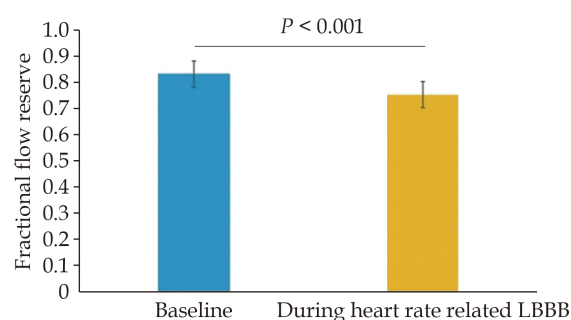


Figure 1 Comparison of fractional flow reserve at baseline and during heart rate related LBBB. The fractional flow reserve values were significantly lower during heart rate related LBBB compared with the basal condition ($P < 0.001$). LBBB: left bundle branch block.

In this retrospective cohort of patients with intermediate left coronary stenoses, development of heart rate related LBBB at higher heart rates was associated with a significant reduction in iFFR compared with controls. The decline in iFFR was accentuated at higher heart rates and was independently linked to heart rate related LBBB, irrespective of stenosis severity or other clinical covariates. These preliminary findings suggest that transient conduction abnormalities can meaningfully distort physiologic assessment of coronary lesions. Potential mechanisms include heart rate-dependent ventricular dyssynchrony, impaired septal contraction, increased microvascular resistance, and reduced diastolic perfusion, all of which may amplify pressure loss across stenoses.^[3] Alternatively, tachycardia-induced LBBB may reflect underlying flow-limiting stenoses, contributing to the observed iFFR differences.^[4] Transient conduction abnormalities may lead to overestimation of lesion severity in the left coronary circulation, potentially affecting revascularization decisions.^[5]

These results also identify avenues for future research. Systematic evaluation of iFFR during controlled tachycardia, pacing, or pharmacologic stress (e.g., dobutamine or atropine) could clarify the impact of transient conduction abnormalities on coronary physiology. Larger, multicenter studies incorporating microvascular assessment may further define the clinical relevance of heart rate related LBBB and determine whether adjustments to physiologic measurements are needed in such patients.

In conclusion, heart rate related LBBB can significantly reduce iFFR, emphasizing the need to consider transient conduction disturbances when interpreting physiologic indices and guiding coronary revascularization in aged patients.

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REFERENCES

- [1] Yin F, Zhang Y, Zhang X, *et al*. Updated meta-analysis of fractional flow reserve versus coronary angiography for guiding percutaneous coronary intervention. *PLoS One* 2025; 20: e0334019.
- [2] Roy-Chaudhury A, Prasada S, Stouffer GA. Interpretation of discordance between non-hyperemic pressure ratios and fractional flow reserve: potential mechanisms and clinical implications. *Rev Cardiovasc Med* 2025; 26: 40417.
- [3] Claridge S, Chen Z, Jackson T, *et al*. Current concepts relating coronary flow, myocardial perfusion and metabolism in left bundle branch block and cardiac resynchronisation therapy. *Int J Cardiol* 2015; 181: 65–72.
- [4] Malozzi C, Wenzel G, Karumbaiah K, *et al*. Chest pain associated with rate-related left bundle branch block and cardiac memory mimicking ischemia. *J Cardiol Cases* 2013; 9: 87–90.



- [5] Seibolt L, Maestas C, Lazkani M, *et al*. Rate-related left bundle branch block and cardiac memory in a patient with bradycardia: case report and literature review. *Clin Cardiol* 2018; 41: 1097–1102.

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