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PREVALENCE OF CLOPIDOGREL RESISTANCE AND CYP2C19*2 GENETIC POLYMORPHISM IN PATIENTS WITH ISCHEMIC HEART DISEASE

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ABSTRACT

Background: Ischemic heart disease (IHD) is a major cause of morbidity and mortality, and clopidogrel is widely used to prevent thrombotic complications. However, variability in clopidogrel response may be influenced by genetic polymorphisms, particularly the loss-of-function CYP2C19*2 allele. **Aim:** To determine the prevalence of CYP2C19*2 genotypes and evaluate their association with clinical presentation and conventional coronary risk factors among patients with IHD in South India. **Materials and Methods:** This prospective observational study included 100 patients with IHD at a tertiary care hospital in South India. Demographic characteristics, cardiovascular risk factors, medication history, clinical presentation, coronary angiographic findings, and left ventricular function were documented. Genomic DNA was isolated from 5 mL of venous blood collected in EDTA tubes using the salting-out method. CYP2C192 polymorphism was analyzed using polymerase chain reaction–restriction fragment length polymorphism (PCR-RFLP). **Results:** The common cardiovascular risk factors were smoking (41%), diabetes mellitus (40%), and hypertension (39%). Among patients with chronic stable angina (CSA), the most frequent genotype was 1*/2* (39.62%), followed by 1*/1* (37.74%) and 2*/2* (22.64%). Among patients with acute coronary syndrome (ACS), the 1*/2* genotype was predominant (55.32%), followed by 1*/1* (27.66%) and 2*/2* (17.02%). Loss-of-function genotypes (1*/2* and 2*/2*) were observed in 62.26% of the CSA group and 72.34% of the ACS group. Statistical significance for this difference was not available. **Conclusion:** The CYP2C19 1*/2* genotype was the most frequently observed genotype in both clinical groups. Loss-of-function genotypes were proportionally more common among patients with ACS than among those with CSA. Further studies incorporating validated platelet-function testing, complete risk-factor association analyses, and larger patient cohorts are needed to establish the relationship between CYP2C19 polymorphism and phenotypic clopidogrel resistance.

INTRODUCTION

Ischemic heart disease (IHD) is a major cause of morbidity and mortality in India and is associated with several cardiovascular risk factors, including age, gender, smoking, hypercholesterolemia, diabetes mellitus, and hypertension. Platelet activation plays a crucial role in the pathogenesis of coronary artery disease (CAD) and ischemic stroke. Aspirin and clopidogrel are widely used antiplatelet agents for the prevention of thrombotic events in these conditions. [1,2] The Antithrombotic Trialists' Collaboration reported that antiplatelet therapy reduces serious vascular events by approximately 25% among high-risk individuals. However, the therapeutic response varies between individuals, and some patients experience recurrent thromboembolic events despite receiving regular antiplatelet treatment. Such patients may be classified as having antiplatelet resistance or a poor pharmacological response, which has been associated with an increased risk of recurrent cardiovascular events.[3,4]

Clopidogrel is a prodrug that requires hepatic bioactivation by cytochrome P450 (CYP) enzymes, particularly CYP2C19, with contributions from other enzymes, including CYP3A4, CYP3A5, and CYP2C9. Genetic polymorphisms affecting these enzymes can reduce the formation of clopidogrel's active metabolite, resulting in diminished platelet inhibition and an increased risk of thrombotic complications. The CYP2C19*2 variant is an important loss-of-function allele associated with reduced clopidogrel responsiveness. Consequently, identifying genetic variations and evaluating their relationship with conventional coronary risk factors may help explain interindividual differences in treatment response. [5-7]

Platelet function can be assessed using light transmittance aggregometry (LTA), a traditional laboratory method; however, its application is limited by variable reproducibility, relatively large sample requirements, prolonged processing time, and the need for technical expertise. Alternative methods, including the PFA-100 analyzer and VerifyNow system, offer more convenient approaches to platelet-function assessment. Nevertheless, differences in testing methodologies, definitions of resistance, and study populations have contributed to variability in reported prevalence estimates and the identification of clinically relevant predictors. [8-10]

Therefore, the present study aimed to determine the prevalence of clopidogrel resistance and CYP2C19*2 loss-of-function genotypes among patients with IHD in South India and to investigate their associations with common coronary risk factors, including diabetes mellitus, hypertension, dyslipidemia, smoking, alcohol consumption, and family history of IHD. Understanding these associations may help clarify the contribution of genetic variation and conventional cardiovascular risk factors to the variability in clopidogrel response.

MATERIALS AND METHODS

1. Study Design and Setting

A prospective observational study was conducted at a tertiary care hospital in South India to determine the prevalence of clopidogrel resistance and evaluate its relationship with associated coronary risk factors in patients with ischemic heart disease (IHD). The study included 100 patients with IHD receiving clopidogrel therapy. Clinical characteristics, cardiovascular risk factors, coronary angiographic findings, left ventricular function, and CYP2C19 genetic variants were assessed.

2. Study Population

Patients diagnosed with IHD who were receiving clopidogrel therapy were considered for inclusion. A detailed clinical history was obtained from all enrolled participants, including demographic characteristics, medication history, clinical presentation, and associated cardiovascular risk factors.

Inclusion Criteria

- Patients diagnosed with ischemic heart disease.

- Patients receiving clopidogrel therapy.
- Patients who provided written informed consent to participate in the study.

Exclusion Criteria

Patients with any of the following conditions were excluded:

- History of bleeding.
- Previous stroke or transient ischemic attack (TIA).
- Known sensitivity to clopidogrel or aspirin.
- Renal dysfunction.
- Hepatic dysfunction.

3. Clinical Assessment and Data Collection

Demographic and clinical information was collected using a structured data collection proforma. The recorded variables included age, gender, diabetes mellitus, hypertension, dyslipidemia, family history of ischemic heart disease, smoking, and alcohol consumption.

Medication history included the use of aspirin, clopidogrel, beta-blockers, angiotensin-converting enzyme inhibitors or angiotensin receptor blockers (ACEI/ARB), and statins. Clinical presentation was categorized as chronic stable angina (CSA), ST-elevation myocardial infarction (STEMI), unstable angina/non-ST-elevation myocardial infarction (UA/NSTEMI), or stent thrombosis.

Coronary angiographic findings were classified as normal coronary arteries, single-vessel disease (SVD), double-vessel disease (DVD), triple-vessel disease (TVD), or left main coronary artery disease (LMCA). Left ventricular function was assessed using the left ventricular ejection fraction (LVEF), with dysfunction defined as LVEF below 55%, according to the study classification.

4. Genetic Analysis of CYP2C19*2

Five millilitres of venous blood was collected from each participant into an ethylenediaminetetraacetic acid (EDTA) vacutainer. Genomic DNA was isolated from the collected blood samples using the salting-out procedure.

Genetic analysis of the CYP2C19*2 polymorphism was performed using the polymerase chain reaction–restriction fragment length polymorphism (PCR-RFLP) technique. The genotypes were classified into three categories: 1*/1*, 1*/2*, and 2*/2*. The 1*/1* genotype was categorized as the normal genotype, whereas 1*/2* and 2*/2* were classified as loss-of-function genotypes for the purpose of analysis.

Genotype distribution was compared between patients presenting with chronic stable angina and those with acute coronary syndrome (ACS). The relationship between CYP2C19*2 genetic variation and associated coronary risk factors, including diabetes mellitus, hypertension, dyslipidemia, smoking, and family history of IHD, was evaluated.

Note: The specific primer sequences, PCR cycling conditions, restriction enzyme, fragment sizes, and laboratory quality-control procedures were not provided in the supplied study details and should be added from the actual laboratory protocol.

5. Assessment of Clopidogrel Resistance

Clopidogrel resistance was considered in relation to the patient's response to clopidogrel therapy and the presence of CYP2C19*2 loss-of-function genetic variants. The study description refers to light transmittance aggregometry (LTA), in which platelet aggregation is assessed using adenosine diphosphate (ADP) as an agonist. Clopidogrel resistance was described as a change in maximal platelet aggregation of 10% or less from baseline following treatment.

However, the supplied methods do not fully specify the platelet-function testing protocol, timing of blood collection, ADP concentration, or whether platelet aggregation was measured in all 100 patients. These details must be confirmed before finalizing the operational definition of clopidogrel resistance. Genetic variation alone should not be treated as a direct measurement of phenotypic platelet resistance.

6. Statistical Analysis

The collected data were entered into a database and analyzed using Statistical Package for the Social Sciences (SPSS), version 19.0. Continuous variables were expressed as mean ± standard deviation (SD), while categorical variables were presented as frequencies and percentages.

Differences in continuous variables were assessed using one-way analysis of variance (ANOVA), where appropriate. Associations between categorical variables, including genotype distribution, clinical presentation, and cardiovascular risk factors, were evaluated using the chi-square test or Fisher's exact test, as appropriate. A p-value below 0.05 was considered statistically significant.

The prevalence of the different CYP2C19*2 genotypes was calculated, and their associations with diabetes mellitus, hypertension, dyslipidemia, smoking, family history of IHD, and clinical presentation were evaluated.

7. Ethical Considerations

The study was approved by the Institutional Ethics Committee. Written informed consent was obtained from all participants before enrolment. Information collected during the study was handled confidentially and used for research purposes.

RESULTS

Demographic Information

The study included 100 patients with a mean age of 50.79 ± 9.47 years. Males constituted the majority of the study population (71%), while females accounted for 29%. Among the cardiac risk factors, diabetes mellitus was present in 40% of patients, followed by hypertension in 39%, smoking in 41%, alcohol consumption in 32%, family history of cardiac disease in 24%, and dyslipidemia in 5%. Regarding medication use, statins were the most commonly prescribed drugs (85%), followed by beta-blockers (83%), clopidogrel (82%), aspirin (73%), and ACE inhibitors/angiotensin receptor blockers (68%). In terms of clinical presentation, chronic stable angina (CSA) was observed in 47% of patients, followed by unstable angina/non-ST-elevation myocardial infarction (UA/NSTEMI) in 30%, ST-elevation myocardial infarction (STEMI) in 27%, and stent thrombosis in 13%. Coronary angiography revealed single-vessel disease in 36% of patients, double-vessel disease in 30%, triple-vessel disease in 22%, normal coronary angiography in 17%, and left main coronary artery disease in 6%. Assessment of left ventricular function showed normal function in 58% of patients, whereas 42% had left ventricular dysfunction with an ejection fraction below 55%.

Table 1. Study Population Demographic Information (N = 100)

Characteristics	Variables	Total Cases (N=100)	Percentage
Age (years)	Mean ± SD	50.79 ± 9.47	—
Gender	Male	71	71.00
	Female	29	29.00
Cardiac Risk Factors	Diabetes	40	40.00
	Hypertension	39	39.00
	Dyslipidemia	5	5.00
	Family history	24	24.00
	Smokers	41	41.00
	Alcoholism	32	32.00
Drugs	Aspirin	73	73.00
	Clopidogrel	82	82.00
	Beta blocker	83	83.00

	ACEI/ARB	68	68.00
	Statins	85	85.00
Presentation	CSA	47	47.00
	STEMI	27	27.00
	UA/NSTEMI	30	30.00
	Stent thrombosis	13	13.00
Coronary Angiography	Normal	17	17.00
	Single Vessel Disease (SVD)	36	36.00
	Double Vessel Disease (DVD)	30	30.00
	Triple Vessel Disease (TVD)	22	22.00
	Left Main Coronary Artery (LMCA) disease	6	6.00
LV Function	Normal	58	58.00
	Left Ventricular Dysfunction (LVEF below 55%)	42	42.00

Genotype Distribution

Table 2 presents the distribution of clopidogrel genotypes among patients with chronic stable angina (CSA; n = 53) and acute coronary syndrome (ACS; n = 47). In the CSA group, the 1*/2* genotype was the most common, observed in 21 patients (39.62%), followed by the 1*/1* genotype in 20 patients (37.74%) and the 2*/2* genotype in 12 patients (22.64%). In the ACS group, the 1*/2* genotype was predominant, occurring in 26 patients (55.32%), followed by the 1*/1* genotype in 13 patients (27.66%) and the 2*/2* genotype in 8 patients (17.02%). Regarding mutation status, the normal genotype (1*/1*) was observed in 37.74% of patients with CSA and 27.66% of those with ACS. Loss-of-function genotypes (1*/2* and 2*/2*) were present in 62.26% of the CSA group and 72.34% of the ACS group. These findings indicate a higher proportion of loss-of-function genotypes among patients with ACS compared with those with CSA. However, statistical significance cannot be established without the corresponding p-value calculated from the final dataset.

Table 2. Genotype Distribution According to Presentation (N = 100)

Variables	Chronic Stable Angina (n=53)	%	Acute Coronary Syndrome (n=47)	%
Genotypes				
1*/1*	20	37.74	13	27.66
1*/2*	21	39.62	26	55.32
2*/2*	12	22.64	8	17.02
Status of Mutation				
Normal (1*/1*)	20	37.74	13	27.66
Loss of Function (1*/2*, 2*/2*)	33	62.26	34	72.34

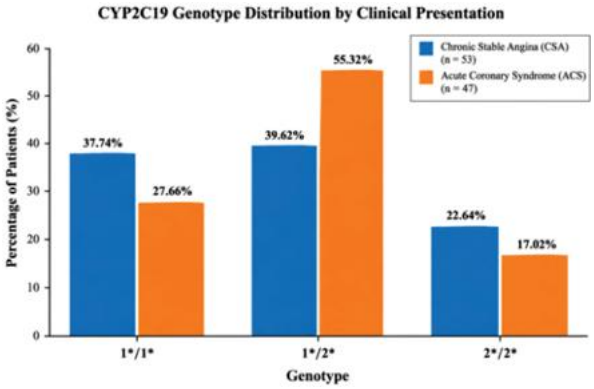


Figure : Genotype Distribution

DISCUSSION

The present study evaluated the distribution of CYP2C19 genotypes among patients with ischemic heart disease (IHD) and explored their relationship with clinical presentation and associated cardiovascular risk factors. The study included 100 patients with a mean age of 50.79 ± 9.47 years, of whom 71% were males and 29% were females. The principal finding was the predominance of the CYP2C19 1*/2* genotype in both chronic stable angina (CSA) and acute coronary syndrome (ACS) groups. Furthermore, loss-of-function genotypes were proportionally more frequent among patients with ACS than among those with CSA. These findings highlight the potential relevance of pharmacogenetic variation in clopidogrel therapy, although the clinical significance of this difference requires confirmation through appropriate statistical analysis and platelet-function assessment.

1. Demographic Characteristics and Cardiovascular Risk Factors

The mean age of the study population was 50.79 ± 9.47 years, with a male predominance of 71%. This demographic distribution indicates that middle-aged and older adults constituted a substantial proportion of the study population. A comparable pattern was reported by Nawaz et al. (2019), who studied 390 patients with IHD receiving clopidogrel and documented a mean age of 53.5 ± 11.9 years, with males accounting for 59.5% of participants. Their study identified clopidogrel resistance in 24.9% of patients, demonstrating that inadequate response to antiplatelet therapy is a relevant clinical concern among patients with IHD [11].

In the present study, smoking was reported in 41% of patients, followed by diabetes mellitus in 40%, hypertension in 39%, alcohol consumption in 32%, family history of cardiac disease in 24%, and dyslipidemia in 5%. These findings demonstrate the presence of multiple cardiovascular risk factors in the study population. Diabetes mellitus and hypertension are particularly important in patients with IHD because they contribute to cardiovascular disease progression and may coexist with altered platelet reactivity. Nevertheless, the present demographic data alone cannot establish whether these factors were associated with CYP2C19 genotype or clopidogrel resistance.

Ghati et al. (2026), in a prospective study of patients with coronary artery disease, reported a high prevalence of antiplatelet resistance and identified family history of coronary artery disease as an independent predictor of clopidogrel resistance. Diabetes mellitus was significantly associated with aspirin resistance in univariate analysis but was not an independent predictor of clopidogrel resistance in the multivariable model [12]. These observations suggest that the relationship between cardiovascular risk factors and antiplatelet response is complex and may vary according to the outcome measured and the population studied.

2. Distribution of CYP2C19 Genotypes

In the present study, the CYP2C19 1*/2* genotype was the most frequently observed genotype in both clinical presentation groups. Among patients with CSA, 21 (39.62%) had the 1*/2* genotype, 20 (37.74%) had the 1*/1* genotype, and 12 (22.64%) had the 2*/2* genotype. In the ACS group, the corresponding proportions were 55.32%, 27.66%, and 17.02%, respectively. These findings demonstrate that the heterozygous 1*/2* genotype was more frequent among patients presenting with ACS than among those with CSA.

CYP2C19 plays an important role in the metabolic activation of clopidogrel, which is administered as a prodrug. The CYP2C19*2 variant is associated with reduced enzymatic activity and decreased formation of the active metabolite, potentially resulting in diminished platelet inhibition. Consequently, individuals carrying loss-of-function alleles

may have an increased likelihood of a reduced pharmacological response to clopidogrel [15]. The pre-dominance of the 1*/2* genotype in the present study is therefore biologically relevant when investigating variability in clopidogrel response.

Blaziak et al. (2025) investigated clopidogrel resistance and CYP2C19 polymorphisms in patients with atrial fibrillation undergoing percutaneous coronary intervention. Their findings highlighted the contribution of CYP2C19 genetic variation to interindividual differences in clopidogrel response [15]. Although their study involved a different clinical population, it supports the rationale for investigating pharmacogenetic variability among patients with IHD.

3. Loss-of-Function Genotypes and Clinical Presentation

When genotypes were classified according to mutation status, loss-of-function genotypes (1*/2* and 2*/2*) were observed in 33 patients (62.26%) with CSA and 34 patients (72.34%) with ACS. Conversely, the normal 1*/1* genotype was observed in 37.74% of patients with CSA and 27.66% of those with ACS. Thus, the proportion of patients carrying loss-of-function genotypes was 10.08 percentage points higher in the ACS group.

This difference raises the possibility that CYP2C19-related variation may contribute to differences in clopidogrel response among patients with different clinical presentations. Reduced conversion of clopidogrel into its active metabolite may lead to inadequate inhibition of platelet aggregation, potentially increasing susceptibility to thrombotic complications. However, the present study's findings establish only a difference in genotype distribution between the two groups. Without a calculated p-value, the statistical significance of this difference cannot be determined.

Rizvi et al. reported clopidogrel resistance in 12 of 71 patients with IHD (17%) using a platelet-function assay. Their study found a significant association between resistance and female gender, but did not demonstrate statistically significant associations with diabetes mellitus, family history of IHD, hypertension, or smoking [13]. These findings illustrate that the relationships between clinical characteristics and clopidogrel response may differ between populations and assessment methods.

Importantly, the prevalence of loss-of-function genotypes should not be equated with the prevalence of phenotypic clopidogrel resistance. Genotyping identifies genetic variants associated with drug metabolism, whereas platelet-function testing evaluates the pharmacodynamic response to treatment. The two approaches provide complementary but distinct information.

4. Relationship with Coronary Risk Factors

The present study documented diabetes mellitus in 40% of patients, hypertension in 39%, smoking in 41%, and a family history of cardiac disease in 24%. These factors are clinically relevant when evaluating patients receiving antiplatelet therapy. However, the available results do not provide genotype-specific comparisons for individual risk factors or their corresponding p-values. Therefore, the independent relationship between these variables and loss-of-function genotypes cannot be established.

In their 2026 study, Ghati et al. reported complete clopidogrel resistance in 29.2% of patients and semi-resistance in an additional 7.6%. Family history of coronary artery disease was identified as an independent predictor of clopidogrel resistance, while diabetes mellitus was associated with aspirin resistance in univariate analysis [12]. Kim et al. (2009) reported clopidogrel resistance in 38.8% of clopidogrel-treated patients and found significant associations between higher systolic and diastolic blood pressure and clopidogrel resistance [14].

Differences between these findings and those of other studies may reflect variations in patient selection, genetic background, drug adherence, concomitant medications, laboratory techniques, and definitions of resistance. Accordingly, the presence of cardiovascular risk factors should not be assumed to indicate clopidogrel resistance without appropriate assessment.

5. Clinical Implications

The present study highlights the potential importance of CYP2C19 genotyping in understanding interindividual variation in clopidogrel response. The higher proportion of loss-of-function genotypes among patients with ACS provides a basis for further investigation into the relationship between genetic variation and clinical outcomes.

Nevertheless, genetic findings alone are insufficient to establish treatment failure. Clopidogrel response may also be influenced by medication adherence, drug interactions, dosage, and other patient-related factors. Future studies combining CYP2C19 genotyping with validated platelet-function assays could clarify whether the observed genetic patterns correspond to reduced platelet inhibition.

Although pharmacogenetic testing may help identify patients who could benefit from an alternative antiplatelet strategy, treatment decisions should be based on the overall clinical context and applicable guidelines rather than genotype distribution alone.

6. Strengths and Limitations

An important strength of the present study is the comparison of CYP2C19 genotype distribution between patients with CSA and ACS, alongside the documentation of cardiovascular risk factors and clinical characteristics. However, the sample size was limited to 100 patients, potentially restricting the precision and generalizability of the findings. The supplied results also lack direct platelet-function measurements, genotype-specific risk-factor analyses, adjusted statistical models, and prospective cardiovascular outcomes. Consequently, the study cannot establish a causal relationship between CYP2C19 variation, clopidogrel resistance, and acute coronary events.

CONCLUSION

The present study demonstrated that the CYP2C19 1*/2* genotype was the most frequently observed genotype in both CSA and ACS groups. Loss-of-function genotypes were more prevalent among patients with ACS (72.34%) than among those with CSA (62.26%). These findings suggest a possible relationship between CYP2C19 genetic variation and clinical presentation in patients with IHD. Larger prospective studies incorporating genotype analysis, platelet-function testing, and clinical follow-up are required to determine the clinical significance of these observations in the South Indian population.

REFERENCES

1. Prabhakaran D, Jeemon P, Roy A. Cardiovascular diseases in India: current epidemiology and future directions. Circulation. 2016;133(16):1605–1620. doi: 10.1161/CIRCULATIONAHA.114.008729.
2. Antithrombotic Trialists' Collaboration. Collaborative meta-analysis of randomised trials of antiplatelet therapy for prevention of death, myocardial infarction, and stroke in high risk patients. BMJ. 2002;324(7329):71–86. doi: 10.1136/bmj.324.7329.71.
3. Mega JL, Close SL, Wiviott SD, Shen L, Walker JR, Hockett RD, et al. Cytochrome P-450 polymorphisms and response to clopidogrel. N Engl J Med. 2009;360(4):354–362. doi: 10.1056/NEJMoa0809171.
4. Sibbing D, Stegherr J, Latz W, Koch W, Mehilli J, Dörrler K, et al. Cytochrome P450 2C19 loss-of-function polymorphism and stent thrombosis following percutaneous coronary intervention. Eur Heart J. 2009;30(8):916–922. doi: 10.1093/eurheartj/ehp041.
5. Holmes MV, Perel P, Shah T, Hingorani AD, Casas JP. CYP2C19 genotype, clopidogrel metabolism, platelet function, and cardiovascular events: a systematic review and meta-analysis. JAMA. 2011;306(24):2704–2714. doi: 10.1001/jama.2011.1880.
6. Bauer T, Bouman HJ, van Werkum JW, Ford NF, ten Berg JM, Taubert D. Impact of CYP2C19 variant genotypes on the clinical efficacy of antiplatelet treatment with clopidogrel: systematic review and meta-analysis. BMJ. 2011;343:d4588. doi: 10.1136/bmj.d4588.

7. Mega JL, Close SL, Wiviott SD, Shen L, Walker JR, Simon T, et al. Genetic variants in ABCB1 and CYP2C19 and cardiovascular outcomes after treatment with clopidogrel and prasugrel in the TRITON-TIMI 38 trial: a pharmacogenetic analysis. Lancet. 2010;376(9749):1312–1319. doi: 10.1016/S0140-6736(10)61273-1.
8. Cattaneo M. Light transmission aggregometry and ATP release for the diagnostic assessment of platelet function. Semin Thromb Hemost. 2009;35(2):158–167. doi: 10.1055/s-0029-1220324.
9. Cattaneo M, Cerletti C, Harrison P, Hayward CPM, Kenny D, Nugent D, et al. Recommendations for the standardization of light transmission aggregometry: a consensus of the working party from the platelet physiology subcommittee of SSC/ISTH. J Thromb Haemost. 2013;11(6):1183–1189. doi: 10.1111/jth.12231.
10. Price MJ, Berger PB, Teirstein PS, Tanguay JF, Angiolillo DJ, Spriggs D, et al. Standard- vs high-dose clopidogrel based on platelet function testing after percutaneous coronary intervention: the GRAVITAS randomized trial. JAMA. 2011;305(11):1097–1105. doi: 10.1001/jama.2011.290.
11. Nawaz U, Noor M, Waheed A. Cytochrome P-450 CYP2C19 genetic polymorphism and its relation with clopidogrel resistance. J Pak Med Assoc. 2023;73(12):2388–2392. doi: 10.47391/JPMA.8025.
12. Ghati N, Narang R, Pati HP, Mishra AK, Basha A. Prevalence and predictors of aspirin and clopidogrel resistance by light transmittance platelet aggregometry in stable coronary artery disease. Indian Heart J. 2026;78(4): 179–186. doi: 10.1016/j.ihj.2026.03.001.
13. Kim H, Lee HK, Han K, Jeon HK. Prevalence and risk factors for aspirin and clopidogrel resistance in patients with coronary artery disease or ischemic cerebrovascular disease. Ann Clin Lab Sci. 2009;39(3):289–294. Full text.
14. Blaziak M, Rakotoarison O, Balcer B, Dolata N, Wietrzyk W, Kuliczkowski W. Prevalence of clopidogrel resistance in patients with atrial fibrillation undergoing percutaneous coronary intervention. Adv Interv Cardiol. 2025;21(2):259–261. doi: 10.5114/aic.2025.151854.
15. Paré G, Mehta SR, Yusuf S, Anand SS, Connolly SJ, Hirsh J, et al. Effects of CYP2C19 genotype on outcomes of clopidogrel treatment. N Engl J Med. 2010;363:1704–1714. doi: 10.1056/NEJMoa1008410.