BENHA MEDICAL JOURNAL bmj
Print ISSN 1110-208X.
Online ISSN 2357-0016

Original article

Systemic Immune Inflammation Index: A Novel Predictor for Coronary Collateral Circulation in Patients with Stable Coronary Artery Disease

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Abstract:

Background: Chronic Coronary Syndrome (CCS) causes increasing coronary artery blood flow limitation. A new inflammatory measure, the systemic immune-inflammation index (SII), may predict cancer treatment failure. This research examined how stable coronary artery disease (CAD) patients' CCD and SII connect. **Methods:** This single-center, cross-sectional research comprised 100 stable CAD patients. After that, patients were divided into two groups based on coronary collateral circulation: Group 1 had 78 healthy collaterals and Group 2 had 22 defective collaterals. We performed coronary angiography, transthoracic echocardiography, electrocardiography, and lab tests. The Rentrop classification system graded collateral vessels. **Results:** Patients with stable coronary artery disease (CAD) who had weak coronary collaterals were more likely to have SII, platelet, neutrophil, and lymphocyte levels, as well as laboratory indices like the Neutrophil-to-Lymphocyte Ratio (NLR), Platelet-to-Lymphocyte Ratio (PLR), and NLR. Then in the multivariant analysis, SII was found to be the only independent predictor of poor coronary collaterals in stable CAD patients underwent coronary angiography [95% CI: 1.0 – 1.014, P value < 0.05]. SII cutoff value of 1135.5 was shown to have the best diagnostic accuracy (sensitivity = 86.4%, specificity = 98.7% and area under curve = 0.893) in prediction of poor coronary collaterals in stable CAD patients underwent Coronary Angiography **Conclusion:** In damaged coronary collaterals, CRP, NLR, PLR, and SII were considerably greater. SII was the only independent predictor of CAD patients' compromised coronary collaterals. The SII cutoff value of 1135.5 best predicts weak coronary collaterals in chronic coronary syndrome patients.

Keywords: Predictor; Disease ; Coronary Collateral Circulation; Systemic Immune Inflammation Index; Stable Coronary Artery

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Received:
Accepted:

Introduction

A variety of stable manifestations of coronary artery disease (CAD) that induce predictable symptoms are referred to as chronic coronary syndrome (CCS). These manifestations are typically caused by atherosclerosis [(1)].In CCS, symptoms generally remain stable over time, lacking the abrupt and severe onset characteristic of acute coronary syndrome (ACS). Patients with CCS experience recurring episodes of angina triggered by specific activities or stress, with the discomfort resolving upon cessation of the triggering factor. This symptom stability is largely due to the slow progression and stability of atherosclerotic plaques, which reduce blood flow without causing sudden ruptures that would lead to ACS [(2)].

Within the heart, there is a circulatory network that is composed of numerous vascular structures with a small diameter that connect the coronary arteries. Due to their tiny diameter and low blood flow, these precursors to coronary collateral circulation (CCC) go unnoticed by individuals with normal coronary arteries or mild to moderate occlusions in the coronary arteries [(3)].

Damage to a major epicardial coronary artery limits blood flow, which in turn reduces myocardial perfusion [(4)]. The smaller-diameter coronary collateral arteries are used to preserve perfusion in this case. To put it in layman's terms, CCC is thought to develop in cases of severe myocardial ischemia [(5)].

Coronary collateralization: a patient-specific variable impacted by biochemical, angiographic, and clinical variables and inflammatory cytokines [(6)]. Given that CCC is caused by severe CAD, it is unclear why there are significant differences among patients with similar degrees of CAD. A number of inflammatory markers and inflammation are both increased in cases of inadequate collateral development, as has been shown in earlier studies [(7)].

Hemostatic indicators, such RLR and NLR ratios, show a connection between CCC production and SAP. The novel systemic immune-inflammation index (SII) has the potential to be a great predictor of treatment-related side effects for some cancers [(8)].

Our goal in conducting this study was to learn more about how SII relates to the emergence of coronary collateral circulation in individuals who have stable coronary artery disease.

Patients and methods

This single center, cross-sectional study was performed in the cardiology department and coronary catheterization unit at Benha University Hospital during the period from March 2023 to March 2024. The study population consisted of 100 patients, with 129 initially enrolled for stable CAD. However, 29 patients were excluded due to not meeting inclusion criteria (18 patients) or declining to participate (11 patients). Group 2 included 22 patients with inadequate coronary collateral circulation (22% of the total), while Group 1 included 78 patients with excellent coronary collateral circulation (78% of the total).

The patients have provided written consent that is informed. An explanation of the study's purpose was provided to each patient, along with a secret code number. After receiving approval from the Research Ethics Committee of the Faculty of Medicine at Benha University, the investigation was implemented.

Inclusion criteria were patient diagnosed with chronic CAD in accordance with the European Society of Cardiology's criteria [(9)] Asymptomatic people with coronary artery disease (CAD) found by imaging, screening, or incidental findings; patients experiencing symptoms of stress-induced angina or ischemia as a result of obstructive CAD; patients who have stabilized following atrial fibrillation (ACS) or revascularization; patients with non-acute heart failure caused by ischemia

or cardiometabolism; and patients who do not have acute heart failure. Coronary angiography (CAG) patients with a stenosis of 95% or greater in one primary coronary channel were the only subjects of this investigation.

Exclusion criteria were these things are not eligible: diseases that affect the immune system, cancer, blood disorders, kidney disease (eGFR <30 ml/min/1.73 m2), liver disease, chronic inflammatory diseases, autoimmune disorders, and persistent infections are among the conditions that can be encountered. Furthermore, individuals who have recently experienced acute coronary syndrome or percutaneous coronary intervention (PCI) are not permitted.

All studied cases were subjected to the following: Full history taking, including hyperlipidemia, diabetes mellitus, **h**ypertension, smoking status and cardiovascular history. **Physical examination:**, vital signs, Body mass index and cardiopulmonary examination**. Laboratory investigations:** Hypersensitivity C-reactive protein (hs-CRP), hepatic and renal functions (AST and ALT), glucose (both fasting and random blood glucose levels), and lipid profile (cholesterol, HDL level, LDL level, and triglycerides) make up the complete blood count (CBC). Before coronary angiography (CAG), laboratory analysis was conducted on antecubital venous blood samples from all patients. Tri-potassium EDTA anticoagulated containers were utilized to collect the various blood samples. In the morning, the samples were collected after a 20-minute period of repose, which followed a 12-hour fast. An autoanalyzer was used to conduct the tests in the laboratory. The Neutrophil-to-Lymphocyte Ratio (NLR) can be easily calculated by dividing the percentage of neutrophils by the total number of lymphocytes. Subtracting the total number of lymphocytes from the total number of platelets yields the PLR. To get the Systemic Immune Inflammation Index (SII), add the platelet count to the NLR. This is an innovative inflammatory index. **Electrocardiography (ECG)**: for identifying abnormalities related to ischemia and arrhythmias. **Transthoracic echocardiography**: Before coronary angiography (CAG), all patients had transthoracic echocardiography (TE). Every measurement was taken on a machine that is available for purchase (Vivid 7, GE Medical Systems, Horten, Norway) and uses a 3.5 MHz transducer. Left ventricular ejection fraction (LVEF) and valve disorders were evaluated using two-dimensional echocardiographic techniques. Left ventricular (LV) volumes and LVEF were estimated using the Simpson method in the apical four-chamber view. **Coronary angiography**: A competent team used cine angiographic equipment (GE Innova 2100-IQ, cine frame rate: 30 fps) and a dye-filled guiding catheter to conduct coronary angiography and revascularization. To begin the left and right guiding catheters, sheaths were inserted into the femoral artery (transfemoral approach) or the radial artery (transradial approach). Standard Judkins technique was implemented to execute coronary angiography. By injecting dye into the left guiding catheter, the left main coronary artery and its branches were initially visualized. The right coronary artery was then better visualized after dye was injected into the right guiding catheter. Within two parallel planes, two interventional cardiologists with extensive experience evaluated the severity of lesions visually. A percentage of luminal diameter stenosis was used to estimate and express coronary artery narrowing. Lesions were considered significant when any artery narrowed by 70% or more, or when the left main or proximal LAD were narrowed by 50% or more. A stenosis greater than 50% in one or more primary coronary arteries was indicative of severe coronary artery disease (CAD). The right coronary artery, the left anterior descending artery, and the circumflex

artery were the three categories into which the culprit vessel was divided, and it was classified as wholly occluded or with 95% or more stenosis. Two well-versed interventional cardiologists, who were unaware of the clinical and demographic data, evaluated the collateral evaluations and CAG images of all participants. Three reviewers, each of whom was blinded to the initial findings, resolved any discrepancies in interpretation. Utilizing the Rentrop classification technique, collaterals were evaluated.

Rentrop classification system

In order to assess the level of collateral circulation in individuals suffering from coronary artery disease, Rentrop et al. (1985) developed the Rentrop classification system. This investigation assessed collateral vessels according to this categorization system.

Grades of collateral filling: In Grade 0, collateral infill is not observed. It is not evident that collateral vessels are filled to supply the epicardial artery. In Grade 1, the collateral vessels are unable to supply the epicardial segment, as they are limited to the side branches of the artery. Collateral vessels partially occupy the epicardial artery, which is grade 2. Grade 3: Collateral vessels totally cover the epicardial artery, extending to all of its distal segments.

This classification allows for a standardized assessment of collateral circulation, helping to determine the adequacy of collateral blood flow in patients with CAD [(10)].

Additionally, the SYNTAX score calculation was affected by any coronary lesion that caused a 50% narrowing of vessels bigger than 1.5 mm. A panel of two seasoned interventional cardiologists computed the SYNTAX score using the most recent web-based software version.

SYNTAX score

CAD's complexity is evaluated and treatment decisions are directed by the SYNTAX score, a cardiology instrument. Its purpose was to aid clinicians in evaluating the severity of CAD. After collecting the SYNTAX score for vessels with a minimum diameter of 1.5 mm, points are assigned to each coronary tree lesion with a diameter narrowing of more than 50%.

AHA categorizes the coronary tree into 16 sections. A score of 1 or 2 is assigned to each segment upon disease identification. After this, a formula is used to weight the score; values for the proximal LAD range from 3.5 to 5.0, while values for the left main and minor branches are 0.5 and 0.5, respectively. In spite of the presence of extensive lesions, the SYNTAX score does not account for branches with a diameter of less than 1.5 mm.

The SYNTAX score takes into account both the presence and severity of narrowing (less than 50% diameter), complete occlusion, or stenosis (50–99% diameter), instead of the percentage diameter stenosis. Non-occlusive lesions are multiplied by 2 while occlusive lesions are multiplied by 5, which is indicative of the complexity of PCI [(11)].**Table 1**

Approval code: MS 21-10-2023

Statistical analysis

In order to analyze the data, we used a computer system and the IBM SPSS software package, version 20.0. It was published by IBM Corp. in Armonk, New York. The qualitative data was represented numerically and as a percentage. We determined that the distribution was normal using the Kolmogorov-Smirnov test. Quantitative data can be mathematically expressed using terms such as median, IQR, range (including minimum and maximum), and standard deviation. For this analysis, a significance level of 5% was selected. If the quantitative variables did not follow a normal distribution, we utilized the Student t-test (t) to compare the two groups. We were able to compare the categorical variables across various groups by using a chi-square test ($\chi 2$).

Results

Demographic data & Risk factors

There was no statistical difference between the two groups regarding age and gender (P value >0.05). Patients of group II had statistically higher incidence of DM [11 patients (55%) vs. 21 patients (26.9%), P value .04], However, there was no statistically significant difference between the two groups in terms of the incidence of hypertension, dyslipidemia, and smoking (P value> 0.05).**Table 2**

Clinical data and LVEF:

Between the groups that were examined, there were no statistically significant differences in body mass index (BMI; P = 0.690), systolic blood pressure (P = 0.363), diastolic blood pressure (P = 0.783), or heart rate (P = 0.959). The mean LVEF was also comparable between the two groups (57.23 ± 8.57 vs. 57.69 ±10.02, P value = 0.863), as demonstrated in **Table 2**

Laboratory data

The mean total cholesterol level was statistically higher in patients with group II (172.06 ± 18.89 vs. 162.23 ± 20.8, P value = 0.037), Also mean platelet and neutrophil levels were significantly higher in patients with group II than those of group I (306.91 ± 65.02 Vs 232.81 ± 49.16 & 5.56 ± 1.94 vs. 4.67 ± 1.08 x 10^3/µL; respectively with P value <0.05). While the mean lymphocyte level was statistically lower in patients of group II (1.1 ± 0.26 Vs 1.9 ± 0.67 10^3 / µL, P value <0.001). Table 3

No statistically significant difference among the two studied groups regarding other laboratory parameters (Glucose, serum creatinine, HDL, LDL, Triglycerides and Hemoglobin) with P value >0.05. **Table 3**

There was statistically significant difference between the two studied groups regarding mean values of CRP level, NLR and PLR (6.86 ± 0.96 vs. 3.57 ± 0.86 & 5.09 ± 1.66 vs. 2.64 ± 0.67 and 296.73 ± 102.11vs. 137.05 ± 52.51; respectively with P value < 0.05). Also, mean value of systemic immune index was statistically higher in patients of group II (1990.18 ± 745.72) vs. (542.49 ± 128.82) in group I with P value < 0.001. Table 3

Coronary angiographic data

No significant difference was observed between the two groups regarding culprit coronary vessel, number of diseased coronary artery and mean Syntax score with P value>0.05. **Table 3**

Table 1: Evaluating Coronary Lesions in Coronary Angio.

1.	Dominance
2.	Number of lesions
3.	Segments involved per lesion, with lesion characteristics
	Total occlusions with subtotal occlusions:
	a. Number of segments
	b. Age of total occlusions
4.	C. Blunt stumps
	d. Bridging collaterals
	e. First segment beyond occlusion visible by antegrade or retrograde filling
	f. Side branch involvement
5.	Trifurcation, number of segments diseased
6.	Bifurcation type and angulation
7.	Aorto-ostial lesion
8.	Severe tortuosity
9.	Lesion length
10.	Heavy calcification
11.	Thrombus
12.	Diffuse disease, with number of segments

Table 2: Relation between coronary collateral circulation and demographic data, comorbidities, examinations, and previous medications

		Subjects				Test of Sig.	P
		Group I (n = 78)		Group II (n = 22)			
Age	**Range.**	44 – 67		45 – 66		t=	0.878
	Mean ± SD.	55.23 ± 7.35		55.5 ± 6.95		0.153	
gender	**Female**	20	25.6	6	27.3	χ^2=	0.695
	Male	58	74.4	16	72.7	0.024	
Diabetes mellitus		21	26.9	11	50.0	4.200	0.040*
Hypertension		37	47.4	14	63.6	1.802	0.179
Dyslipidemia		10	12.8	6	27.3	2.667	0.102
Smoking		22	28.2	7	31.8	0.109	0.742
BMI (kg/m^2)	**Range.**	23.9 – 32.1		24.1 – 31.4		t=	0.690
	Mean ± SD.	28.18 ± 2.47		27.94 ± 2.33		0.401	
Systolic BP	**Range.**	115 – 135		115 – 135		t=	0.353
	Mean ± SD.	126.92 ± 6.51		125.45 ± 6.53		0.934	
Diastolic BP	**Range.**	65 – 90		65 – 90		t=	0.783
	Mean ± SD.	77.82 ± 8.36		77.27 ± 7.67		0.276	
Heart rate	**Range.**	64 – 85		65 – 85		t=	0.959
	Mean ± SD.	74.72 ± 6.58		74.64 ± 6.79		0.051	
LVEF (%)	**Range.**	40.7 – 74.5		40.7 – 73.7		t=	0.863
	Mean ± SD.	57.64 ± 10.02		57.23 ± 8.57		0.173	
Aspirin		19	24.4	6	27.3	0.078	0.780
B-blockers		33	42.31	10	45.45	4.421	0.351
Angiotensin–aldosterone antagonists		40	51.3	13	59.1	0.420	0.517
Statins		17	21.8	4	18.2	0.135	0.713
Clopidogrel		4	5.1	1	4.5	0.012	0.912
Calcium channel blockers		30	38.4	9	40.9	11.427	0.432
Nitrate		5	6.4	3	13.6	1.217	0.270

Data are presented as frequency (%) unless otherwise mentioned, *: statistically significant as p value <0.05. BMI: Body mass index, BP: Blood pressure, SD: Standard Deviation.

At the univariate logistic regression analysis: A robust correlation was observed between the presence of deficient coronary collaterals and the stable CAD patients' levels of platelets, neutrophils, lymphocytes, and laboratory indices such as NLR, PLR, and SII. Later, in the multivariant analysis, SII was identified as the sole independent predictor of weak coronary collaterals in stable CAD patients who underwent coronary angiography [95% CI: 1.0 – 1.014, P value < 0.05]**Table 4**

SII cutoff value of 1135.5 was shown to have the best diagnostic accuracy (sensitivity = 86.4%, specificity = 98.7% and area under curve (AUC) = 0.893) in prediction of poor coronary collaterals in stable CAD patients underwent Coronary Angiography. **Figure 1**

Table 3: Relation between coronary collateral circulation and lab investigations, laboratory indices, and coronary angiographic data

		Subjects (n = 100)		Test of Sig.	P
		Group I (n = 78)	**Group II (n = 22)**		
Glucose (mg/dL)	**Range.**	72 – 150	72 – 151	t=	0.175
	Mean ± SD.	107.19 ± 23.25	115 ± 25.23	1.366	
Creatinine (mg/dL)	**Range.**	0.59 – 1.25	0.62 – 1.19	t=	0.387
	Mean ± SD.	0.93 ± 0.21	0.88 ± 0.19	0.869	
AST (U/L)	**Range.**	7 – 27	7 – 27	t=	0.158
	Mean ± SD.	17.64 ± 6.31	15.41 ± 7.16	1.422	
ALT (U/L)	**Range.**	8 – 31	8 – 32	t=	0.163
	Mean ± SD.	19.96 ± 7.14	17.45 ± 8.21	1.407	
Total cholesterol (mg/dL)	**Range.**	138 – 200	137 – 200	t=	0.037*
	Mean ± SD.	162.06 ± 18.89	172.23 ± 20.8	2.110	
HDL (mg/dL)	**Range.**	29 – 43	29 – 43	t=	0.425
	Mean ± SD.	35.32 ± 3.95	36.09 ± 4.12	0.801	
LDL (mg/dL)	**Range.**	83 – 148	85 – 146	t=	0.594
	Mean ± SD.	116.77 ± 19.31	114.32 ± 17.63	0.535	
Triglyceride (mg/dL)	**Range.**	70 – 162	74 – 161	t=	0.756
	Mean ± SD.	115.77 ± 26.15	113.73 ± 30.37	0.312	
Hemoglobin (mg/dL)	**Range.**	11.1 – 15.9	11.5 – 15.7	t=	0.703
	Mean ± SD.	13.64 ± 1.65	13.49 ± 1.3	0.383	
Platelets (10^3 /µL)	**Range.**	150 – 307	205 – 417	t=	<0.001*
	Mean ± SD.	232.81 ± 49.16	306.91 ± 65.02	5.796	
WBC (10^3 /µL)	**Range.**	4.2 – 13.5	2.9 – 13.3	t=	0.505
	Mean ± SD.	7.89 ± 2.06	8.24 ± 2.52	0.670	
Neutrophil (10^3 /µL)	**Range.**	3 – 6.8	1.7 – 8.8	t=	0.006*
	Mean ± SD.	4.67 ± 1.08	5.56 ± 1.94	2.804	
Lymphocyte (10^3 /µL)	**Range.**	0.8 – 4.1	0.7 – 1.7	t=	<0.001*
	Mean ± SD.	1.9 ± 0.67	1.1 ± 0.26	5.477	
CRP	**Range.**	2 – 5	4.8 – 8.3	15.382	<0.001*
	Mean ± SD.	3.57 ± 0.86	6.86 ± 0.96		
NLR	**Range.**	1.5 – 3.8	1.9 – 7.5	10.422	<0.001*
	Mean ± SD.	2.64 ± 0.67	5.09 ± 1.66		
PLR	**Range.**	41.2 – 275	129.4 – 455.6	9.972	<0.001*
	Mean ± SD.	137.05 ± 52.51	296.73 ± 102.11		
SII	**Range.**	403 – 1200	411 – 2734	16.494	<0.001*
	Mean ± SD.	542.49 ± 128.82	1990.18 ± 745.72		
Rentrop collateral grades	**0**	0	0.0	χ^2=100.0	<0.001*
	1	0	0.0		
	2	40	51.3		
	3	38	48.7		
Culprit coronary vessel	**Left anterior descending coronary artery**	26	33.3	χ^2= 2.330	0.312
	Left circumflex coronary artery	13	16.7		
	Right coronary artery	39	50.0		
Number of diseased coronary artery	**One-vessel disease**	31	39.7	χ^2= 3.881	0.144
	Two-vessel disease	12	15.4		
	Three-vessel disease	35	44.9		
Syntax score	**Range.**	9 – 33	10 – 35	t=	0.462
	Mean ± SD.	21.37 ± 7.3	22.68 ± 7.51	0.739	

Data are presented as frequency (%) unless otherwise mentioned, SD: Standard deviation, CRP: C-reactive protein, NLR: Neutrophil-to-Lymphocyte Ratio, PLR: Platelet-to-Lymphocyte Ratio, SII: Systemic Immune Inflammation Index. *: statistically significant as P value <0.05.

Table 4: Univariate and multi variate analysis of factors affecting coronary collateral circulation

	Univariate			Multivariate		
	p	**Exp(B)**	**95% CI**	**p**	**Exp(B)**	**95% CI**
Glucose	0.176	1.014	(0.994 – 1.035)	—	—	—
Creatinine	0.384	0.351	(0.033 – 3.704)	—	—	—
AST	0.159	0.948	(0.880 – 1.021)	—	—	—
ALT	0.164	0.954	(0.894 – 1.019)	—	—	—
Total cholesterol	**0.042***	0.974	(0.949 – 0.999)	—	—	—
HDL	0.422	1.050	(0.932 – 1.183)	—	—	—
LDL	0.590	0.993	(0.968 – 1.019)	—	—	—
Triglyceride	0.753	0.997	(0.980 – 1.015)	—	—	—
Hemoglobin	0.699	0.942	(0.697 – 1.274)	—	—	—
Platelets	**<0.001***	1.026	(1.014 – 1.039)			
WBCs	0.501	1.078	(0.867 – 1.341)	—	—	—
Neutrophil	**0.009***	1.628	(1.129 – 2.348)	—	—	—
Lymphocyte	**<0.001***	0.010	(0.001 – 0.102)	—	—	—
CRP	0.065	3911.351	(0.590 – 25910711.7)	—	—	—
NLR	**<0.001***	9.765	(2.997 – 31.812)	0.056	76.991	(0.891 – 6642.599)
PLR	**<0.001***	1.027	(1.015 – 1.039)	0.115	1.026	(0.994 – 1.058)
SII	**<0.001***	1.005	(1.002 – 1.007)	**0.042***	1.007	(1.000 – 1.014)

AST: Aspartate transaminase, ALT: Alanine aminotransferase, HDL: High density lipoprotein cholesterol, LDL: Low density lipoprotein cholesterol, WBCs: White blood cells, CRP: C-reactive protein, NLR: Neutrophil-to-Lymphocyte Ratio, PLR: Platelet-to-Lymphocyte Ratio, SII: Systemic Immune Inflammation Index, *: statistically significant as P value <0.05.

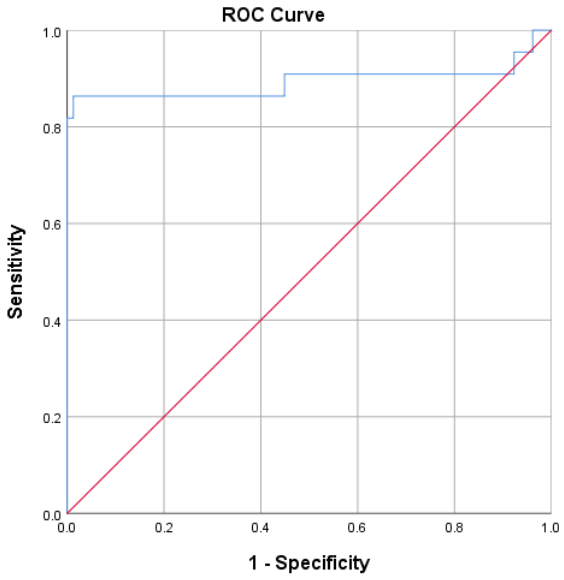

Figure 1: Receiver operating characteristic (ROC) curves for the Systemic immune-inflammation index (SII) for predicting poor CCC

Discussion

CCS encompasses a wide range of symptoms caused by structural and/or functional changes associated with microcirculation and/or chronic diseases of the coronary arteries. Asymptomatic hypoperfusion (ischaemia) or angina, dyspnea, or other types of chest pain may be present as a short-lived, reversible imbalance between the blood supply and the demand from the heart muscle caused by these changes. This condition is frequently (but not always) precipitated by emotional distress, exertion, or other stressors. Chronic coronary diseases are commonly progressive and can destabilize suddenly if an acute coronary syndrome develops, even though they remain stable over the long term. [12].

The systemic immune-inflammation index (SII) was shown to be able to determine the immunological and inflammatory status after a thorough evaluation of the neutrophil, platelet, and lymphocyte counts acquired from regular CBC analysis. Current evidence suggests that SII is useful for predicting cardiovascular diseases and has also been validated as an independent prognostic factor for several cancers. This index has the potential to serve as a standalone predictor of CV events in CAD patients [13].

In our study, 22 patients (22%) had poor coronary collateral circulation.

This was concordant with Sivri and Ozturk ceyhan [14] showed that, using Rentrop classification, 85 patients (37%) had poor collaterals.

However, Zhang et al. [13] Those 716 patients (62%) were identified as having inadequate coronary collateral circulation. The larger sample size (1150 patients) and the unique population (CTO patients versus patients with stable CAD in our cohort) may be the reasons for the increased incidence observed in this study.

There was no statistically significant difference between the two patient groups in terms of age and gender in the current study (P value > 0.05).

This was consistent with Adali.et al. [15] showed that age and gender were comparable between patients with good and poor coronary collaterals (P value = 0.275 & 0.568; respectively).

However, this was in contrast with Esenboga et al [16] detected that patients with poor collateral group [Rentrop score = 0-1] were older and had female predominance [64.68 ± 11.46 vs. 62.28 ± 9.87 & 42.3% vs. 26.7%; respectively with P value < 0.05]. This difference may be due to different type of population (stable CAD patients with CTO) and relatively large sample size.

In our study, there was statistically higher incidence of DM in patients with poor collateral group (P value = 0.040).

In agreement with our results; Sivri and Ozturk [14] showed that patients with poor collaterals had higher incidence of DM than those with good collaterals. [67.01% vs. 43.9%, P value = 0.003].

Laboratory data in our study revealed that patients in group II had significantly higher mean total cholesterol levels, platelet counts and neutrophil levels. Conversely, mean lymphocyte levels were significantly lower in group II (P < 0.05).

These findings are consistent with Adali et al. [15], who also demonstrated significantly higher platelet and neutrophil counts and significantly lower lymphocytic count among patients with poor coronary collateral circulation (267.5±65.2 vs. 237,9±50.1, 7.32.9 vs. 5.6±1.6 & 1.9±0.85 vs. 2.2±0.88; respectively, p value< 0.05).

Also, Sivri and Ozturk [14] detected that total cholesterol level was significantly higher in patients with poor coronary collateral (214±25 vs. 195±2, p value= 0.001)

However, Esenboga et al. [16] reported no significant difference regarding platelet and lymphocytes count, p value>0.05.

In our study, regarding laboratory indices, group II exhibited higher mean values of CRP (6.86 ± 0.96 vs. 3.57 ± 0.86, P < 0.05), NLR (5.09 ± 1.66 vs. 2.64 ± 0.67, P < 0.05), PLR (296.73 ± 102.11 vs. 137.05

± 52.51, P < 0.05), and SII (1990.18 ± 542.49, P < 0.001).

Similarly, our findings align with those of Kelesoglu et al. [17] and Adali et al. [15], who exhibited a robust correlation between enhanced inflammatory markers and inadequate collateral circulation. Patients with inadequate coronary collateral exhibited significantly elevated levels of CRP, PLR, NLR, and SII (p value < 0.05). Again Sivri and Ozturk [14] reported that CRP levels and SII levels were significantly higher in patients with poor coronary collateral grade (9.5±4.1 vs. 4.1±2.4 & 1328.4±832.5 vs.1040.5±611.1; respectively with p value< 0.05).

There were no significant differences among the analyzed groups in terms of the mean Syntax score, the number of diseased coronary arteries, or the culprit coronary vessel (P > 0.05).

These conclusions are in line with Kelesoglu et al. [17], who also found that culprit vessel, number of affected vessel and syntax score were not statistically significant, p value < 0.05.

Discordant with our result, Zhang et al. [13] found that LCX culprit vessel was associated with poor coronary collateral and patients with good collateral formation had higher proportion of multivessel lesions (p value<0.05).

In our study, significant factors associated with impaired coronary collaterals in stable CAD patients were identified through univariate logistic regression analysis: platelet count, neutrophil count, lymphocyte count, NLR, PLR, and SII. The most accurate diagnostic accuracy was demonstrated with a SII cutoff value of 1135.5 (sensitivity = 86.4%, specificity = 98.7%).

Similarly, Kelesoglu et al. [17] Impairment of coronary collateral circulation was found to be independently predicted by a high level of SII, dyslipidemia, a high level of CRP, and NLR, according to this study (OR:1.005, 95% CI: 1.003-1.006, p<0.001). In order to predict substandard CCC, the optimal cutoff value for SSI was determined to be 729.8, with a specificity of 74.6% and a sensitivity of 78.4%.

This was also consistent with Ozkan et al. [8] p value= 0.027. The SII cutoff value of 1103 was predictive for detecting a high coronary thrombus burden, with a sensitivity of 74.4% and a specificity of 74.6%.

Conclusion

CRP, NLR, PLR, and SII levels were significantly elevated in patients with impaired coronary collaterals. The only independent predictor of impaired coronary collaterals in patients with chronic coronary syndrome was SII. SII cutoff value of 1135.5 was shown to have the best diagnostic accuracy in prediction of poor coronary collaterals in chronic coronary syndrome patients (sensitivity = 86.4, specificity = 98.7).

Sources of funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Author contribution

Authors contributed equally to the study**.**

Conflicts of interest

No conflicts of interest

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To cite this article: Mahmoud S. Abdelmoneum , Khaled E. Elrabat, Mohamed E. Abd-Ellatif, Hager I. Allam. Systemic Immune Inflammation Index: A Novel Predictor for Coronary Collateral Circulation in Patients with Stable Coronary Artery Disease. BMFJ XXX, DOI: 10.21608/bmfj.2025.378708.2384.