Kerbala Journal of Pharmaceutical Sciences

ISSN: 2221-7207(Print) / **ISSN**: 3006-7189 (Online)

Atherogenic Indices for Cardiovascular Outcomes in Patients with Chronic Coronary Syndrome Undergoing Percutaneous Coronary Intervention: A Key Role or Stand By

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Received: 12/07/2024

Accepted: 28/07/2024

Published: 31/12/2024

Keywords: PCI, CA, AIP, AC, CR I&II

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DOI:10.62472.kjps.v15.i25.43-57

Abstract

Background: This study explores the link between atherogenic indices and cardiovascular outcomes in patients with chronic coronary syndrome (CCS) undergoing percutaneous coronary intervention (PCI). It aims to determine if these indices can provide valuable prognostic information for risk stratification and personalized treatment strategies.

Method: A retrospective study analyzed medical records of 120 CCS patients, revealing 72 underwent PCI and 48 underwent Catheter Angiography.AC, AIP, Castelli's I , II and C-index were determined as non-HDL / HDL , log (TG/ HDL) , TC/ HDL , LDL / HDL and LDL– HDL respectively.

Results: The study compared atherogenic indices between PCI patients and CA patients, finding that CA patients had significantly higher values for most atherogenic indices despite a seemingly better lipid profile. The CA group has a significantly higher C-index (85.8 ± 18.7) compared to the PCI group (37.1 ± 57.4), indicating a potentially greater risk of atherosclerotic events in the CA group. The PCI group has a slightly higher average AIP (0.7 ± 0.5) compared to the CA group (0.6 ± 0.1). The CA group has higher values for both Castelli's indices (I: 5.4 ± 0.7, II: 3.6 ± 0.6) compared to the PCI group (I: 4.0 ± 1.9, II: 2.0 ± 1.8). The CA group has a higher average AC index (4.4 ± 0.7) compared to the PCI group (3.0 ± 1.9).

Conclusion: Daily practice should consider parameters like AC, AIP, CR I&II, which can better reflect complex lipid metabolism and are more easily calculated than traditional lipid parameters.

المؤشرات المسببة لتصلب الشرايين لنتائج القلب والأوعية الدموية لدى المرضى المصابين بمتلازمة الشريان التاجي المزمنة الذين يخضعون للتدخل التاجي عن طريق الجلد: دور رئيسي أو بديل

رشا محمد شرموخ ، رنا مجيد حميد ,اثير حميد عودة ,صالح يحيى الجواد

الخلاصة

المقدمة: تستكشف هذه الدراسة العلاقة بين مؤشرات تصلب الشرايين ونتائج القلب والأوعية الدموية لدى المرضى الذين يعانون من متلازمة الشريان التاجي المزمن (CCS) الذين يخضعون للتدخل التاجي عن طريق الجلد (PCI). ويهدف إلى تحديد ما إذا كانت هذه المؤشرات يمكن أن توفر معلومات إنذارية قيمة لتقسيم المخاطر واستراتيجيات العلاج الشخصية.

الطريقة: قامت دراسة بأثر رجعي بتحليل السجلات الطبية لـ 120 مريضًا من مرضى CCS، وكشفت أن 72 منهم خضعوا لـ PCI و48 خضعوا لتصوير الأوعية الدموية بالقسطرة. تم قياس AC وAIP و Castelli I 's وII و مؤشر C على أنه non-HDL / HDL و log (TG/ HDL) و TC/ HDL و LDL / HDL و LDL– HDLعلى التوالي.

النتائج: قارنت الدراسة مؤشرات تصلب الشرايين بين مرضى PCI ومرضى CA، ووجدت أن مرضى CA لديهم قيم أعلى بكثير لمعظم مؤشرات تصلب الشرايين على الرغم من أن ملف الدهون يبدو أفضل. تتمتع مجموعة CA بمؤشر C أعلى بكثير (85.8 ± 18.7) مقارنة بمجموعة PCI (37.1 ± 57.4)، مما يشير إلى احتمال وجود خطر أكبر لأحداث تصلب الشرايين في مجموعة CA. تتمتع مجموعة PCI بمتوسط AIP أعلى قليلاً (0.7 ± 0.5) مقارنة بمجموعة CA (0.6 ± 0.1). تتمتع مجموعة CA بقيم أعلى لكلا مؤشري Castelli (I: 5.4 ± 0.7، II: 3.6 ± 0.6) مقارنة بمجموعة PCI (I: 4.0 ± 1.9، II: 2.0 ± 1.8). تتمتع مجموعة CA بمتوسط أعلى لمؤشر AC (4.4 ± 0.7) مقارنة بمجموعة PCI (3.0 ± 1.9).

الاستنتاج: يجب أن تأخذ الممارسة اليومية في الاعتبار معلمات مثل AC وAIP وCR I&II ، والتي يمكن أن تعكس بشكل أفضل استقلاب الدهون المعقد ويتم حسابها بسهولة أكبر من معلمات الدهون التقليدية.

الكلمات المفتاحية: PCI, CA, AIP, AC, CR I&II

1. Introduction

Coronary artery disease (CAD) was determined by angiography to be an atherosclerotic lesion of at least 50% in one segment of a major coronary artery, which includes the right coronary artery, left circumflex, or left anterior descending artery (RCA) (Deng et al., 2023) where fat and cholesterol build up on the inner wall of the coronary artery due to obstruction of blood flow to the heart muscle. (Jasim and Lefta, 2022).In more than 90% of cases, the cause of myocardial ischemia is atherosclerotic plaque progression and rupture which leads to thrombus formation and obstruction of blood flow in the coronary arteries.(AL-Husseini and EL-Mosawi, 2021). Percutaneous coronary intervention (PCI) is the method most frequently used to treat coronary artery disease through improving myocardial perfusion. It is highly effective in reducing symptoms for those with stable angina and enhances the prognosis for individuals suffering from acute coronary syndromes.(Khan and Ludman, 2022). Lipids are the fundamental and essential components for the body's requirements, as represented by triglycerides (TG), phospholipids, fatty acids, and total cholesterol, Since lipids are the body's most potent energy source, they are all involved in the creation of cell membranes and some of them are the source of steroid hormones (Baqi et al., 2020). However, Lipid profiles are the primary causes of CVD risk; every lipid profile type is associated with an increased risk of CAD. Where decrease high-density lipoprotein (HDL) levels , increase low-density lipoprotein (LDL) , total cholesterol, TG levels in serum.(Jasim and Lefta, 2022). Elevated lipids levels (cholesterol, fats, and triglyceride) predispose the patient to a various serious and sometimes lethal complications such as cardiovascular disease.(Mosa et al., 2021). A higher incidence of substantial troponin I elevation during PCI was linked to pre-procedural elevated LDL cholesterol in individuals with chronic coronary syndrome. Patients having elective PCI may have a higher risk of cardiac injury if their pre-procedural LDL cholesterol is elevated. (Hasan et al., 2023). One known risk factor for the development of cardiovascular disease is hyperlipidemia, particularly LDL(Zhao et al., 2018). Additionally, prior research has demonstrated that LDL level is associated with infarction size and is a spirited role in PCI prognosis(Qin et al., 2020, Bodde et al., 2019). Furthermore, long-term cardiovascular risk prevention is possible with lipid-lowering therapy.(Sakamoto and Ogawa, 2010). Most atherogenic cholesterol is LDL. The relationship between LDL cholesterol and atherosclerosis has been established. Additionally, it was discovered that ischemic heart disease (IHD) increases by 2% for every 1% increase in serum total cholesterol levels. (Hasan et al., 2023). Dyslipidemia plays vital roles in the physiopathology of CAD and, consequently, in atherosclerosis. The risk of cardiovascular disease steadily declines as the concentrations of HDL cholesterol and apolipoprotein-A (apo-A) increase, and rises as the concentrations of LDL cholesterol and Apolipoprotein-B (apo-B) increase.(Kavurma and Bennett, 2008). One of the main causes of atherosclerotic cardiovascular disease (ASCVD) is atherogenic lipoproteins, specifically LDL cholesterol (Boren et al., 2020). Reduced levels of atherogenic lipids, specifically LDL, can stop the development of coronary atherosclerosis and improve cardiovascular outcomes. The degree of improvement is directly correlated with the reduction in LDL levels.(Koskinas et al., 2021). It is important to note the lipid profile values of STEMI patients, since they were shown to have considerably higher LDL values upon admission compared to other patient groups. This might point to the necessity of concentrating on more extensive screening in order to identify patients with asymptomatic lipid problems early on.(Dyrbus et al., 2019). A 10% decrease in overall mortality, a 23% decrease in

the risk of major cardiovascular incidents, a 20% reduction in the risk of mortality from cardiovascular causes, and a 17% decrease in the risk of stroke are all achieved by lowering LDL by every 38 mg/dL (1 mmol/L), according to a meta-analysis of randomized controlled trials (RCTs) using statins. (Trialists, 2010). The Dyslipidemia International Study (DYSIS) found that 21.7% of patients were able to achieve the therapeutic target of LDL <70 mg/dL (1.8 mmol/L), which was significantly higher than for lower-risk groups. The study involved a cohort of over 57,000 patients, of whom over 44,000 were classified as high CV risk.(Gitt et al., 2016)

The study comprised PCI patients at follow-up, and after a year of follow-up, the mean values of lipids and the prevalence of dyslipidemia were much lower than those at baseline. Blood lipid levels were influenced by age, gender, smoking status, and food management.(Qiu et al., 2020) patients with an LDL level above 70 mg/dL were at risk up to five times higher than those with a level below 70 mg/dL. This finding made a compelling case for the necessity of LDL treatment in patients prior to revascularization.(Chen et al., 2021)

1.1.Atherogenic Indices

Numerous lipid markers have already been used to predict the likelihood of developing CVD and coronary atherosclerosis. Majority of these consist of plasma lipoprotein and lipid concentrations, whilst occasional involvement of plasma apolipoproteins. It's intriguing that lipid ratios have recently been utilized as indicator of lipoprotein and lipid risks(Kim et al., 2017). Several studies show that altering lipid ratios instead of using conventional lipid markers is crucial. (Nwagha et al., 2010)

1.2.Atherogenic coefficient (AC)

The ratio of non-high-density lipoproteins cholesterol (non-HDL) to HDL(Nwagha et al., 2010). It is an alternate diagnostic method that has been applied to forecast the likelihood of experiencing cardiovascular events.

AC = non-HDL / HDL

Non- HDL = TC – HDL

1.3.Atherogenic Index of Plasma (AIP)

An unusual lipid ratio that shows the logarithm of the TG to HDL molar ratio.(Gómez-Álvarez et al., 2020) . Evidence gathered over time demonstrated that AIP is a significant predictive index that positively correlates with CVD.

AIP = log (TG/ HDL)

1.4.Castelli's Risk Indexes (I & II)

(sometimes known as cardiac risk indexes) are two lipid ratios, the CRI-I is the ratio of TC to HDL, whilst the CRI-II is the ratio of LDL to HDL, has notably favorable correlations to the risk of CVD (Igharo et al., 2020). Numerous studies assessed and verified their favorable association with CVD. (Tecer et al., 2019)

CRI-I= TC/ HDL ratio

CRI-II = LDL / HDL ratio

1.5.Cholesterol Index (C-Index)

A straightforward measure that more accurately than the other indices forecasts the likelihood of getting CAD. (Ulusoy, 2013)

C- index= LDL – HDL

2. Patients and Methods

Following obtaining permission Kerbala University College of Medicine committee on ethics, the data of 72 patients who underwent PCI in Karbala Center for Heart Diseases and Surgery (Karbala Heart Center) and Imam Al – Hassan Al Mujtaba teaching hospital in Kerbala city. As the control group, 48 patients were randomly chosen from a group of patients who had coronary angiography (CA) on the same date because there was a suspicion of CVD based on symptoms including angina pectoris, effort dyspnea, ischemic alterations in electrocardiography, and positive effort test results. Patients with ACS, Peripheral vascular disease (PVD) , Chronic kidney disease (CKD) , Stroke , Preeclampsia , cancer and underwent a PCI two weeks ago or less were excluded from the study. Prior to sampling, all study participants gave their verbal consent. Every patient whose elective cardiac catheterization was scheduled underwent a review of their medical history, a physical examination, standard blood tests, an echocardiography, and an electrocardiogram. On the day of the intervention, patients who smoked were classified as smokers.

2.1. Angiographic Lesion Complexity Score Calculation

A lesion was considered complex if it had undergone treatment and had at least one of the following high-risk angiographic lesion characteristics: Type C, bifurcation, unprotected left main trunk (UPLMT), chronic total occlusion (CTO), and thrombus development. When performing the coronary angiography, the operator assessed whether these features were present. Patients were categorized based on absolute complicated lesion status (yes/no), and by how many of the five complex lesion criteria overall were met(score 0 (no complex lesion) , score 1(one complex lesion), score 2(two complex lesions), score 3(three complex lesions) , score 4(four complex lesions), and score 5(all complex lesions).(Endo et al., 2015)

2.2. Biochemical Parameters and Lipid Index Computation

The examination of lipid profile samples was conducted using Abbot-ARCHITECT c4000 clinical chemistry (Corelaboratory, 2018), and AC, AIP, Castelli's I , Castelli's II and C-index were calculated as non-HDL / HDL , log (TG/ HDL) , TC/ HDL , LDL / HDL and LDL – HDL respectively.

2.3. Statistical Analyses

The graphical Pad Prism was used to create the data analysis for this project. We ran descriptive statistics on every group's data. For categorical data, values were shown as n (%), and for normal data, scale variables were shown as mean ± 2 standard deviation. The Shapiro-Wilk test was used to examine the data distribution and determine normality numerically. In order to assess the link within the case study, biomarkers were compared. Analytical statistical studies indicated significant variations in categorical variables among the parameters. All hypothesis test results with two-sided p-values less than 0.05 were deemed statistically significant.

Through the use of receiver operating characteristic (ROC) analysis, the ideal threshold for critical instances was found with good specificity and sensitivity. All P values were discovered to be two-sided, and a $P < 0.05$ was regarded as statistically significant

3. Results

Table 1 summarizes the demographic characteristics of participants in two groups: Percutaneous Coronary Interventions (PCI) and Catheter Angiography (CA). Results were shown that males made up the bulk of participants

in both groups: 83.3% in PCI and 79.2% in CA, and Females represented a smaller portion of participants: 16.7% in PCI and 20.8% in CA. Kerbala was the primary residence for a larger proportion of participants in the group CA (83.3%) compared to PCI (56.9%). Conversely, participants from outside Kerbala were more prevalent in the PCI (43.1%). compared to CA group (16.7%). The mean age was similar for both groups: 57.7 years old (± 8.5 SD) for PCI and 57.1 years old (± 11.1 SD) for CA, and the mean BMI was higher in the CA group (31.3 kg/m² ± 5.7 SD) compared to the PCI group (29.5 kg/m² ± 5.5 SD).

Table 1: Demographics Characteristic of The Study

Demographics		**Percutaneous Coronary Interventions (PCI)**	**Catheter Angiography (CA)**
Sex No. (%)	**Male**	60(83.3%)	38 (79.2%)
	Female	12(16.7%)	10 (20.8%)
Residence No. (%)	**Kerbala**	41(56.9%)	40(83.3%)
	Other Iraqi people	31(43.1%)	8 (16.7%)
Age, mean ±2SD (year)		57.7± 8.5	57.1±11.1
BMI, mean ±2SD (kg/m2)		29.5 ±5.5	31.3 ± 5.7

Table 2 compared the medical history of participants in two groups: Percutaneous Coronary Interventions (PCI) and Catheter Angiography (CA). Results were indicated a higher percentage of participants in the CA group reported never smoking (72.9%) compared to the PCI group (61.1%). Current smoking was more prevalent in the PCI group (33.3%) compared to CA (25.0%). Passive smoking was minimal in both groups. The CA group had a higher proportion of participants with no history of DM (60.4%) compared to PCI (44.4%). Conversely, the PCI group had a higher percentage of participants with Type 2 DM (55.6%) compared to CA (39.6%).

Anticoagulant use was similar between the two groups, with a vast majority (over 88%) in both groups reporting current use. Family history of CVD was uncommon in both groups, with the vast majority (over 93%) reporting no family history. Results were also included the distribution of obesity stages which differed between the groups-obesity was the most common stage in both groups, but slightly more prevalent in CA (54.2%) compared to PCI (45.8%). Higher obesity classes were more frequent in the CA group, with a notably higher percentage in Class 2 (20.8% vs. 1.4% in PCI).

Table 2: Medical History of The Study Groups

Medical History	**Group 1 Percutaneous Coronary Interventions (PCI)**	**Group2 Catheter Angiography (CA)**
Smoking, No. (%)		
No	44(61.1%)	35 (72.9%)
Active	24(33.3%)	12 (25.0%)
Passive	4(5.6%)	1(2.1%)
DM, No. (%)		
No	32(44.4%)	29 (60.4%)

Type 2	40(55.6%)	19 (39.6%)
Anticoagulant, No. (%)		
No	8(11.1%)	5 (10.4%)
Yes	64(88.9%)	43 (89.6%)
Family History of CVD, No. (%)		
No	67(93.1%)	47 (97.9%)
Yes	5(6.9%)	1(2.1%)
Obesity. Stage, No. (%)		
Normal Weight	9(12.5%)	1 (2.1%)
Pre-Obesity	33(45.8%)	26 (54.2%)
Obesity Class-1	26(36.1%)	7 (14.6%)
Obesity Class-2	1(1.4%)	10 (20.8%)
Obesity Class-3	3(4.2%)	4 (8.3%)

Table 3 compared the Lesion characteristics of participants in two groups: Percutaneous Coronary Interventions (PCI) and Catheter Angiography (CA). results were indicated a higher percentage of participants in the CA group reported never Calcification lesion (70.8 %) compared to the PCI group (43.1%) , PCI group advertised Calcification lesion (56.9%) compared to the CA group (29.2%) . The CA group had a higher proportion of participants with no bifurcation (75.0%) compared to PCI (66.7%). Conversely, the PCI group had a higher percentage of participants with bifurcation (33.3%) compared to CA (25.0 %). Similarly, PCI group has a higher percentage of Chronic Total Occlusion (CTO) (26.4%) in comparison to the CA group (18.8%). On the contrary, those who do not have CTO, their percentage in the CA group (81.3%) greater than PCI group (73.6%). On the other hand, Type C lesion reported with higher percentage in the PCI group (62.5%) than the CA group (33.3%), the remaining percentage of PCI group (37.5%) with no Type C is less than CA group (66.7%). No Unprotected Left Main Trunk (UPLMT) in all PCI group and very low percentage in CA group (10.4%). In our study when comparing Angiographic Lesion Complexity Score in two groups (PCI and CA) reported that CA group have a higher percentage (64.6%) of O score (least complexity) than PCI group (29.2%) but, PCI group has greater percentage of score 1 (one complex lesion) and score 2 (two complex lesion) (31.9%) and (27.8%) respectively compared with CA group (6.3%) and (8.3%) respectively . PCI group has a lower percentage of score 3 (three complex lesion) (11.1%) than CA group (20.8%). No high score (4 and 5) in both groups.

Table 3: Lesion Characteristics of The Study Groups

Lesion characteristics	**Percutaneous Coronary Interventions (PCI)**	**Catheter Angiography (CA)**
Calcification		
no	31 (43.1%)	34 (70.8%)
yes	41 (56.9%)	14 (29.2%)
Bifurcation		
no	48 (66.7%)	36 (75.0%)
yes	24 (33.3%)	12 (25.0%)
Chronic Total Occlusion (CTO)		
no	53 (73.6%)	39 (81.3%)
yes	19 (26.4%)	9 (18.8%)
Type C		
no	27 (37.5%)	32 (66.7%)
yes	45 (62.5%)	16 (33.3%)

Unprotected Left Main Trunk (UPLMT)		
no	72 (100.0%)	43 (89.6%)
yes	0 (0.0%)	5 (10.4%)
Angiographic Lesion Complexity Score		
0 (no complex lesion)	21 (29.2%)	31(64.6%)
1(one complex lesion)	23 (31.9%)	3(6.3%)
2(two complex lesions)	20 (27.8%)	4(8.3%)
3(three complex lesions)	8 (11.1%)	10(20.8%)
4(four complex lesions)	0 (0.0%)	0 (0.0%)
5(all complex lesions)	0 (0.0%)	0 (0.0%)

Comparison in Lipid Profile Levels Between PCI And CA Groups

Table 4 and Fig.1 demonstrated the mean and standard deviation (SD) of lipid profile levels in the two groups. Results were shown that the CA group had a slightly higher average total cholesterol level (162.1 mg/dL ± 39.9 SD) compared to the PCI group (146.5 mg/dL ± 63.2 SD). Also, the CA group had a considerably higher average LDL level (120.5 mg/dL ± 25.5 SD) compared to the PCI group (74.2 mg/dL ± 32.8 SD). While PCI group had a higher average TG level (194.6 mg/dL ± 117.8 SD) compared to the CA group (134.7 mg/dL ± 34.4 SD). Both groups had relatively low HDL levels, with similar averages: 35.7 mg/dL ± 11.5 SD in the PCI group and 34.7 mg/dL ± 9.7 SD in the CA group.

Table 4: Mean Differences of Lipid Profile Levels Among the Studies Groups

Lipid profile	PCI	CA
Total cholesterol (mg/dL)		
Mean±SD	146.5±63.2	162.1±39.9
	TG (mg/dL)	
Mean±SD	194.6±117.8	134.7±34.4
HDL (mg/dL)		
Mean±SD	35.7±11.5	34.7±9.7
LDL (mg/dL)		
Mean±SD	74.2±32.8	120.5±25.5

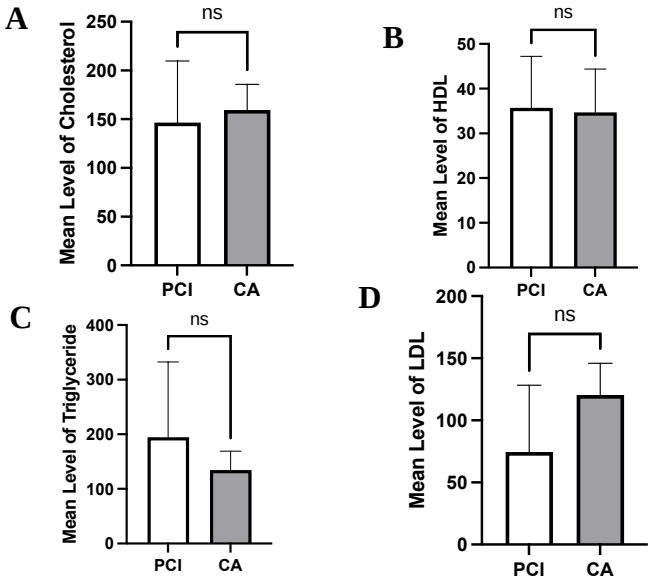

Figure 1: Mean Differences of Lipid Profile Levels Among Study Groups. A) refers to cholesterol levels. **B)** refers to high density lipoprotein**. C)** refers to triglycerides. **D)** refers to low density lipoprotein.

Comparison of Atherogenic Indices in PCI And CA Groups

Regarding the lipid profile comparisons between patients undergoing PCI and CA. The findings reveal interesting differences in cholesterol profiles between the two groups. The CA group had slightly higher average total cholesterol and significantly higher LDL cholesterol compared to the PCI group. Results were shown a potentially higher burden of atherogenic lipoproteins (LDL) in the CA group, this was agreed with the previous research who shown the role of LDL in the contribution of coronary artery plaque formation (Mortensen et al., 2022).Conversely, the PCI group had a significantly higher average TG level compared to the CA group. Elevated TG, often associated with metabolic syndrome, can also be a risk factor for cardiovascular disease. Both groups had relatively low HDL levels, with no significant difference between them. In spite of the differences in the mean levels of lipid, however both study groups were having coronary artery disease. Dyslipidemia is an independent major risk factor for CAD. This variation might be due to lifestyle interventions and a wide range of risk factor results in CAD progression.(Shahid et al., 2020). Table 5 & Fig.2 presented the mean and standard deviation (SD) of atherogenic indices in patients undergoing elective PCI and those undergoing CA. There was a mean difference in most atherogenic indices between the PCI and CA groups. The CA group has a significantly higher C-index (85.8 ± 18.7) compared to the PCI group (37.1 ± 57.4). A higher C-index generally indicates a greater likelihood of atherosclerotic events. While the PCI group has a slightly higher average AIP (0.7 ± 0.5) compared to the CA group (0.6 ± 0.1). The CA group has higher mean values for both Castelli's Indices (I and II) (5.4 ± 0.7) and (3.6 ± 0.6) compared to the PCI group (4.0 ± 1.9, 2.0 ± 1.8). Similar to other indices, the CA group has a higher average AC index (4.4 ± 0.7) compared to the PCI group (3.0 ± 1.9).

Table 5: Mean differences of atherogenic indices Levels among the studied groups

Atherogenic Indices	CA	PCI
C-index		
Mean± 2SD	85.8±18.7	37.1±57.4
AIP		
Mean± 2SD	0.6±0.1	0.7±0.5
Castelli's I		
Mean± 2SD	5.4±0.7	4±1.9
Castelli's II		
Mean± 2SD	3.6±0.6	2±1.8
AC index		
Mean± 2SD	4.4±0.7	3±1.9

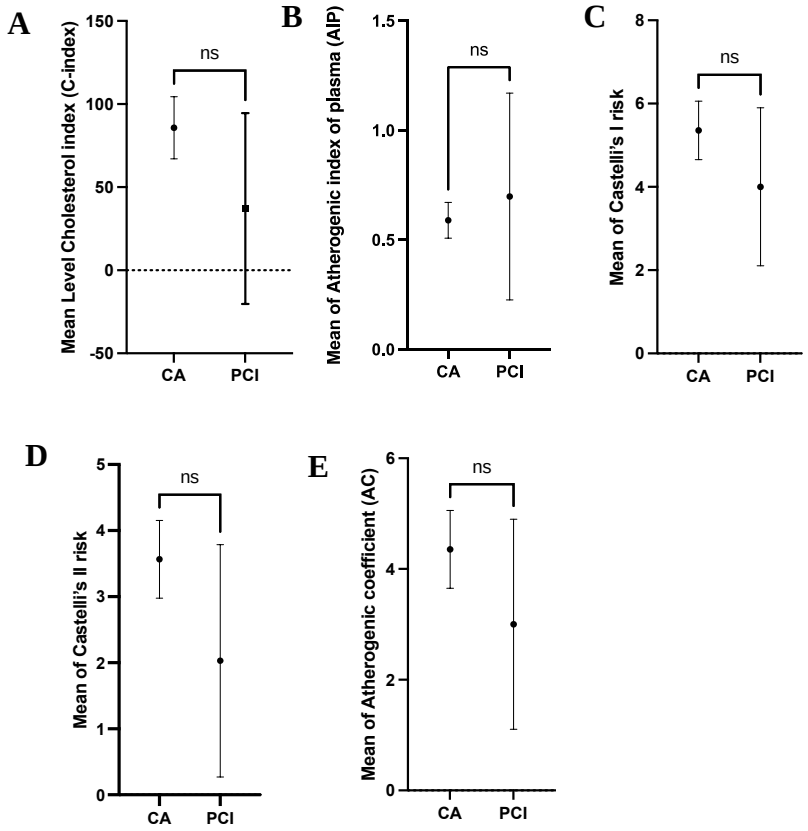

Figure 2: Mean Differences of Atherogenic Indices Levels Among Study Groups. A) C-index. B) Atherogenic index. C) Castelli's risk indexes (I). D) Castelli's risk indexes (II). E) Atherogenic coefficient

4. Discussion

Recently, it has been confirmed that atherogenic Index of Plasma (AIP) is a novel marker for cardiovascular illnesses in the modern era(Wang et al., 2023, Zheng et al., 2022, Qin et al., 2020). examined AIP as a continuous variable and discovered a strong positive association between the probability of dying from all causes and AIP level (Kasapkara and Erdoğan, 2023) . Dyslipidemia is caused by an imbalance of these plasma lipids and is typified by low levels of HDL and high levels of LDL, TG, and total cholesterol (Hoogeveen and Ballantyne, 2021) . While lowering LDL levels is one of the treatment goals for CAD, even after achieving this goal, there is still a significant cardiovascular risk, which motivates researchers to look into more precise risk factors in these patients (Ikezaki et al., 2021) . As a useful predictor, the AIP represents the atherogenic lipid profile and offers important information about the remaining cardiovascular risk, making it a powerful predictor of cardiovascular events. Additional ongoing research (Wang et al., 2023) revealed evidence that patients with higher AIP levels were more likely to experience MACCE than patients with lower AIP levels. This increased risk was attributed to the increased possibility of unplanned repeat revascularization. Prior studies have indicated a strong correlation between AIP levels and both the stability of plaque and the severity of coronary artery lesions.(Hu et al., 2023)

This suggests that patients with high AIP levels are more vulnerable to the rapid development and rupture of coronary plaques, which increases the risk of unanticipated recurrent revascularization. Secondly, a number of studies have shown a strong correlation between high levels of AIP and insulin resistance, which is linked to an increased risk of cardiovascular events (Salazar et al., 2013). Thirdly, obese patients had a higher likelihood of having a high AIP level (Zhu et al., 2018), and show a higher incidence of diabetes mellitus, hypertension, and metabolic syndrome (Wen, 2023) , they collectively have a major role in the worse clinical results after PCI.

The ratio of T.G./HDL represents a valuable indicator for valuing IHD risk and personalized therapeutic approaches (Shwaikh, 2023).On the other hand, results were shown that patients undergoing coronary angiography tend to have higher Castelli's I (CRI) and (CRII) values compared to those undergoing elective PCI, this finding was consistence with other research in different context who investigate the relationship between Castelli's I and II and ischemia severity (Doganay, 2023). It was found that Patients with ischemia had higher CRI levels; CRI-II levels, but not CRI-I, were linked with the degree of ischemia. The existence and severity of ischemia were both co-independently predicted by CRI-II, and the prediction of ischemia severity by CRI-II threshold values increased gradually.(Doganay, 2023). Atherosclerosis is the main cause of AD, and disorders associated with atherosclerosis frequently have a poor prognosis (Chunli Shao, 2020). The pathophysiology of atherosclerosis is known to involve mechanisms including lipid accumulation in the artery intima, activation of inflammatory cells like T lymphocytes and monocytes, and matrix protein synthesis (Graeme J. Koelwyn, 2018) . This is in line with the observation that patients with ischemia, regardless of severity, have impaired lipid metabolism, increased monocytes, and elevated CRP levels. Prior research has indicated the function of CRI derived from lipid profiles in the prognostication of cardiovascular illness. Zhang et al (Yurong Zhang, 2012) revealed that the risk of ischemic stroke is correlated with CRI-I, a measure of coronary plaque production, in both men and women. Dai et al (Michelle Dai 1 et al., 2022) found that there is a positive connection between CRI-I and CRI-II and aortic calcification. Afsin et al. (Afsin1 et al., 2021) demonstrated that sluggish coronary flow can be independently predicted by CRI-II. While these results confirm that CRI is a useful screening method for CAD prediction. The stimulation of inflammation can hasten atherosclerosis (Meng-Yu Wu 1, 2017) . After tissue damage, macrophages gather in the damaged tissue as a result of an inflammatory response. Additionally, it has been proposed that HDL might prevent leukocyte migration and activation (Rolf Spirig, 2013). When activated monocytes take up oxidized LDL cholesterol molecules, they develop into macrophages. Reversing the effects of oxidized LDL and decreasing monocyte activation are two functions of HDL cholesterol (Sumra Nazir 2020). Pro- and anti-inflammatory cytokines are secreted as a result, and CRP production rises. Thus, atherosclerosis is accelerated by an inflammatory response (Lina Badimon, 2018). This mechanism aligned with the favorable connection observed between CRIs and inflammatory markers. Prior research revealed a positive relationship between CAD patients' CRP levels and the degree of ischemia (Yue Liu MD, 2020) . The diagnostic efficacy of CRI-II generated from LDL and HDL cholesterol levels may be explained by these mechanisms. Additionally, CRI-II provided progressive threshold values for differentiating the severity of ischemia. Beyond just determining whether ischemia is present, CRI-II can be a cheap and simple screening tool for predicting the severity of ischemia. This study compared atherogenic indices between patients undergoing PCI and CA . The findings show that the CA group, despite having a seemingly "better" lipid profile in some aspects, had significantly higher values

for most atherogenic indices. This finding was highlighted the potential value of atherogenic indices in cardiovascular risk assessment. By incorporating these indices alongside traditional lipid profiles. The specific components contributing to a high atherogenic index can inform targeted managements. The CA group exhibited higher mean values for C-index, Castelli's I & II indices, and the AC index compared to the PCI group. These indices generally reflect a higher risk of atherosclerotic events. These findings were consistence with other who suggests that atherogenic indices might provide a more comprehensive picture of cardiovascular risk compared to traditional lipid profiles alone.(Jihong Deng a 1, 2023).

5. Conclusion

Parameters like AC, AIP, CR I&II which may be calculated more readily and that can better reflect the complicated lipid metabolism, should be taken into consideration in daily practice as well to follow-up of traditional lipid parameters.

6. Declarations

Authors' contributions: RM, RMH and SY were designed the experiments, wrote the manuscript; RM, RMH ,SY performed experiments and collected data, editing and prepare the manuscript for journal submission. RM, RMH ,SY and AH were checking the final approved of the version to be published. All authors read and approved the final manuscript.

7. Conflict of interest

The authors declare no conflict of interest.

8. Funding resources

No external fund was received.

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