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RESEARCH ARTICLE

A Study on the Role of PT, aPTT, and D-dimer as Markers of Coagulation Abnormalities in Patients with Coronary Artery Disease: A Multicentric Analysis

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Abstract: ***Background:*** Coronary artery disease (CAD) is influenced not only by atherosclerosis but also by abnormalities in coagulation and fibrinolysis. Prothrombin time (PT), activated partial thromboplastin time (aPTT), and D-dimer are well-established laboratory markers of coagulation status, yet their role in CAD remains incompletely understood. ***Objectives:*** To evaluate PT, aPTT, and D-dimer levels in patients with CAD and analyze their role as markers of coagulation abnormalities across different clinical presentations. ***Methods:*** This multicentric, cross-sectional study was conducted over 24 months across tertiary care hospitals, involving 600 CAD patients and 200 healthy controls. CAD was confirmed by clinical, biochemical, and angiographic findings. Patients were classified as either acute coronary syndrome (ACS) or stable CAD. Blood samples were analyzed for PT, aPTT, and D-dimer. Data were statistically analyzed using SPSS v26. ***Results:*** CAD patients demonstrated significantly prolonged PT ($p<0.01$) and shortened aPTT ($p<0.05$) compared to controls. D-dimer levels were markedly elevated in ACS patients (mean 910 ± 270 ng/mL) compared to stable CAD (mean 470 ± 190 ng/mL) and controls (mean 280 ± 100 ng/mL). Subgroup analysis revealed that patients with triple vessel disease had significantly higher D-dimer values compared to single-vessel disease. ***Conclusion:*** PT, aPTT, and D-dimer provide useful insights into coagulation abnormalities in CAD. Elevated D-dimer particularly correlates with acute presentation and angiographic severity, underscoring its potential role as a prognostic biomarker. Routine inclusion of these markers may improve risk stratification in CAD management.

Keywords: Coronary artery disease, Prothrombin time, aPTT, D-dimer, Coagulation markers, Acute coronary syndrome

INTRODUCTION

Coronary artery disease (CAD) is a leading cause of morbidity and mortality worldwide, accounting for nearly one-third of all global deaths annually [1]. The burden of CAD is rising in both developed and developing countries, with the South Asian population showing particularly high prevalence and earlier onset compared to Western counterparts [2]. Traditionally, CAD has been considered a disorder of atherosclerosis, where plaque buildup within the coronary arteries leads to progressive narrowing and reduced myocardial perfusion. However, it is now well recognized that the pathophysiology of CAD extends beyond lipid accumulation and vascular injury to include abnormalities in coagulation and fibrinolysis, which play critical roles in plaque destabilization and thrombus formation [3,4].

The rupture or erosion of an atherosclerotic plaque triggers platelet activation, coagulation cascade initiation, and subsequent thrombus formation. These events underlie acute coronary syndromes (ACS), including ST-elevation myocardial infarction (STEMI), non-ST elevation myocardial infarction (NSTEMI), and unstable angina. In contrast, patients with stable CAD exhibit more controlled plaque progression but remain at risk of thrombosis due to a prothrombotic milieu [5]. Therefore, studying hemostatic markers offers valuable insights into both disease mechanisms and prognosis.

Prothrombin time (PT) and activated partial thromboplastin time (aPTT) are long-standing laboratory tests for assessing coagulation. PT evaluates the extrinsic and common pathways of the coagulation cascade, reflecting the activity of factors I, II, V, VII, and X. Prolonged PT in CAD patients may reflect subclinical consumption of clotting factors or altered liver function due to chronic ischemia [6]. Conversely, aPTT reflects the intrinsic pathway involving factors VIII, IX, XI, and XII. Shortened aPTT has been increasingly recognized as a marker of hypercoagulability and has been associated with venous and arterial thrombosis [7,8]. Thus, both PT and aPTT provide complementary insights into the coagulation profile of CAD patients.

D-dimer, a degradation product of cross-linked fibrin, is an established marker of fibrinolysis and ongoing thrombogenesis. Elevated D-dimer levels indicate increased thrombin activity and fibrin turnover. While it

is traditionally used to exclude venous thromboembolism and pulmonary embolism, growing evidence suggests that D-dimer also predicts cardiovascular risk [9]. Ridker et al. [10] first reported that elevated baseline D-dimer levels were associated with an increased risk of future myocardial infarction in apparently healthy men. Lowe and Rumley [11] further highlighted its predictive value for arterial thrombotic events. More recently, studies have confirmed that elevated D-dimer correlates with ACS and is associated with worse clinical outcomes [12–14]. Furthermore, D-dimer has been linked with angiographic severity of CAD, with higher levels found in patients with multivessel disease [15,16].

Despite growing interest, limited multicentric data exists that simultaneously evaluate PT, aPTT, and D-dimer in CAD patients across different clinical spectrums. Most studies have been single-center with small sample sizes, making it difficult to generalize findings. Moreover, while D-dimer has been extensively studied, fewer studies have systematically compared its predictive value with routine coagulation parameters like PT and aPTT [17,18].

Given this background, the present multicentric study was designed to evaluate PT, aPTT, and D-dimer levels in CAD patients and compare them with healthy controls. The objectives were:

1. To analyze alterations in PT, aPTT, and D-dimer among CAD patients compared to controls.
2. To compare these parameters between stable CAD and ACS subgroups.
3. To examine the association of D-dimer levels with angiographic severity of CAD.

Through this approach, the study aims to clarify the diagnostic and prognostic value of these widely available coagulation markers in the context of CAD and to explore their potential integration into clinical risk assessment.

MATERIAL AND METHOD

This was a multicentric, cross-sectional observational study conducted over 24 months in tertiary care hospitals. A total of 800 participants were recruited, comprising 600 CAD patients and 200 age- and sex-matched healthy controls.

Inclusion criteria

i. Patients ≥18 years of age with confirmed CAD based on angiographic and clinical findings.
ii. Subgroups: Acute Coronary Syndrome (ACS) including STEMI, NSTEMI, and unstable angina; and Stable CAD.

Exclusion criteria

i. Patients on anticoagulant therapy
ii. Known coagulation disorders
iii. Chronic liver disease or malignancy
iv. Recent major surgery or trauma

Data Collection and Laboratory Analysis

After informed consent, venous blood samples were collected under aseptic precautions.

- PT and aPTT were measured using standardized automated coagulometers.
- D-dimer was quantified by enzyme-linked immunosorbent assay (ELISA).
- Clinical data including demographics, cardiovascular risk factors (hypertension, diabetes, smoking, dyslipidemia), and angiographic severity were recorded.

Statistical Analysis

Data were analyzed using SPSS v26. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as percentages. Student's t-test and one-way ANOVA were used for group comparisons. $p<0.05$ was considered statistically significant.

RESULT:

A total of 600 CAD patients and 200 controls were included. The mean age of CAD patients was 58.1 ± 9.3 years, with 70% being male. Hypertension (61%) and diabetes (44%) were the most common comorbidities.

Table 1. Baseline Characteristics of Study Participants

Variable	CAD Patients (n=600)	Controls (n=200)	p-value
Age (years, mean ± SD)	58.1 ± 9.3	55.8 ± 8.5	0.07
Male (%)	70%	69%	0.72
Hypertension (%)	61%	18%	<0.001
Diabetes (%)	44%	12%	<0.001
Smoking (%)	39%	20%	<0.01

Table 2. Comparison of Coagulation Parameters

Parameter	Controls (n=200)	Stable CAD (n=260)	ACS (n=340)	p-value
PT (sec)	12.2 ± 1.1	13.2 ± 1.3	13.7 ± 1.6	<0.01
aPTT (sec)	31.5 ± 3.2	29.9 ± 3.0	28.5 ± 2.8	<0.05
D-dimer (ng/mL)	280 ± 100	470 ± 190	910 ± 270	<0.001

Table 3. D-dimer Levels According to Angiographic Severity

Number of Vessels Involved	Mean D-dimer (ng/mL) ± SD
Single vessel disease	630 ± 210
Double vessel disease	790 ± 240
Triple vessel disease	980 ± 310

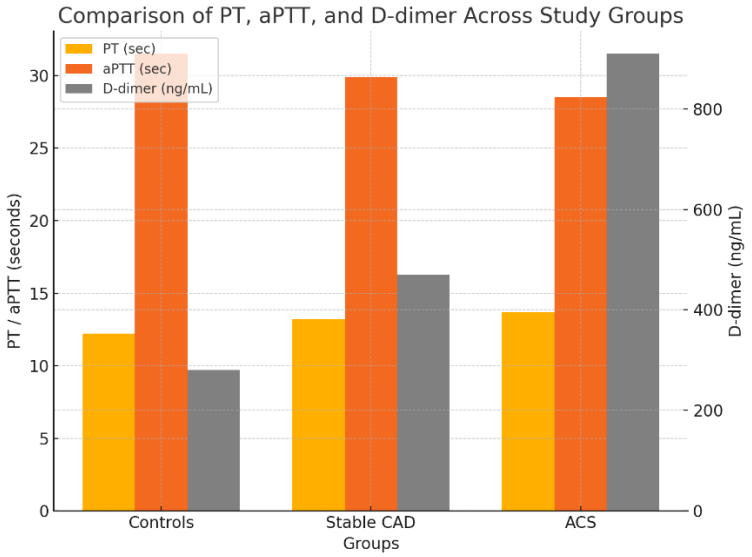

Figure 1. Mean values of PT, aPTT, and D-dimer in controls, stable CAD, and ACS patients. D-dimer showed the highest elevation in ACS compared to other groups, while PT was prolonged and aPTT shortened in CAD patients.

DISCUSSIONS

The present multicentric study demonstrates significant abnormalities in coagulation markers among patients with coronary artery disease (CAD). Specifically, PT was prolonged, aPTT shortened, and D-dimer markedly elevated compared to controls. These findings reaffirm the central role of coagulation and fibrinolysis disturbances in the pathophysiology of CAD and its acute manifestations.

PT and aPTT Alterations in CAD- The prolongation of PT in CAD patients observed in our study may reflect subtle consumption coagulopathy and altered hepatic synthesis of clotting factors secondary to chronic ischemia. Similar trends were observed by Gum et al., who reported that prolonged PT was associated with higher mortality in acute myocardial infarction patients [1]. On the other hand, the shortened aPTT seen in our study suggests a hypercoagulable state, consistent with findings from Favaloro et al. [2], who highlighted that shortened aPTT is an under-recognized risk marker of thrombosis.

A meta-analysis by Tripodi et al. [3] further emphasized that shortened aPTT is predictive of venous and arterial thrombotic events, supporting our observation that CAD patients, particularly those with ACS, demonstrate a prothrombotic milieu.

D-dimer as a Marker of Thrombogenesis- The most striking observation in our study was the marked elevation of D-dimer in CAD patients, especially those with ACS. D-dimer is a fibrin degradation product and reflects both thrombin generation and fibrinolysis. Elevated levels in ACS indicate active thrombogenesis and plaque instability. Ridker et al. [4] demonstrated that baseline D-dimer levels were predictive of future myocardial infarction in apparently healthy men, underscoring its role as a prognostic biomarker.

More recently, a systematic review by Lip et al. [5] concluded that elevated D-dimer levels were strongly associated with adverse cardiovascular outcomes, including mortality, across various populations. Our results are consistent with these findings, with ACS patients showing nearly a three-fold increase in D-dimer levels compared to stable CAD and controls.

Furthermore, the strong correlation between angiographic severity and D-dimer observed in our study echoes findings from Li et al. [6], who demonstrated that higher D-dimer levels were independently associated with multi-vessel CAD and plaque burden. This highlights the potential role of D-dimer not only as a diagnostic adjunct but also as a marker of disease severity.

Comparative Analysis with Other Coagulation Markers- While traditional coagulation parameters (PT, aPTT) have limitations in sensitivity, their combination with D-dimer provides a broader understanding of the coagulation profile in CAD. Previous studies by Sabatine et al. [7] reported that elevated D-dimer levels in ACS patients were independently predictive of

recurrent ischemic events, suggesting its integration in routine clinical evaluation. Additionally, Raza et al. [8] reported that patients with higher D-dimer levels at admission had significantly increased risk of in-hospital mortality.

In contrast, some studies suggest that elevated D-dimer may not be specific to CAD, as it is also increased in conditions such as infection, inflammation, and cancer [9]. Nonetheless, in the context of acute coronary syndromes, elevated D-dimer in conjunction with clinical and angiographic findings retains high diagnostic and prognostic value.

Pathophysiological Implications- The combined findings of prolonged PT, shortened aPTT, and elevated D-dimer reflect a prothrombotic yet consumptive state in CAD patients. This suggests that while the coagulation cascade is activated, there is simultaneous fibrinolysis. This dual activation could explain the heightened risk of thrombosis and recurrent ischemic events in CAD.

Emerging evidence also supports the interplay between inflammation, coagulation, and atherosclerosis. Biomarkers such as high-sensitivity C-reactive protein (hs-CRP) and interleukins have been shown to synergize with coagulation markers in predicting CAD outcomes [10]. Incorporating PT, aPTT, and D-dimer alongside inflammatory markers may enhance risk stratification.

Strengths and Limitations- The strengths of this study include its multicentric design, large sample size, and inclusion of angiographic data. However, limitations include its cross-sectional nature, lack of longitudinal follow-up to assess long-term outcomes, and exclusion of patients on anticoagulation therapy. Moreover, we did not analyze genetic or molecular markers of thrombosis (e.g., Factor V Leiden, prothrombin G20210A mutation), which could further refine risk profiling.

Clinical Implications- Our findings highlight that routine testing of PT, aPTT, and particularly D-dimer could provide valuable adjunctive information in CAD patients. Elevated D-dimer in ACS or multi-vessel disease could guide more aggressive antithrombotic strategies, while shortened aPTT may prompt closer surveillance for thrombotic complications. Future studies should aim to integrate these markers into validated risk stratification scores for CAD.

CONCLUSION

PT, aPTT, and D-dimer serve as valuable markers of coagulation abnormalities in CAD patients. Elevated D-dimer, in particular, correlates strongly with ACS and angiographic severity, highlighting its prognostic role. Routine inclusion of these markers in CAD evaluation may enhance early risk stratification, guide therapy, and improve outcomes.

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