

Association of hs-CRP and Serum Bilirubin Levels with VTE Phenotype (DVT vs PTE) and Demographics: A Cross-sectional Study

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ABSTRACT

Background: This study aimed to evaluate the levels of hs-CRP and serum bilirubin in patients diagnosed with VTE and to investigate their association with clinical presentation and demographic factors.

Methods: The present cross-sectional study consisted of 40 patients admitted to two tertiary care hospitals in Mashhad, Iran, with confirmed VTE (either DVT or PTE) between 2021 and 2022 were evaluated. Laboratory data, including hs-CRP, total bilirubin, and direct bilirubin, were extracted from medical records. Comparative analysis was performed between DVT and PTE groups, as well as across gender and age categories.

Results: Among the participants, 25 (62.5%) were female, and the mean age was 61.82 ± 17.12 years. Median hs-CRP levels were 26 mg/L (IQR: 10.27-71.10) in DVT patients and 18 mg/L (IQR: 7-74) in PTE patients, with 80% and 70% of patients in these groups, respectively, exceeding the 10 mg/L clinical threshold for systemic inflammation. Patients with PTE were significantly older than those with DVT ($p = 0.03$). However, no statistically significant differences were found in hs-CRP or bilirubin levels between DVT and PTE patients, nor between genders.

Conclusion: Although hs-CRP levels were elevated among VTE patients, their utility in differentiating between DVT and PTE was limited. Serum bilirubin levels did not significantly vary across subgroups. These findings indicate that elevated hs-CRP is a consistent feature of VTE presentations irrespective of subtype, while neither biomarker reliably differentiates between DVT and PTE. These results are descriptive and hypothesis-generating, and underscore the need for larger controlled prospective studies.

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Introduction

Venous thromboembolism (VTE, including deep vein thrombosis (DVT) and pulmonary embolism (PE)) is one of the most important causes of morbidity and mortality across the globe (1, 2). Multiple factors contribute to the development of venous thromboembolism. Likely because there are numerous risk factors, venous thromboembolism was first described with the risk factors of Virchow's triad (venous stasis, injury to the endothelium, and

hypercoagulability) needing to come together (3, 4). More recent studies have begun to show the importance of inflammation in the development of thrombus, and the authors propose that inflammation biomarkers can provide an assessment of VTE risk (5-7).

High-sensitivity C-reactive protein (hs-CRP) is an acute-phase protein produced in the liver in response to inflammatory processes. Elevated hs-

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CRP levels have been shown to correlate with an increased risk for cardiovascular events, and the association with VTE has been investigated (8, 9). According to the meta-analysis conducted by Kunutsor et al. (2017), each one standard deviation increase in log-transformed CRP levels is associated with a 14% increased risk of VTE (5). Similarly, in the Atherosclerosis Risk in Communities (ARIC) study, it was found that individuals with CRP levels in the highest decile (≥ 8.55 mg/L) had a twofold increased risk of VTE as compared to those with lower levels (10). These findings support hs-CRP as a potentially useful biomarker for risk identification for VTE. Conversely, some studies have not found a significant association between hs-CRP levels and VTE risk. For instance, the Tromsø Study, a large population-based cohort study, concluded that hs-CRP was not associated with future development of VTE (6). These discrepancies may be due to differences in study design, population characteristics, and the timing of hs-CRP measurements relative to VTE events.

Bilirubin is an end product of heme degradation and has antioxidant and anti-inflammatory properties (11, 12). Lower serum bilirubin concentrations have been associated with higher oxidative stress and inflammation, both of which are contributory factors to thrombogenesis (13-15). Duman et al. (2019) found that patients with VTE had significantly lower levels of total bilirubin than healthy controls, which may be protective against thrombus formation. They also reported an independent association with bilirubin levels and VTE alongside hs-CRP concentrations and white blood cells in VTE, thus demonstrating the association between oxidative stress, inflammation, and thrombosis (11).

hs-CRP and bilirubin can potentially be known as VTE risk stratification factors. However, the inconsistencies in the literature highlight the need for further studies on these biomarkers and their contribution to the pathophysiology of VTE. Knowing the connection between these biomarkers and VTE may help with early detection, prevention strategies, and treatment for clinical VTE. The present study was designed to evaluate hs-CRP and serum bilirubin levels in patients with confirmed VTE and to characterise their distribution across the two primary VTE phenotypes (DVT vs. PTE) and demographic subgroups (age and gender). Given the cross-sectional design and the absence of a healthy control group, the objective was not to establish normative reference values but to generate descriptive, hypothesis-generating evidence on the distribution of these inflammatory and oxidative markers within the VTE patient population.

Methods

Study Design and Setting

The present cross-sectional study was conducted on patients admitted to the two centers affiliated with the

Mashhad University of Medical Sciences, Mashhad, Iran, including Imam Reza and Qaem Hospitals, from 2021 to 2022. Patients were recruited using a census sampling method, whereby all consecutive eligible patients admitted with a confirmed diagnosis of acute venous thromboembolism (deep vein thrombosis or pulmonary embolism) during the study period were included, provided they met the inclusion and exclusion criteria. During the study period, the patients who were admitted to our centers with clinical presentations of an acute venous thromboembolism (VTE) including: pulmonary embolism (PE) or deep vein thrombosis (DVT) were selected by census sampling method due to the following inclusion criteria: patients with confirmed PE on CT pulmonary angiography or lung ventilation perfusion scan, and patients with confirmed VTE on color duplex ultrasound study. However, individuals presenting with a medical history of hepatic, pancreatic, biliary, cardiac, and rheumatological disorders, active malignancies, antiphospholipid syndrome (APS), current active infections, and being under the medication with Phenobarbital and phenytoin, were excluded from our study.

The protocol of the current study was approved by the Research Ethics Committee of Mashhad University of Medical Sciences, Mashhad, Iran (Ref: IR.MUMS.MEDICAL.REC.1399.050). Written informed consent to participate was obtained from all of the participants.

Data collection

Patients' data, including demographic information (age and gender), laboratory data (Total and direct bilirubin, and High-Sensitivity C-reactive protein (hsCRP) levels), and the confirmed diagnosis of the patient (PE or DVT) were documented from each patient's medical records. Data were abstracted from medical records by the single trained investigator; a formal blinded dual-extraction procedure was not employed, which is acknowledged as a limitation of the study.

Laboratory measurements

Blood samples were obtained as part of routine clinical evaluation at the time of hospital admission, prior to initiation of anticoagulant or immunosuppressive therapy. Serum hs-CRP levels were measured using a high-sensitivity immunoturbidimetric assay, and total and direct bilirubin levels were determined using standard enzymatic colorimetric methods. All assays were performed in the central hospital laboratory using commercially available kits according to the manufacturer's instructions. The analytical performance of the assays complied with routine clinical laboratory quality control standards.

Statistical analysis

Although the study was carried out based on the census sampling method, the minimal sample size was calculated. Due to the Duman et al study (11), by considering the mean levels of bilirubin in patients with PE, the minimal required sample size was calculated as 40 patients.

Statistical analyses were conducted using SPSS v.21 for Windows (SPSS, Chicago, Illinois). Quantitative data were expressed as mean $\pm$ standard deviation (SD), while qualitative data were presented as frequency (percentage). To compare quantitative variables, an independent sample t-test was utilized, and the chi-square test was applied to qualitative variables. A P value of <0.05 was considered statistically significant. Given the limited sample size, multivariable regression analyses were not performed to avoid overfitting and unreliable parameter estimation.

The distribution of continuous variables was assessed prior to statistical analysis. Because hs-CRP, total bilirubin, and direct bilirubin exhibited non-normal distributions, these variables are presented as median and interquartile range (IQR), and comparisons between the DVT and PTE groups were performed using the Mann-Whitney U test. Age was approximately normally distributed and is presented as mean $\pm$ standard deviation (SD); comparisons between groups were performed using the independent-samples t-test. Categorical variables were analyzed using Fisher's exact test because of the relatively small sample size and the presence of expected cell counts below five. On the basis of Shapiro-Wilk testing, hs-CRP values were found to be non-normally distributed in both the DVT and PTE groups; accordingly, hs-CRP is reported as median (IQR) and analyzed using the Mann-Whitney U test in all tables and comparisons throughout this manuscript. Instead, hs-CRP levels were analyzed descriptively and categorized based on a clinically accepted cutoff of 10 mg/L, which is commonly used to indicate significant systemic inflammation (16). Continuous variables with non-normal distribution were analyzed using non-parametric methods.

Results

According to the study protocol, 40 patients who presented the inclusion criteria were studied. The studied population consisted of 15 males (37.5%) and 25 females (62.5%). The mean age of them was evaluated as 61.82 ± 17.12 years. The data revealed that the studied population included 12 (30%) patients with DVT, 26 (65%) patients with PTE, and 2 (5%) patients represented both PTE/DVT. Among the 26 PTE patients, 12 had thrombus in the main pulmonary artery ("main pulmonary artery PTE"), which is a subgroup of the PTE patients, not a separate study group. Despite the incidence rate of PTE and DVT being 66.7% and 33.4% in females, and 30.8% and 58.3% in males, respectively, there was no significant relationship between gender and diagnosis (95%CI=

0.32-1.43, $P=0.14$). Further analysis demonstrated that the mean age of patients with PTE and DVT was 66.8 ± 16.05 and 52.58 ± 16.89 years, respectively. In two patients diagnosed with both DVT/PTE, the mean age was 52.50 ± 3.53 years. Statistical analysis revealed a significant difference in age between the PTE and DVT patient groups, with the PTE group being older than the DVT group (95%CI= 52.09-65.24, $P=0.03$). Table 1 represents the sudden population demographic and laboratory data.

Table 1. Demographic and laboratory data of the studied population

Variable	Diagnosis		
	PTE	DVT	PTE/DVT
Age (year)	66.80 ± 16.05	52.58 ± 16.89	52.50 ± 3.53
Gender			
Female (%)	18 (69.20)	5 (41.7)	2 (100)
Male (%)	8 (30.8)	7 (58.3)	0
hs-CRP (mg/L)	4.1 ± 4.73	3.21 ± 3.17	3.89 ± 4.53
Total bilirubin (mg/dL)	0.91 ± 0.47	0.92 ± 0.38	0.90 ± 0.56
Direct bilirubin (mg/dL)	0.44 ± 0.25	0.34 ± 0.16	0.40 ± 0.28

There was no statistically significant relationship between gender and levels of total bilirubin (male: 0.8 ± 0.3 mg/dL, female: 0.9 ± 0.5 mg/dL, $P=0.2$), direct bilirubin (male: 0.4 ± 0.1 mg/dL, female: 0.4 ± 0.2 mg/dL, $P=0.5$), and hs-CRP (male: 3.2 ± 2.9 mg/L, female: 5.6 ± 4.6 mg/L, $P=0.3$). Table 2 demonstrates this relationship.

Table 2. Data on the relationship between gender and laboratory markers

Variable	Female (mean $\pm$ SD)	Male (mean $\pm$ SD)	P-value
Total bilirubin (mg/dL)	0.9 ± 0.5	0.8 ± 0.3	0.2
Direct bilirubin (mg/dL)	0.4 ± 0.2	0.4 ± 0.1	0.5
hs-CRP (mg/L)	5.6 ± 4.6	3.2 ± 2.9	0.3

hs-CRP levels were above the conventional reference range in the majority of patients. Specifically, only 20% of patients with DVT, 30% of those with PTE, and 20% of patients with PTE in the main artery had hs-CRP levels below 10 mg/L. When hs-CRP levels were evaluated using a clinically accepted cutoff of 10 mg/L, the majority of patients in both DVT and PTE groups demonstrated elevated hs-CRP values, reflecting a high inflammatory burden at presentation. However, no statistically significant difference was observed between VTE subtypes when hs-CRP was analyzed as a categorical variable. (Fisher's exact test, $P=0.48$) (Table 3)

Table 3. Distribution of patients according to hs-CRP clinical cutoff (10 mg/L)

Variable	DVT n (%)	PTE n (%)	P-value*
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<10 mg/L	2 (20)	8 (30)	0.48
≥10 mg/L	10 (80)	18 (70)	

* Fisher's exact test

Additional analysis in [Table 4](#) compared the levels of hs-CRP, total, and direct bilirubin in the studied population due to being a DVT or PTE patient. The data revealed that there is no significant relationship between these variables, while the significance levels (p-values) are reported as 0.746, 0.883, and 0.193 for hs-CRP, total, and direct bilirubin, respectively.

Due to non-normal distribution of hs-CRP values across DVT and PTE groups, these data are presented as median (IQR) and compared using the Mann-Whitney U test, unlike [Tables 1](#) and [2](#), which present mean ± SD.

Table 4. The comparison of the hs-CRP, total, and direct bilirubin in both DVT and PTE patients

Variable	DVT Median (IQR)	PTE Median (IQR)	P-value*
hs-CRP (mg/L)	26 (10.27-71.10)	18 (7-74)	0.746
Total bilirubin (mg/dL)	0.90 (0.62-1)	0.80 (0.55-1.15)	0.883
Direct bilirubin (mg/dL)	0.30 (0.20-0.50)	0.30 (0.30-0.60)	0.193

IQR= interquartile range / * Mann-Whitney U test

Discussion

The present study investigated the potential associations between hs-CRP, serum bilirubin levels, and the occurrence of venous thromboembolism (VTE), including its two primary clinical manifestations: deep vein thrombosis (DVT) and pulmonary thromboembolism (PTE). The data demonstrate that while hs-CRP levels were elevated in both DVT and PTE patients compared to normal levels, no statistically significant differences were observed in hs-CRP, total bilirubin, or direct bilirubin levels between the DVT and PTE groups. However, our findings contribute to the ongoing discourse regarding the role of inflammatory and oxidative stress markers in thrombotic pathophysiology.

Elevated hs-CRP levels, observed in the majority of our VTE patients, could align with the inflammatory theory of thrombogenesis. Inflammation is increasingly recognized as a contributor to venous thrombus formation, possibly by promoting endothelial dysfunction and pro-coagulant activity. Previous studies have shown elevated CRP levels in patients with cardiovascular disease and thromboembolic events, suggesting a shared inflammatory basis ([8](#), [10](#), [17](#)). In our study, only 20–30% of patients had hs-CRP levels below 10 mg/L, indicating a high inflammatory burden in VTE presentations. These results are consistent with the findings of Kunutsor et al., who reported a 14% increased risk of VTE for each standard deviation rise in CRP ([5](#)). Interestingly, despite elevated levels of hs-CRP, we did not observe

statistically significant differences between genders or between VTE subtypes, suggesting that hs-CRP alone may not be sufficient for differential risk stratification within the VTE spectrum. Additionally, the Tromsø study had previously investigated the predictive role of hs-CRP, suggesting that timing and patient selection could influence findings ([6](#)); However, our cross-sectional study, limited sample size, and single-point measurements may partly explain the absence of more robust associations.

In terms of serum bilirubin, our study did not find significant differences between PTE and DVT patients or between genders. However, it is important to contextualize these findings. Bilirubin, particularly in its unconjugated form, has demonstrated anti-inflammatory and anti-oxidative effects ([12](#), [14](#), [18](#)). These properties could theoretically confer vascular protection and reduce thrombotic risk. Duman et al. found lower bilirubin levels among VTE patients compared to normal individuals ([11](#)); a finding not entirely represented in our study, possibly due to the absence of a normal control group. The observed lack of statistical significance in bilirubin and hs-CRP variations between VTE subtypes may also be attributed to sample size limitations. Subtle pathophysiological differences between DVT and PTE may probably require greater sample sizes to detect. Additionally, both biomarkers may reflect broader systemic inflammation and oxidative stress without being specific to thrombus location or type.

Another important finding in our study is the age-related distribution of VTE subtypes. Patients with PTE were older than those with DVT, which may be reflective of more complex or delayed clinical courses leading to embolic events. Age has been previously associated with increased thrombotic risk, both due to physiological changes in hemostasis and increased exposure to comorbid conditions ([1](#), [19](#)). Gender distribution also suggested a higher prevalence of PTE in females and DVT in males in our sample, although the differences were not statistically significant. While hormonal factors, especially in premenopausal women or those on hormone replacement therapy, have been implicated in thrombosis risk, our study did not classify by such variables, limiting interpretability.

From a clinical viewpoint, the integration of hs-CRP and bilirubin into VTE risk assessment protocols remains uncertain. Their value may be more prominent in combination with other established risk factors or in longitudinal studies assessing recurrence or complication rates. Future research with larger sample sizes, control groups, and longitudinal follow-up is necessary to validate the predictive and diagnostic value of these

biomarkers.

Several limitations of the present study should be acknowledged. First, the cross-sectional design and relatively small sample size limited the ability to perform multivariable analyses and adjust for potential confounders such as body mass index, disease severity, timing of blood sampling, fasting status, medication use, and prior thromboembolic history. In addition, biomarker measurements were obtained at a single time point during acute presentation, which may reflect transient inflammatory responses rather than baseline levels. Consequently, the observed associations should be interpreted as descriptive and hypothesis-generating rather than causal. Another important limitation of this study is the significant difference in age between the DVT and PTE groups. Because age may influence systemic inflammatory markers and bilirubin metabolism, it represents a potential confounding factor in the comparison of biomarker levels between the two groups. Owing to the relatively small sample size and the limited number of patients within each subgroup, reliable multivariable age-adjusted analyses could not be performed without a substantial risk of model overfitting. Consequently, the observed comparisons of hs-CRP and serum bilirubin should be interpreted with caution, as it cannot be excluded that age-related differences may have influenced the results. Future studies with larger sample sizes are warranted to validate these findings using appropriately adjusted multivariable analyses. Our results should not be interpreted as evidence of underlying pathophysiological mechanisms or causal relationships between inflammatory biomarkers, bilirubin, and VTE phenotype. Rather, they represent observational findings within a single-center cohort and should be regarded as exploratory. Larger prospective studies with adequate statistical power and adjustment for relevant confounding variables are required to determine whether these biomarkers differ according to VTE phenotype and whether they have potential diagnostic or prognostic value.

Conclusion

In this cross-sectional study, no statistically significant differences in hs-CRP, total bilirubin, or direct bilirubin levels were observed between patients with DVT and those with PTE. These findings represent descriptive observations from a relatively small, single-center cohort and should be interpreted cautiously in light of the study's methodological limitations, including the limited sample size and the absence of multivariable adjustment for potential confounding factors. The present results do not support conclusions regarding the clinical utility of hs-CRP or serum bilirubin for risk stratification, diagnosis, or clinical decision-making in patients with venous thromboembolism. Rather, these findings should be considered hypothesis-generating and warrant confirmation in larger, prospective studies with appropriate adjustment for potential confounders.

Abbreviation list

- DVT: deep vein thrombosis
- VTE: venous thromboembolism
- PE: pulmonary embolism
- Hs-CRP: high-sensitivity C-reactive protein
- ARIC: Atherosclerosis Risk in Communities
- APS: antiphospholipid syndrome
- SD: standard deviation

Ethics approval and consent to participate

The protocol for conducting the present study was approved by the ethics committee of Mashhad University of Medical Sciences, Mashhad, Iran (IR.MUMS.MEDICAL.REC.1399.050). Written informed consent was obtained from all of the participants.

Consent for publication

All authors have provided consent for publication

Availability of data and materials

The data supporting this study's findings are available on request from the corresponding author. However, due to privacy or ethical restrictions, the data are not publicly available.

Competing interests

The authors have no competing interests to declare.

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Authors' contributions

Conducted the main idea of the study: M.M

Supervision: M.M

Data gathering: H.K

Data analysis: F.E

Drafting of the manuscript. All authors reviewed and accepted the manuscript: F.E, H.K, M.M and FR

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