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Evaluating the Relationship of Mean Platelet Volume and HbA1c with Diabetic Retinopathy in Adults with Diabetes

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Abstract
Diabetic retinopathy is a common microvascular complication of diabetes and a leading cause of vision impairment in adults. Early identification of biomarkers associated with its development and progression is critical for improving patient outcomes. Blood samples were collected to measure MPV and HbA1c levels using standardized laboratory techniques. The results indicated that adults with diabetic retinopathy had significantly higher mean MPV (11.2 ± 0.9 fL) and HbA1c (8.4% ± 1.1%) compared to those without retinopathy (MPV: 10.2 ± 0.7 fL; HbA1c: 7.1% ± 0.8%; $p < 0.001$). Further stratification revealed a positive correlation between both MPV and HbA1c levels with the severity of retinopathy, with proliferative stages demonstrating the highest values. Multivariate regression analysis confirmed that elevated MPV and poor glycemic control were independent predictors of retinopathy, even after adjusting for age, diabetes duration, and blood pressure. These findings suggest that routine monitoring of MPV and HbA1c may provide valuable clinical insight into the risk and progression of diabetic retinopathy. Integrating these hematologic and glycemic markers into regular diabetic care could facilitate earlier intervention and reduce the burden of vision loss in affected individuals.

Keywords: Diabetic retinopathy, Mean platelet volume, Glycated hemoglobin, Type 2 diabetes, Biomarkers, Microvascular complications, Glycemic control

Introduction

The pathogenesis of diabetic retinopathy is multifactorial and involves chronic hyperglycemia, oxidative stress, inflammation, and platelet dysfunction. Chronic hyperglycemia leads to the formation of advanced glycation end-products, vascular endothelial damage, and capillary basement membrane thickening, all of which contribute to retinal microangiopathy.

In addition to hyperglycemia, platelet dysfunction has emerged as a critical factor in the development of diabetic microvascular complications. Mean platelet volume (MPV), an indicator of platelet size and activity, reflects platelet aggregation potential and thrombogenicity. Elevated MPV is associated with enhanced platelet activation and increased risk of vascular complications in diabetes. Several studies have suggested that higher MPV values correlate with the presence and severity of diabetic retinopathy, indicating its potential as a hematological biomarker for early detection and risk stratification.

Despite the recognized importance of HbA1c and MPV individually, there is limited comprehensive research evaluating the combined relationship of these markers with diabetic retinopathy. Understanding this relationship is particularly relevant in clinical settings, where identifying reliable and easily measurable predictors can facilitate early intervention and reduce the burden of vision loss. This is especially critical in populations with high diabetes prevalence and limited access to advanced ophthalmologic care, where simple biomarkers may guide timely referral and management.

The present study aims to investigate the relationship between MPV, HbA1c, and the presence and severity of diabetic retinopathy in adults with diabetes. By analyzing these hematologic and glycemic parameters, the study seeks to determine whether they can serve as practical indicators of DR risk and progression. Such insights may improve clinical decision-making, allowing healthcare providers to implement preventive strategies, optimize glycemic control, and closely monitor patients at higher risk of retinal complications.

In summary, diabetic retinopathy represents a major public health challenge with significant implications for visual health and quality of life. The identification of simple, reliable biomarkers such as MPV and HbA1c could transform the approach to early detection and management. This study addresses a critical gap in current research by exploring the combined predictive value of these markers, providing an evidence-based foundation for improving patient outcomes and reducing the societal burden of diabetes-related visual impairment.

Methods

Quality Control and Ethical Considerations

All laboratory analyses were performed in a certified laboratory following standardized protocols. Ophthalmologic examinations were conducted by experienced clinicians blinded to the patients' laboratory results to reduce observer bias. Participant confidentiality was maintained throughout the study, and data were anonymized for analysis. Adverse events related to blood sampling or ophthalmologic examination were monitored and managed according to standard clinical guidelines.

Limitations of the Methods

While the cross-sectional design allows identification of associations between MPV, HbA1c, and DR, it does not

establish causality. Variations in pre-analytical factors, such as time between sample collection and analysis for MPV, may influence results. Additionally, hospital-based recruitment may limit generalizability to community-dwelling individuals with diabetes.

Results

Prevalence and Severity of Diabetic Retinopathy

Among the study population, 138 participants (55.2%) were found to have diabetic retinopathy, while 112 participants (44.8%) had no evidence of retinopathy. Among those with DR, the distribution of severity was as follows: mild non-proliferative DR in 52 participants (37.7%), moderate non-proliferative DR in 48 participants (34.8%), severe non-proliferative DR in 22 participants (15.9%), and proliferative DR in 16 participants (11.6%). The remaining 112 participants exhibited no signs of retinopathy.

Mean Platelet Volume (MPV) and Diabetic Retinopathy

The mean MPV for participants with diabetic retinopathy was 11.2 ± 0.9 fL, which was significantly higher than the mean MPV of 10.2 ± 0.7 fL observed in participants without DR ($p < 0.001$). When stratified by DR severity, MPV values increased progressively: mild NPDR (10.8 ± 0.8 fL), moderate NPDR (11.1 ± 0.7 fL), severe NPDR (11.5 ± 0.6 fL), and proliferative DR (11.9 ± 0.8 fL). The differences in MPV across severity groups were statistically significant ($p < 0.001$), indicating a positive association between platelet volume and retinopathy severity (Table 2).

Glycated Hemoglobin (HbA1c) and Diabetic Retinopathy

The mean HbA1c in participants with DR was 8.4% ± 1.1%, compared to 7.1% ± 0.8% in participants without DR ($p < 0.001$). Stratification by severity revealed an increasing trend: mild NPDR (7.9% ± 0.9%), moderate NPDR (8.3% ± 0.8%), severe NPDR (8.8% ± 0.9%), and proliferative DR (9.2% ± 1.0%), with statistically significant differences between groups ($p < 0.001$).

Subgroup Analysis by Diabetes Duration

Participants were stratified into three groups based on diabetes duration: ≤5 years (n = 78), 6–10 years (n = 102), and >10 years (n = 70). The prevalence of DR increased with longer diabetes duration: 28.2% in ≤5 years, 57.8% in 6–10 years, and 82.9% in >10 years. Both MPV and HbA1c levels showed an increasing trend with longer diabetes duration, reflecting progressive metabolic and hematologic changes associated with chronic hyperglycemia (Table 3).

Combined MPV and HbA1c Analysis

Participants were categorized into four groups based on MPV (high vs. low) and HbA1c (≥8% vs. <8%). The group with high MPV and HbA1c ≥8% exhibited the highest prevalence of DR (85%), while participants with low MPV and HbA1c <8% had the lowest prevalence (22%). This stratified analysis highlighted the potential synergistic effect of elevated MPV and poor glycemic control on retinopathy risk.

Discussion

The present study aimed to evaluate the relationship between mean platelet volume (MPV), glycated hemoglobin (HbA1c), and the presence and severity of diabetic retinopathy (DR) in adults with type 2 diabetes. The findings demonstrate significant associations between both MPV and HbA1c levels and DR, indicating that these markers may serve as valuable indicators of retinal microvascular damage and disease progression. This discussion will contextualize these results, compare them with previous research, explore potential pathophysiological mechanisms, and consider clinical implications and limitations.

Association Between MPV and Diabetic Retinopathy

In this study, participants with DR exhibited significantly higher MPV compared to those without DR, and MPV increased progressively with the severity of retinopathy. These results align with prior research suggesting that platelet activation plays a critical role in the pathogenesis of diabetic microvascular complications. Elevated MPV reflects larger, more reactive platelets, which possess greater pro-thrombotic potential and can contribute to endothelial dysfunction. In the context of diabetes, chronic hyperglycemia induces oxidative stress and inflammation, which in turn promotes platelet activation. The observed positive correlation between MPV and DR severity suggests that increased platelet reactivity may exacerbate retinal capillary damage, leading to progression from non-proliferative to proliferative stages of the disease.

The independent predictive value of MPV, as demonstrated in the multivariate analysis, underscores its potential as a simple hematological biomarker for DR risk assessment. Unlike more complex retinal imaging techniques, MPV can be measured readily in routine blood tests, making it a cost-effective tool, particularly in resource-limited settings. Furthermore, the stratified analysis showing higher DR prevalence among participants with elevated MPV and longer diabetes duration supports the hypothesis that chronic platelet activation contributes cumulatively to microvascular damage over time.

Association Between HbA1c and Diabetic Retinopathy

The study also demonstrated a strong association between HbA1c and both the presence and severity of DR. Participants with higher HbA1c levels were significantly more likely to exhibit DR, and HbA1c increased with worsening disease severity. This finding is consistent with the established role of chronic hyperglycemia as a primary driver of microvascular complications in diabetes. Elevated HbA1c reflects poor long-term glycemic control, which promotes the formation of advanced glycation end-products (AGEs), thickening of the capillary basement membrane, and endothelial dysfunction—all key mechanisms in the pathogenesis of DR.

Moreover, the combination of high MPV and elevated HbA1c appeared to confer the highest risk of DR, suggesting a synergistic effect of platelet activation and poor glycemic control. This interaction may indicate that individuals with both metabolic dysregulation and increased platelet reactivity are particularly susceptible to retinal

microvascular injury, highlighting the need for integrated monitoring and management strategies.

Comparison with Previous Studies

Similarly, multiple large-scale cohort studies have confirmed that HbA1c is a strong predictor of DR incidence and progression. However, few studies have simultaneously examined the combined effects of MPV and HbA1c on DR, and this study contributes novel evidence regarding their joint predictive value. By demonstrating that both markers independently and synergistically correlate with DR, this study adds to the understanding of the multifactorial pathogenesis of diabetic microvascular complications.

Pathophysiological Implications

The findings of this study support the concept that both metabolic and hematologic factors contribute to the development of diabetic retinopathy. Chronic hyperglycemia promotes oxidative stress, inflammation, and endothelial dysfunction, while platelet hyperactivity, as reflected by elevated MPV, may exacerbate vascular damage through microthrombus formation and increased blood viscosity. These mechanisms likely act in concert, amplifying retinal microvascular injury and accelerating disease progression. Clinically, this suggests that interventions targeting both glycemic control and platelet activity may be effective in reducing the risk or severity of DR.

Clinical Implications

The identification of MPV and HbA1c as independent predictors of DR has practical significance. Routine measurement of MPV alongside HbA1c could facilitate early identification of patients at higher risk of developing retinopathy, enabling timely referral to ophthalmologic services and closer monitoring. Moreover, integrating MPV into risk stratification models may improve prognostic accuracy and inform individualized therapeutic approaches. For example, patients with elevated MPV and poor glycemic control may benefit from intensified glycemic management, lifestyle interventions, and consideration of antiplatelet strategies under clinical supervision.

Future Research Directions

Future studies should adopt longitudinal designs to assess the temporal relationship between MPV, HbA1c, and DR progression. Investigating the role of interventions that reduce platelet activation, in combination with optimal glycemic control, could clarify whether these markers are modifiable risk factors. Additionally, multicenter studies with larger, more diverse populations would enhance the generalizability of findings and facilitate development of predictive models for clinical use. Research exploring the molecular mechanisms linking platelet hyperactivity and hyperglycemia to retinal microvascular injury could further elucidate the pathophysiology of DR and identify novel therapeutic targets.

Conclusion

This study demonstrated a significant relationship between mean platelet volume (MPV), glycated hemoglobin (HbA1c), and diabetic retinopathy (DR) in adults with type 2 diabetes. Participants with DR exhibited higher MPV and HbA1c levels compared to those without retinopathy, and both markers increased progressively with disease severity. Multivariate analysis confirmed that elevated MPV and poor glycemic control were independent predictors of DR, while combined elevation of both markers was associated with the highest prevalence of retinopathy. These findings highlight the interplay between hematologic and metabolic factors in the development and progression of DR.

The results underscore the potential clinical utility of MPV and HbA1c as accessible and cost-effective markers for early identification of patients at increased risk of DR. Integrating these parameters into routine diabetes management may facilitate timely ophthalmologic assessment and targeted interventions, ultimately helping to reduce the burden of vision-threatening complications. Further longitudinal studies are warranted to establish causality, assess the predictive value of these markers over time, and explore whether therapeutic strategies targeting platelet activity alongside optimal glycemic control can mitigate the progression of diabetic retinopathy.

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