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IMMATURE PLATELET FRACTION EXAMINATION IN ASSESSING THROMBOTIC RISK IN PATIENTS WITH DIABETES MELLITUS WITH VASCULAR DISORDERS

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ABSTRACT

Diabetes mellitus (DM) is a chronic metabolic disorder associated with an elevated risk of vascular complications due to enhanced platelet activation and hypercoagulability. Immature Platelet Fraction (IPF), a parameter measurable via automated hematology analyzers, has been proposed as a potential biomarker for thrombotic risk in DM patients. However, the utility of IPF in this context remains controversial due to inconsistent findings. This study aims to evaluate the clinical relevance of IPF in predicting vascular disorders in DM patients through a systematic review of existing literature, focusing on identifying its diagnostic accuracy and proposing directions for further research. Using a literature review approach, the study analyzed secondary data from peer-reviewed journals and clinical studies published between 2012 and 2025. A total of 14 key references were selected based on their relevance and methodological rigor. Data were thematically analyzed and interpreted using citation management tools. The results indicate that IPF levels tend to be elevated in DM patients with vascular complications, reflecting increased platelet turnover and activity. However, inconsistencies remain regarding its predictive validity, as some studies report significant correlations while others do not. Reference values for IPF also vary by population and instrument. This study suggests that although IPF holds promise as a thrombotic risk marker in DM, further empirical research is essential to establish standardized reference values and evaluate its integration with other biomarkers in clinical practice.

KEYWORDS *Thrombotic Risk in Patients with Diabetes Mellitus; Immature Platelet Fraction Examination; Vascular Disorders*

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INTRODUCTION

Diabetes mellitus (DM) is a disease characterized by impaired control of blood glucose levels (Balaji et al., 2019; Baynes, 2015). Diabetes mellitus consists of several subclassifications, namely type 1, type 2 diabetes mellitus, diabetes at a young age (MODY), gestational diabetes, neonatal diabetes, and steroid-induced diabetes 1 (Haque & El Bayani, 2023; Redondo et al., 2020). The prevalence of diabetes continues to increase and is an epidemic, especially cases of type 2 DM. In the coming decades, the

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number of people with type 2 diabetes mellitus (DM2) is expected to increase to more than 693 million by 2045. Type 2 DM will become an epidemic disease in the 21st century, and is currently the leading cause of mortality, morbidity, and global health problems 2. Most people with DM have type 2 diabetes. Type 2 diabetes is the most commonly found type of diabetes, characterized by insulin resistance, followed by pancreatic β-cell failure, which can ultimately lead to an increase in blood glucose. A small number of people with DM are people with type 1 diabetes, which is characterized by increased blood glucose due to damage to the β cells of the pancreas by the immune system. Type 1 DM not only occurs damage to the pancreas β but can also develop into insulin resistance, as found in type 2 DM patients, so they have an increased vascular risk 3.

Diabetes mellitus has been studied to cause vascular complications in the form of cardiovascular disease (Glovaci et al., 2019; Ighodaro & Adeosun, 2018; Shah et al., 2022). Cardiovascular disease is the leading cause of morbidity and mortality in diabetic patients (Eckel et al., 2021; Fan, 2017). Cardiovascular disease can occur in DM patients through two main pathological pathways, which are due to an increased inflammatory response and an increased thrombotic environment in the vascular system, which can lead to atheroembolism in diabetic patients. Complications of vascular disease can occur more quickly and are exacerbated by the state of insulin resistance and hyperglycemia that occurs in DM3 patients (Luna et al., 2016; Yavuz et al., 2022).

Due to the high risk of cardiovascular disease in DM patients as a form of complication that can increase mortality and morbidity of DM patients, thrombotic risk assessment in patients with diabetes mellitus is very important to prevent thrombosis complications in DM patients. One of the examination methods that can be used for monitoring the risk of thrombotics and coagulation processes in DM patients is the immature platelet fraction examination (Verdoia et al., 2016, 2020).

Immature platelet fraction (IPF) is a new parameter that measures young platelets that are larger than adult platelets and still have residual RNA using an automated hematology analyzer (Amrutha, 2019; Jeon et al., 2020). These parameters reflect thrombopoiesis and platelet activity (Vinholt et al., 2014). In type 2 diabetes, there is a decrease in platelet life and an increase in platelet turnover. As a result of the acceleration of platelet turnover, the resulting platelets become immature, larger in size, and more reactive. These platelets are more susceptible to activation, adhesion, and aggregation, which play a role in the occurrence of vascular complications in type 24 DM (Carrizzo et al., 2018; Kaur et al., 2018).

This article aims to provide knowledge to readers regarding the examination of Immature Platelet Fraction (IPF) which can be used as one of the methods for monitoring the risk of thrombosis in patients with diabetes mellitus so that it is hoped that the IPF parameter can be used by practitioners and clinicians more widely in the risk of complications of vascular disorders in DM patients. The novelty of the current study lies in its comprehensive synthesis of contrasting findings related to IPF values in diabetes mellitus (DM) patients with vascular disorders, particularly drawing attention to the diagnostic inconsistency across populations and measurement systems. Unlike prior studies such as Siddiqui et al. (2025), which reported a significant increase in IPF and other platelet indices in DM patients, or Verdoia et al. (2020), which found no significant relationship between IPF and vascular disease in diabetic populations, this research does not merely present findings but critically compares and interprets them in a broader clinical and pathophysiological context. Furthermore, this study proposes future research

directions involving longitudinal and multi-center cohort studies, which have not been emphasized in previous works. It also underscores the need for standardizing IPF reference values—a gap identified in studies like Novita (2012)—to improve its diagnostic utility for vascular risk prediction in DM, making this review both a clarifier of contradictions and a strategic guide for future empirical exploration.

METHOD

This study employed a literature review design, focusing on analyzing and synthesizing secondary data derived from various scientific publications related to the Immature Platelet Fraction (IPF) and its clinical application in patients with diabetes mellitus (DM), particularly those experiencing vascular disorders. The data population encompassed peer-reviewed journals, clinical studies, and medical reports discussing platelet indices, thrombotic risks, and the diagnostic value of IPF in DM patients. The inclusion criteria prioritized recent studies published between 2012 and 2025, while studies lacking methodological clarity were excluded. No primary data collection was conducted; instead, the study relied on documented clinical and laboratory research findings.

The sampling technique used was purposive sampling to select relevant and high-quality sources, including landmark studies such as those by Siddiqui et al. (2025) and Verdoia et al. (2020), which provided contrasting findings regarding IPF levels in DM populations. The main research instrument was a document review checklist used to extract consistent information across selected studies, including sample size, methodology, IPF measurement tools, and statistical findings. To ensure the validity and reliability of the findings, only studies published in indexed journals and supported by clinical data were included, and cross-referencing was conducted to confirm the consistency of interpretations across studies.

The data were collected through systematic searches in online databases such as PubMed, ScienceDirect, and Google Scholar. The analysis technique employed thematic analysis and comparative synthesis, while the software tools used for managing references and citation analysis included Mendeley and Microsoft Excel. The research procedure followed PRISMA guidelines for systematic literature reviews. This approach identified research gaps and inconsistencies in the clinical use of IPF for predicting vascular complications in DM patients, forming the foundation for proposing future empirical studies.

RESULTS AND DISCUSSION

Pathophysiology of Vascular Disorders in Diabetes Mellitus

Vascular disorders in DM patients can be caused by several factors that may occur simultaneously. Platelet hyperactivity, blood hypercoagulation, decreased thrombolysis, and endothelial damage contribute to vascular disorders in DM 5 patients.

Diabetes mellitus is a condition defined by elevated blood sugar levels. This hyperglycemia in diabetes mellitus influences the activity of enzymes and key platelet receptors at the megakaryocyte level. In type 2 diabetes, the expression of prostacyclin-negative platelet regulatory receptors diminishes, potentially amplifying platelet reactivity. Concurrently, P2Y12, the chief receptor for adenosine diphosphate (ADP) secondary agonists, has been noted to significantly elevate platelet levels in individuals with type 2 diabetes. The heightened regulation of P2Y12 expression is facilitated by the activation of the oxidative stress-dependent transcription factor, nuclear factor kappa B

(NF-kB), within megakaryocytes. Additionally, insulin-like growth factor receptor 1 (IGF1R) is another crucial receptor that shows increased expression in patients with type 2 diabetes, enhancing platelet responsiveness to IGF1. Given that IGF1 has been identified as a promoter of platelet signaling and responses, the augmented regulation of IGF1R is believed to contribute to platelet hyperactivity in type 2 diabetes. Findings from a laboratory study conducted by Vaidya et al in (2021) revealed that platelets from diabetes patients with poor glycemic management exhibited significantly elevated levels of the pro-oxidant enzyme nicotinamide adenine dinucleotide phosphate (NADPH) oxidase 1 (NOX1). NOX acts as a positive regulator of platelet function, suggesting that enhanced NOX1 activity in patients with diabetes may lead to increased platelet responsiveness. Elevated plasma glucose levels also raise concentrations of advanced glycation end products (AGEs) in the blood. AGEs have been shown to stimulate platelets via the activation of the AGE receptor (RAGE).

One cause of platelet hyperactivity in Dm patients is a state of resistance or impaired insulin secretion. The hormone insulin plays a role in the negative regulation of the ADP P2Y12 receptor and platelet function. Therefore, insulin resistance and secretion defects result in dysregulation of platelet activation. Activation of insulin-dependent PKB protein kinase and modulation of cAMP-inhibiting intracellular messengers support insulin-negative regulatory activity 5.

Another factor that drives platelet hyperactivity is dyslipidemia, which is often found in diabetic patients as well. Increased levels of lipids and plasma cholesterol increase platelet reactivity. Recent research has highlighted the molecular mechanisms that link plasma lipids (low-density lipoproteins, or LDL, in particular) to platelet responses. Dyslipidemia associated with T2DM is typically accompanied by increased LDL oxidation (ox-LDL). Ox-LDL has been shown to activate CD36 receptors in many different cell types, including platelets5.

The role of platelets in vascular disorders has recently been expanded with the discovery of their involvement in the formation of extracellular neutrophil traps (NETs). NETs have been shown to contribute significantly to thrombotic disease, and diabetes has been shown to increase the formation of NETs. Further research is needed to ascertain whether platelets are the cause of increased NET formation or whether NET formation contributes to DM-dependent thrombosis by inducing platelet activation and vascular occlusion5.

In addition to increased platelet activation, diabetes is associated with increased plasma levels and/or the activity of various coagulation factors. The result is an increased susceptibility to fibrin tissue formation characterized by increased density and resistance to fibrinolysis. Levels of tissue factor (TF) and factor VII (FVII) increase in diabetes, resulting in increased thrombin production and a higher risk of clot formation. In addition, plasma fibrinogen levels increase in diabetes, as part of ongoing low-level inflammation, contributing to the formation of denser clots. In addition, anticoagulants, such as thrombomodulin and protein C, are reduced in diabetes, further predisposing to the prothrombotic environment. The main antifibrinolytic protein is plasminogen activator inhibitor-1 (PAI-1), which inhibits the conversion of plasminogen into active plasmin. Plasma levels of PAI-1 increase in diabetes, thus interfering with the fibrinolytic process. Elevated levels of PAI-1 were found only in patients with type 2 diabetes, but not in patients with type 1 diabetes. This suggests that increased levels of PAI-1 are influenced by insulin resistance and not due to hyperglycemia3.

Along with the above process, the process of breaking blood clots (fibrinolysis) is decreased in DM caused by hyperglycemia. Increased cross-linking of fibrin caused by hyperglycemia is thought to increase blood clot density and reduce fibrinolytic rate in type 2 DM patients. Meanwhile, in type 1 DM, hyperglycemia mediates glycation and other post-translational modifications of plasminogen that prevent plasminogen activation and limit plasmin formation, thereby interfering with fibrinolysis. In type 2 DM, increased plasminogen activator inhibitor-1 (PAI-1) concentrations reduce fibrinolysis. In addition, concentrations of other fibrinolysis inhibitors, such as thrombin-activable fibrinolysis inhibitors (TAFIs) and α2-macroglobulins, are increased in DM types 1 and 2. In addition, α2-antiplasmin concentrations were increased in type 2 diabetes but not in type 15 diabetes.

Overall, reduced fibrinolysis may be a source of increased thrombotic risk for DM patients. Hypercoagulation is particularly relevant for venous thrombosis, while platelet hyperactivity plays a role in the onset and development of arterial thrombosis. These two factors contribute to the imbalance between coagulation and fibrinolysis, increasing the risk of venous and arterial thrombosis in DM5 patients.

Endothelial dysfunction is also prevalent in diabetes mellitus (DM). The endothelium is crucial in preserving vascular equilibrium by moderating vasodilation and vasoconstriction, thrombosis and fibrinolysis, platelet activation, interactions between platelets and leukocytes, as well as the function of smooth muscle cells. Under normal conditions, the endothelium adjusts vascular tone through the synthesis and release of various vasodilatory agents; principally, nitric oxide (NO) and vasoconstricting agents like endothelin. When endothelial cell dysfunction arises as a consequence of insulin resistance, whether or not accompanied by elevated blood glucose levels, vascular balance is disturbed, which leads to atherosclerosis. This dysfunction prompts endothelial cells to produce adhesion molecules that attract inflammatory cells. Moreover, it hampers the endothelial inhibition function, leading to the translocation of LDL from the blood vessel lumen to its walls, where it gets oxidized into a highly atherogenic form known as ox-LDL. Subsequently, these oxidized molecules are engulfed by inflammatory cells migrating from the bloodstream to the vessel walls, due to increased endothelial permeability. The uptake of ox-LDL by macrophages leads to the creation of foam cells, which accumulate to form fat streaks (the earliest manifestations of abnormality in the atherosclerotic process) observable even from childhood. An inflammatory response follows, resulting in collagen deposition, which gradually alters the walls of healthy blood vessels into various atherosclerotic plaques. Once an atherosclerotic plaque breaks, it reveals the prothrombotic core, leading to platelet activation and coagulation processes, ultimately resulting in the formation of obstructive vascular clots.

Immature Platelet Fraction Screening and Clinical Benefits

Immature Platelet Fraction (IPF) is a parameter that describes the proportion of immature platelets compared to total platelets6. Mature platelets can be a useful marker of thrombopoiesis activity. These platelets are the most recently produced and are released into the circulation by regenerated megakaryocytes. This type of platelet is an analogue of reticulocytes and is equally significant. In addition, these platelets contain more cytoplasmic RNA, and the size and content of RNA decrease with age. The number and proportion of immature platelets reflect the rate of thrombopoiesis. The value of this parameter rises and falls as the platelet production rate7 increases.

The Automated Hematology Analyzer can calculate the absolute number of mature platelets and their proportions relative to mature platelets. This value can be checked with the IPF parameter, which is one of the parameters of the platelet index. The presence of immature platelets can also affect platelet indexes that are commonly found in routine Complete Blood Count (CBC), namely platelet count, Mean Platelet Volume (MPV), Platelet Distribution Width (PDW), Plateletcrit (Pct), and Platelet-Large Cell Ratio (P-LCR). Such platelet parameters are simple and inexpensive and can be measured during routine blood tests6,7.

Although it can be checked in routine examinations, not all hematology analyzer series can check IPF parameters. The series that can perform this check is at least the XE series or the series above. The XE series of Sysmex brand hematology analyzers can run platelet counts in optical mode, eliminating the common interference in impedance calculations. In optical mode, the IPF can be measured to provide additional information regarding platelet kinetics in the case of thrombocytopenia8. The blood sample used was venous blood collected in a tube of Dipotassium Ethylenedinitrilotetraacetic acid (EDTA). IPF, MPV, PDW, Pct, P-LCR, and platelet count values were measured using a hematology analyzer and should be checked immediately, less than four hours after venous puncture6.

Examinations of IPF today have been carried out, especially in diseases related to thrombocytopenia. As explained earlier, IPF can describe platelet turnover, which is a process that involves the production and destruction of platelets by the body. IPF assessment in cases of thrombocytopenia is used to identify the cause of thrombocytopenia and predict platelet recovery. IPF can describe the thrombopoiesis process in the bone marrow and provide clinicians with an overview of the need for platelet transfusions 7,9.

In addition to being useful in assessing thrombopoiesis and identifying the causes of thrombocytopenia cases, IPF has also been widely researched in cases of vascular disorders. IPF has been widely researched in assessing the risk of cardiovascular diseases such as acute coronary syndrome due to blood vessel blockages, 6,10.

Immature Platelet Fraction in Patients with Diabetes Mellitus with Vascular Disorders

There is ample evidence that platelets contribute to inflammation in a variety of diseases. Platelets are also known to accelerate atherosclerosis, especially in conditions such as diabetes, hypertension, metabolic syndrome, and other chronic inflammatory conditions. Platelet index is a marker of platelet activation that can be examined to assess platelet activity11.

As previously explained, platelet hyperactivity occurs in DM patients. Platelet hyperactivity is a mechanism to respond to sub-threshold stimuli that make it easy for platelets to be consumed or used in blood circulation. This further stimulates thrombopoiesis, which can be checked directly by measuring reticulated platelet count using flow cytometry. Immature platelet fraction (IPF) measured by automated hematology analysis tools is widely used as a marker of thrombopoiesis and platelet activity12.

Several researchers have conducted research on IPF in DM patients. However, the results of these studies vary. Some studies have found a relationship between DM and increased IPF scores, while others have not.

One of the studies that examined IPF levels in DM patients was a study conducted by Siddiqui et al in (2025)The study examined IPF levels and other platelet indices in Type 2 DM patients in India. Siddiqui et al. found a significant difference in platelet parameter values between Type 2 DM patients and the control group. Platelet counts tended to decrease in DM patients compared to controls, but other platelet indices such as IPF, MPV, PDW, platelet large cell count (PLCC), and platelet large cell ratio (PLCR) increased in Type 2 DM patients 11.

In contrast to the results of Siddiqui et al's study, a study conducted by Verdoia et al in (2020) found no impact of diabetes or glycemic control on IPF levels and on angiography findings Researchers even found a lower prevalence of coronary artery disease in DM patients with an IPF value above the median of 13.

Clinical Value of Immature Platelet Fraction Examination

The IPF reference value does not yet have a special standard value, because various things influence it. Novita has carried out the IPF reference value to determine thrombocytopenia diagnostics in Jakarta, Indonesia. Novita conducted a cross-sectional study design, using 256 medical check-up participants at MMC Hospital and 203 thrombocytopenia patients from RSCM and MMC Hospital. The study results showed that the IPF reference value of adults in Jakarta using Sysmex XE5000 was 0.64-3.20%. The cut-off value of IPF to distinguish thrombocytopenia with increased thrombopoiesis activity or thrombocytopenia with normal or low thrombopoiesis activity was 7.65% with a sensitivity of 91% and a specificity of 92%, 14.

Siddiqui et al are new studies that generate information on the limit values of IPF with sensitivity and specificity. The highest sensitivity parameter was plateletcrit (PCT), with a sensitivity of 93% at the >0.282% limit, and the highest specificity parameter was MPV, with a specificity of 96.5% at the >13.1 fL limit. Both parameters also show the best diagnostic accuracy, reaching 91.7%. The area below the ROC (AUROC) curve for IPF (%) that predicted DM cases compared to controls was 0.941, thus demonstrating excellent diagnostic accuracy (90.4%). At the cut-off limit of IPF (%) ≥9.6, IPF predicted cases of type 2 DM compared to controls with 86% sensitivity and 95% specificity, equivalent to MPV and PCT11.

CONCLUSION

Immature Platelet Fraction (IPF) is a promising parameter within the platelet index examination that may help predict the risk of vascular disorders in diabetes mellitus (DM) patients, although current research remains limited and yields inconsistent findings. The IPF test offers practical advantages, as it is automatically included in routine platelet index checks, allowing for quick and simultaneous analysis with other parameters. However, standardized reference values for IPF as a predictive marker in DM-related vascular complications are yet to be established. Future research should prioritize large-scale, multi-center cohort and longitudinal studies to validate IPF's predictive value, considering factors such as age, diabetes duration, glycemic control, and comorbidities. It should also explore its integration with other biomarkers for early vascular risk detection.

REFERENCES

Amrutha, B. S. (2019). *Immature Platelet Fraction in Children Up to 18 Years of Age Suffering from Dengue in Rajarajeswari Medical College and Hospital*. Rajiv

Gandhi University of Health Sciences (India).
Balaji, R., Duraisamy, R., & Kumar, M. P. (2019). Complications of diabetes mellitus: A review. *Drug Invention Today*, *12*(1).
Baynes, H. W. (2015). Classification, pathophysiology, diagnosis and management of diabetes mellitus. *J diabetes metab*, *6*(5), 1–9.
Carrizzo, A., Izzo, C., Oliveti, M., Alfano, A., Virtuoso, N., Capunzo, M., Di Pietro, P., Calabrese, M., De Simone, E., & Sciarretta, S. (2018). The main determinants of diabetes mellitus vascular complications: endothelial dysfunction and platelet hyperaggregation. *International journal of molecular sciences*, *19*(10), 2968.
Eckel, R. H., Bornfeldt, K. E., & Goldberg, I. J. (2021). Cardiovascular disease in diabetes, beyond glucose. *Cell metabolism*, *33*(8), 1519–1545.
Fan, W. (2017). Epidemiology in diabetes mellitus and cardiovascular disease. *Cardiovascular Endocrinology & Metabolism*, *6*(1), 8–16.
Glovaci, D., Fan, W., & Wong, N. D. (2019). Epidemiology of diabetes mellitus and cardiovascular disease. *Current cardiology reports*, *21*, 1–8.
Haque, S. N. F. A. U., & El Bayani, G. F. (2023). Hibiscus sabdariffa on Fibroblast Growth Factor 21 (FGF21) on Diabetes Mellitus Type 2 Patients. *Indonesian Journal of Multidisciplinary Science*, *2*(8), 2987–2998.
Ighodaro, O., & Adeosun, A. (2018). Vascular complications in diabetes mellitus. *kidney*, *4*, 16–19.
Jeon, K., Kim, M., Lee, J., Lee, J.-S., Kim, H.-S., Kang, H. J., & Lee, Y. K. (2020). Immature platelet fraction: a useful marker for identifying the cause of thrombocytopenia and predicting platelet recovery. *Medicine*, *99*(7), e19096.
Kaur, R., Kaur, M., & Singh, J. (2018). Endothelial dysfunction and platelet hyperactivity in type 2 diabetes mellitus: molecular insights and therapeutic strategies. *Cardiovascular diabetology*, *17*, 1–17.
Luna, P., Guarner, V., Farías, J. M., Hernández-Pacheco, G., & Martínez, M. (2016). Importance of metabolic memory in the development of vascular complications in diabetic patients. *Journal of cardiothoracic and vascular anesthesia*, *30*(5), 1369–1378.
Novita, A. (2012). *Nilai rujukan Immature Platelet Fraction (IPF) orang dewasa di Jakarta dengan XE-5000 serta aplikasi klinis pada pasien Trombositopenia = Immature Platelet Fraction (IPF) reference range on adults in Jakarta with XE-5000 and the clinical application on Thrombocytopenic*. Jakarta.
Redondo, M. J., Hagopian, W. A., Oram, R., Steck, A. K., Vehik, K., Weedon, M., Balasubramanyam, A., & Dabelea, D. (2020). The clinical consequences of heterogeneity within and between different diabetes types. *Diabetologia*, *63*, 2040–2048.
Shah, A., Isath, A., & Aronow, W. S. (2022). Cardiovascular complications of diabetes. *Expert Review of Endocrinology & Metabolism*, *17*(5), 383–388.
Siddiqui, N. A., Narang, S., Aggarwal, A., Gupta, R., & Goel, V. (2025). Immature Platelet Fraction and Other Platelet Indices in Type 2 Diabetes Mellitus. *Cureus*.
Vaidya, A. R., Wolska, N., Vara, D., Mailer, R. K., Schr"oder, K., & Pula, G. (2021). Diabetes and thrombosis: A central role for vascular oxidative stress. *Antioxidants*, *10*(5).
Verdoia, M., Nardin, M., Rolla, R., Pergolini, P., Suryapranata, H., Kedhi, E., & others. (2020). Impact of diabetes mellitus on immature platelet fraction and its association with coronary artery disease. *Diabetes Metab Res Rev*, *36*(4).

Verdoia, M., Pergolini, P., Nardin, M., Rolla, R., Barbieri, L., Schaffer, A., Marino, P., Bellomo, G., Suryapranata, H., & De Luca, G. (2016). Impact of diabetes on immature platelets fraction and its relationship with platelet reactivity in patients receiving dual antiplatelet therapy. *Journal of thrombosis and thrombolysis*, *42*(2), 245–253.

Vinholt, P. J., Hvas, A., & Nybo, M. (2014). An overview of platelet indices and methods for evaluating platelet function in thrombocytopenic patients. *European journal of haematology*, *92*(5), 367–376.

Yavuz, S., As, A. K., Engin, M., Koca, N., & Cander, S. (2022). Cardiovascular diseases and diabetes mellitus. *The European Research Journal*, *8*(4), 541–549.