Mapping the Link Between PRECISE-DAPT and Angiographic Thrombus Burden in STEMI

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Abstract

Background: The Dual Antiplatelet Therapy (PRECISE-DAPT) score, originally developed to balance ischemic and bleeding risks after percutaneous coronary intervention (PCI), has recently emerged as a potential surrogate marker of thrombotic biology. In patients presenting with ST-segment elevation myocardial infarction (STEMI), where thrombus formation is the central pathophysiologic event, several studies have suggested a link between high PRECISE-DAPT values and elevated angiographic thrombus burden. This association is intriguing, as the score was designed to predict bleeding, not thrombosis, yet its components—advanced age, renal dysfunction, anemia, leukocytosis, and prior bleeding—also mirror systemic inflammation, endothelial dysfunction, and hypercoagulability, all of which influence intracoronary thrombus formation. This review aims to synthesize current evidence exploring the relationship between the PRECISE-DAPT score and angiographically assessed thrombus burden in STEMI. It also evaluates the mechanistic plausibility of this relationship, its impact on reperfusion success, procedural strategies, and clinical outcomes, and explores whether integrating thrombus assessment with bleeding risk tools could refine decision-making in acute coronary syndromes. A structured review of PubMed, Scopus, and Web of Science was conducted focusing on studies assessing PRECISE-DAPT in STEMI and its correlation with thrombus grade, no-reflow, distal embolization, or infarct size. Observational cohorts, post-hoc analyses of randomized trials, and mechanistic imaging studies were included. Across multiple cohorts, a higher PRECISE-DAPT score correlates with greater angiographic thrombus burden and adverse reperfusion indices. Elevated scores often accompany higher leukocyte counts, reduced hemoglobin, and impaired renal clearance—biomarkers of inflammatory and prothrombotic states. Patients in the upper quartiles of PRECISE-DAPT tend to experience lower rates of complete ST-segment resolution and increased no-reflow, suggesting that bleeding risk scores may indirectly reflect underlying thrombotic potential.

Conclusion: The PRECISE-DAPT score may capture systemic conditions that predispose to both bleeding and thrombosis, bridging a paradoxical yet clinically meaningful spectrum of cardiovascular risk. Understanding its relationship with thrombus burden offers a novel angle for integrated risk assessment in STEMI. Prospective validation and mechanistic studies are warranted to confirm causality and refine individualized antithrombotic strategies..

Keywords: *PRECISE-DAPT, Angiographic Thrombus Burden , STEMI*

Introduction

ST-segment elevation myocardial infarction (STEMI) remains one of the most critical emergencies in cardiology, representing the culmination of atherosclerotic plaque rupture and subsequent thrombotic coronary occlusion. Despite significant advances in primary percutaneous coronary intervention (PCI), thrombus burden continues to play a decisive role in determining reperfusion quality, distal embolization, and long-term ventricular recovery. Angiographic thrombus grading, though semi-quantitative, provides essential information that guides procedural decisions such as aspiration thrombectomy, glycoprotein IIb/IIIa inhibitor use, and stenting strategy. A higher thrombus burden correlates with impaired TIMI flow, microvascular obstruction, and increased mortality in the acute phase of STEMI [1].

The PRECISE-DAPT score, initially designed to predict bleeding risk following PCI, has recently garnered interest for its potential connection with thrombosis-related outcomes. It incorporates five routinely measured clinical variables: age, creatinine clearance, hemoglobin concentration, white blood cell count, and history of prior bleeding. While this score was validated primarily for identifying patients at high bleeding risk to tailor DAPT duration, several of its components overlap with biological determinants of thrombus formation. For instance, advanced age and renal impairment contribute to endothelial dysfunction and platelet hyperactivity, while anemia and leukocytosis reflect inflammatory and oxidative stress pathways that can amplify thrombogenesis [2,3].

These mechanistic intersections raise an intriguing hypothesis: a high PRECISE-DAPT score may not only identify bleeding-prone individuals but also reflect underlying systemic conditions conducive to increased intracoronary thrombus formation. In clinical observations, patients with higher PRECISE-DAPT scores tend to present with greater angiographic thrombus load, reduced pre-procedural TIMI flow, and higher incidence of no-reflow following PCI [4–6]. Such findings suggest that the score may act as a mirror of overall cardiovascular vulnerability rather than a unidimensional bleeding index.

Despite these observations, the association between the PRECISE-DAPT score and thrombus burden in STEMI has not been comprehensively analyzed. Most studies have been single-center and observational, leaving uncertainty regarding causality, confounders, and predictive validity. Moreover, the physiological links between score components and thrombogenesis remain poorly delineated in current literature. Understanding this relationship could yield clinical benefits by integrating bleeding and thrombotic risk stratification into a single, practical tool.

Therefore, the primary aim of this review is to synthesize existing evidence on the relationship between the PRECISE-DAPT score and angiographic thrombus burden in patients with STEMI. It will explore potential biological mechanisms connecting the two, evaluate implications for procedural and pharmacologic management, and identify research gaps requiring future validation. This integrative approach may ultimately refine patient selection for intensified antithrombotic therapy and guide personalized STEMI management strategies [1–6].

To ensure that this review is grounded in verifiable and high-quality evidence, a structured literature search strategy was implemented across multiple scientific databases, including PubMed/MEDLINE, Scopus, and Web of Science, covering publications up to October 2025. The search terms combined keywords and Medical Subject Headings (MeSH) relevant to both the PRECISE-DAPT score and thrombus burden in STEMI, such as: *"PRECISE-DAPT," "thrombus burden," "ST-segment elevation myocardial infarction," "primary PCI," "angiographic thrombus," "TIMI thrombus grade,"* and *"bleeding and ischemic risk scores."* Boolean operators (AND, OR) were used to maximize sensitivity and specificity in capturing pertinent studies [7].

Studies were eligible for inclusion if they: (1) enrolled adult patients with STEMI undergoing primary PCI; (2) reported PRECISE-DAPT score or its components in association with thrombus burden or related angiographic parameters (e.g., TIMI flow, myocardial blush grade, distal embolization, no-reflow); and (3) were published in peer-reviewed journals with full-text availability in English. Both prospective and retrospective cohort studies were considered, as well as post hoc analyses of randomized trials where sufficient data on PRECISE-DAPT and angiographic thrombus were available. Case

reports, editorials, and conference abstracts were excluded to avoid bias from incomplete datasets [8].

Data extraction focused on study characteristics (author, year, population size, inclusion criteria), definitions of thrombus burden, methods for calculating PRECISE-DAPT, and reported associations, including correlation coefficients, odds ratios, or regression analyses adjusted for confounders. Each study was independently screened by two reviewers, and discrepancies were resolved by consensus. The Newcastle–Ottawa Scale (NOS) was applied to assess the quality of non-randomized studies, emphasizing selection bias, comparability, and outcome assessment [9].

In addition to quantitative associations, mechanistic and translational studies exploring the biological overlap between PRECISE-DAPT components and thrombogenesis were included to strengthen interpretative depth. Reference lists of eligible papers were manually searched to capture missed publications and related reviews.

Finally, data synthesis prioritized validated, reproducible evidence over speculative findings. Only studies with clear methodologies and reliable statistical interpretation were included in this narrative synthesis, ensuring the accuracy of conclusions drawn regarding the potential link between PRECISE-DAPT score and coronary thrombus burden in STEMI [10–12].

PRECISE-DAPT: Components, Calculation, and Intended Use

The PRECISE-DAPT score was developed as a standardized and evidence-based tool to guide the duration of dual antiplatelet therapy (DAPT) following percutaneous coronary intervention. It integrates five clinical and laboratory parameters—age, creatinine clearance, hemoglobin, white blood cell (WBC) count, and prior bleeding history—to quantify bleeding risk at the time of PCI. This composite model was derived and validated in large multinational cohorts, including over 14,000 patients across multiple randomized trials, demonstrating consistent predictive power for out-of-hospital bleeding events [13].

Each component of the score reflects a physiological axis contributing to both bleeding and thrombotic risk. Advanced age and renal dysfunction are known to alter platelet function, impair vascular integrity, and disrupt hemostatic balance. Low hemoglobin and anemia, beyond their role in bleeding risk, are associated with elevated sympathetic tone, oxidative stress, and enhanced platelet aggregation. Elevated WBC count signifies systemic inflammation and activation of the coagulation cascade, both of which play a central role in the pathogenesis of coronary thrombosis [14]. These overlapping biological mechanisms provide the conceptual basis for exploring a possible association between a high PRECISE-DAPT score and increased intracoronary thrombus burden in STEMI.

The score is calculated using a web-based or software tool available through the European Society of Cardiology's official resources. A value of ≥25 indicates high bleeding risk and traditionally supports consideration of shorter DAPT duration, whereas a score <25 suggests lower bleeding risk, allowing for prolonged therapy when ischemic risk is elevated. Importantly, the PRECISE-DAPT score's validation was robust across acute coronary syndrome (ACS) and stable CAD populations, showing discrimination (C-statistics around 0.73–0.74) for major bleeding outcomes at one year post-PCI [15].

In recent years, investigators have begun to examine whether this same score could serve as an indirect reflection of thrombotic biology. Because many of its components mirror systemic vulnerability—renal impairment, anemia, leukocytosis, and age-related inflammation—these factors may not only predispose to bleeding but also indicate a prothrombotic milieu. This duality suggests that the PRECISE-DAPT score could paradoxically identify patients at both extremes of risk, bridging the conventional dichotomy between bleeding and thrombosis in the context of STEMI [16–18].

Defining and Measuring Coronary Thrombus Burden

Coronary thrombus burden represents a pivotal determinant of procedural complexity and clinical outcomes in patients with ST-segment elevation myocardial infarction (STEMI). It reflects the extent of intracoronary clot formation secondary to plaque rupture and platelet activation. Accurate evaluation of thrombus burden is essential because it influences pre-procedural planning, reperfusion strategy, and the likelihood of distal embolization or no-reflow. Angiographic assessment remains the cornerstone for thrombus evaluation in the catheterization laboratory, providing a practical and widely reproducible grading system to stratify thrombus severity during primary PCI [19].

The most frequently used classification is the Thrombolysis In Myocardial Infarction (TIMI) thrombus grade, ranging from Grade 0 (no angiographic evidence of thrombus) to Grade 5 (total vessel occlusion due to thrombus). This semi-quantitative scale is applied before and after wiring or gentle balloon dilatation to better visualize residual thrombus load. High thrombus burden (Grades 4–5) has been consistently associated with impaired reperfusion, longer procedural time, increased stent thrombosis, and higher mortality at follow-up. It also guides therapeutic decisions, including the need for aspiration thrombectomy, use of glycoprotein IIb/IIIa inhibitors, or deferred stenting in select patients [20,21].

While angiography offers immediate and pragmatic thrombus assessment, it underestimates true clot volume because it visualizes only luminal filling defects. Advanced intravascular imaging modalities such as optical coherence tomography (OCT) and intravascular ultrasound (IVUS) have provided deeper insight into thrombus morphology, composition, and its relation to plaque characteristics. OCT studies reveal that high-burden thrombus often overlays lipid-rich, thin-cap fibroatheromas with abundant inflammatory cell infiltration—features that align with systemic inflammatory markers also captured within the PRECISE-DAPT score components such as leukocytosis and anemia [22,23].

Another method of indirect thrombus quantification involves measuring thrombus aspiration volume, microvascular obstruction on cardiac magnetic resonance imaging (CMR), or angiographic indices such as myocardial blush grade and corrected TIMI frame count. These surrogate parameters correlate well with TIMI thrombus grade and provide prognostic value regarding myocardial salvage and left ventricular recovery. Despite minor interobserver variability, combining angiographic and imaging-based thrombus assessment enhances precision in correlating systemic risk scores like PRECISE-DAPT with local coronary pathology [24,25].

In summary, coronary thrombus burden is a multifaceted parameter reflecting the interplay of systemic inflammation, plaque vulnerability, and coagulation dynamics. Its accurate measurement through angiographic grading, supported by intracoronary imaging, is vital for evaluating potential associations between systemic risk indices such as the PRECISE-DAPT score and localized thrombotic phenomena in STEMI [26].

Biological Bridge – Why a Bleeding Score Might Track Thrombus Load

The paradoxical relationship between the PRECISE-DAPT score, a bleeding risk model, and coronary thrombus burden lies in the shared biological and pathophysiological mechanisms linking bleeding predisposition and thrombogenesis. Several of the score's components reflect systemic alterations that influence both hemostasis and vascular inflammation, suggesting that elevated PRECISE-DAPT values may identify patients with a heightened prothrombotic milieu despite their nominal bleeding susceptibility. Understanding this overlap is essential to interpreting why patients with higher scores may present with greater angiographic thrombus burden during STEMI [27].

Age, the most heavily weighted component of the PRECISE-DAPT score, contributes to vascular stiffness, endothelial dysfunction, and platelet hyperreactivity. Aging is associated with increased oxidative stress, elevated fibrinogen levels, and impaired nitric oxide bioavailability, which collectively promote a thrombogenic environment. In elderly patients with STEMI, these changes often coincide with microvascular dysfunction, explaining both higher thrombus burden and greater risk of microvascular obstruction following PCI [28].

Renal dysfunction, another key component of the score, represents a potent prothrombotic condition. Reduced glomerular filtration leads to the accumulation of uremic toxins that impair endothelial function, promote platelet activation, and increase circulating tissue factor levels. Patients with chronic kidney disease (CKD) have elevated levels of fibrinogen and von Willebrand factor, creating a state of concurrent platelet activation and impaired fibrinolysis. These processes contribute to denser, more resistant thrombi, frequently observed angiographically as higher thrombus grades in STEMI [29].

Anemia and low hemoglobin, traditionally markers of bleeding risk, also predict adverse ischemic outcomes. Reduced oxygen-carrying capacity induces tissue hypoxia and sympathetic activation, which enhance shear stress and platelet reactivity. Moreover, anemia often coexists with systemic inflammation and oxidative stress, fostering endothelial damage and thrombus formation. The same

inflammatory pathway is reflected by elevated white blood cell (WBC) count—another PRECISE-DAPT parameter—which serves as a direct marker of leukocyte-driven thrombogenesis through neutrophil extracellular traps (NETs), cytokine release, and monocyte-platelet aggregate formation [30,31].

Finally, prior bleeding history, while indicating vulnerability to hemorrhagic events, often accompanies conditions such as gastrointestinal pathology, chronic inflammation, or vascular fragility, all of which coexist with systemic endothelial dysfunction. Therefore, the PRECISE-DAPT score captures an aggregate biological signature—age-related vascular damage, renal dysfunction, anemia, and leukocytosis—that represents both bleeding and thrombotic risk. The intertwined pathways of inflammation, oxidative stress, and coagulation underpin this dual predictive nature, explaining why patients with higher PRECISE-DAPT scores may paradoxically exhibit a larger intracoronary thrombus burden at STEMI presentation [32–34].

Observational Evidence Linking PRECISE-DAPT to Thrombus Burden in STEMI

Among available cohorts, the clearest signal comes from a retrospective study of 204 consecutive STEMI patients undergoing primary PCI, in which the PRECISE-DAPT score was significantly higher in those with high thrombus burden (TIMI thrombus grades 4–5) versus lower grades. In multivariable analysis adjusting for baseline troponin I, left ventricular ejection fraction, and pain-to-balloon time, the PRECISE-DAPT score emerged as an independent predictor of high thrombus burden. These findings suggest that the score, though developed for bleeding risk, tracks angiographic clot load at presentation, reinforcing the concept that its components mirror systemic prothrombotic biology captured at the bedside [35].

The association extends beyond static thrombus grading to dynamic reperfusion surrogates. In a separate observational cohort of primary-PCI STEMI, higher admission PRECISE-DAPT values were independently associated with the angiographic no-reflow phenomenon—an endpoint tightly linked to distal embolization and microvascular obstruction. This relationship between a bleeding score and microvascular failure argues that PRECISE-DAPT may encapsulate inflammatory and hemorheologic conditions that both promote upstream thrombus formation and hinder downstream myocardial perfusion after lesion crossing and stenting [36].

Complementary evidence connects PRECISE-DAPT to spontaneous reperfusion—a clinical antithesis of heavy thrombus load. In a multicenter study, higher PRECISE-DAPT scores were inversely related to the presence of spontaneous reperfusion (pre-PCI TIMI 2–3 flow), with multivariable modeling indicating the score as an independent predictor of absent spontaneous reperfusion. Taken together with the no-reflow data, these observations triangulate a consistent pattern: as the PRECISE-DAPT score rises, angiographic markers shift toward larger upstream clot and poorer downstream flow, aligning a "bleeding" score with thrombotic severity in STEMI [37–39].

Context from related literature supports external validity. Although focused on a different risk tool, a contemporary acute MI study found the DAPT score associated with intracoronary thrombus burden, underscoring that composite clinical indices can reflect clot load in real-world practice. Separately, broader PCI populations show that PRECISE-DAPT not only predicts bleeding but also associates with adverse ischemic outcomes, implying that the score integrates elements of global illness severity (age, renal function, anemia, leukocytosis) that drive both sides of the bleeding–thrombosis ledger. These converging data justify prospective validation of PRECISE-DAPT specifically against standardized thrombus metrics and reperfusion endpoints in STEMI [40–41].

Reperfusion quality after primary PCI is commonly gauged by epicardial TIMI flow, myocardial blush grade (MBG), and ST-segment resolution (STR). MBG robustly reflects microvascular perfusion and independently predicts mortality, while early STR tightly correlates with infarct size and left-ventricular function. Heavy upstream thrombus—through distal embolization and microvascular plugging—degrades these indices, linking thrombus biology to downstream tissue-level success. This framework underpins why any bedside score that mirrors thrombotic/inflammatory tone (e.g., PRECISE-DAPT) might track poorer reperfusion metrics in STEMI [42–45,48].

Across observational STEMI cohorts, higher admission PRECISE-DAPT scores associate with angiographic no-reflow—an outcome tightly linked to distal embolization, microvascular obstruction, and adverse prognosis. In a 335-patient primary-PCI study, PRECISE-DAPT independently predicted no-reflow after multivariable adjustment, suggesting the score captures upstream thrombo-inflammatory conditions that predispose to microvascular failure at the moment of reperfusion. Contemporary reviews of no-reflow pathophysiology further reinforce the mechanistic plausibility—incorporating platelet/fibrin aggregates, neutrophil extracellular traps, vasoconstriction, and edema—as channels through which systemic risk signatures degrade tissue-level flow [36,45,51].

Concordant signals appear when examining spontaneous reperfusion before wire passage, the functional opposite of heavy thrombus burden. A multicenter analysis found PRECISE-DAPT to be an independent predictor of absent spontaneous reperfusion (lower pre-PCI TIMI 2–3 flow), and broader syntheses describe links between pro-thrombotic profiles and the rarity of spontaneous lysis. Translational data add biologic texture: patients exhibiting spontaneous reperfusion show lower platelet reactivity and a more favorable endogenous fibrinolytic profile—traits expected to align with lower PRECISE-DAPT strata. Collectively, these strands imply a gradient in which rising PRECISE-DAPT corresponds to less spontaneous reperfusion and worse tissue-level outcomes [37,39,49].

These associations carry procedural implications. If a high PRECISE-DAPT flags patients at risk for no-reflow, operators may anticipate embolic load and microvascular injury, favor meticulous lesion preparation, judicious anticoagulation, and selective (not routine) use of adjuncts. Randomized evidence shows routine thrombus aspiration does not improve outcomes and may increase stroke, underscoring the need for tailored—rather than indiscriminate—approaches in high-thrombus lesions. Emerging clinical tools to predict no-reflow at the table, integrated with angiographic thrombus grading, could be pragmatically combined with PRECISE-DAPT to pre-empt microvascular complications [21,46,52]

In the cath lab, thrombus burden directly steers tactics; however, routine manual aspiration has fallen out of favor after large randomized trials showed no clinical benefit and a signal for stroke. TASTE and TOTAL both found that systematic thrombectomy did not reduce death or reinfarction versus PCI alone, and TOTAL reported an increased risk of stroke, leading international guidelines to discourage routine use. Accordingly, in patients with high thrombus (often overlapping with high PRECISE-DAPT), operators should default to meticulous wiring and gentle lesion preparation rather than automatic aspiration, reserving thrombectomy for bailout scenarios when there is persistent large thrombus or failure to establish flow. This strategy aligns with contemporary guidance and trial evidence. [47–51]

Selective adjuncts can be deployed when angiography reveals bulky thrombus, slow flow, or no-reflow. Glycoprotein IIb/IIIa inhibitors are supported as bailout therapy (not routine upstream use) in the presence of large thrombus or thrombotic complications. For rapid platelet inhibition—especially if oral P2Y12 loading is recent or absorption is uncertain—intraprocedural cangrelor reduces periprocedural ischemic events and stent thrombosis without excess severe bleeding, with supportive analyses in high-risk PCI and intraprocedural stent thrombosis contexts. Integrating these options with a high PRECISE-DAPT (thrombo-inflammatory signature) and high angiographic thrombus can rationalize targeted, time-limited intensification rather than blanket escalation. [50,52–55]

Anticoagulation should reflect the dual risks flagged by PRECISE-DAPT (bleeding) and thrombus grade (thrombosis). Unfractionated heparin remains the default in primary PCI; randomized data (HEAT-PPCI) showed fewer ischemic events with heparin versus bivalirudin in a contemporary STEMI setting, whereas MATRIX and VALIDATE-SWEDEHEART suggested trade-offs: bivalirudin lowers bleeding but may increase acute stent thrombosis unless followed by a post-PCI infusion. In a patient with very high PRECISE-DAPT (bleeding-prone) but also heavy thrombus (thrombosis-prone), a pragmatic approach is adequate heparinization with vigilant ACT monitoring; bivalirudin with a short post-PCI infusion can be considered when bleeding risk predominates, acknowledging mixed evidence and the need for careful bailouts against acute stent thrombosis. [56–59]

Beyond drugs, technique matters: minimize distal embolization by avoiding aggressive predilatation in occluded vessels, consider small, controlled inflations, and ensure optimal stent sizing and expansion.

Deferred stenting and distal protection devices have not shown routine benefit and should not be used indiscriminately. For evolving no-reflow, an algorithmic response—intracoronary vasodilators (adenosine, nitroprusside, verapamil), aspiration only if a large removable thrombus persists, and selective GP IIb/IIIa—links mechanistic insights to immediate rescue. These procedural choices sit naturally at the intersection of a patient's systemic profile (captured in PRECISE-DAPT) and the lesion's thrombus phenotype on angiography. [50,60–62]

Balancing ischemic protection and bleeding avoidance after primary PCI for STEMI remains one of the most challenging tasks in interventional cardiology. The PRECISE-DAPT score was developed to optimize this equilibrium by identifying patients who benefit from shorter or longer dual antiplatelet therapy (DAPT) durations. However, in the specific subset of STEMI patients with high angiographic thrombus burden, the interplay between PRECISE-DAPT-defined bleeding risk and the need for potent platelet inhibition becomes complex. Thrombus-rich lesions require strong, rapid, and consistent $P2Y_{12}$ inhibition to prevent distal embolization and acute stent thrombosis, yet high PRECISE-DAPT patients are simultaneously the ones most vulnerable to bleeding. [63,64]

Evidence from major randomized trials underscores the ischemic advantage of potent $P2Y_{12}$ inhibitors in STEMI. In the TRITON–TIMI 38 trial, prasugrel reduced stent thrombosis and recurrent ischemic events compared with clopidogrel, particularly in patients with large thrombus or complex lesions. Similarly, the PLATO trial demonstrated that ticagrelor decreased cardiovascular death and reinfarction versus clopidogrel in the overall acute coronary syndrome population, including STEMI subsets, with early divergence of event curves suggesting rapid inhibition of thrombus propagation. However, both agents also increased non-CABG-related bleeding. Within these data, PRECISE-DAPT's high-score subgroup roughly corresponds to the patients who experienced most bleeding events, emphasizing that potency-driven benefit carries a measurable bleeding cost. [65–67]

Real-world registry studies further refine this trade-off. High PRECISE-DAPT patients treated with potent $P2Y_{12}$ inhibitors experienced fewer ischemic events but proportionally more bleeding, whereas low-score patients enjoyed the largest net clinical benefit. Shortening DAPT to 3–6 months in those with scores ≥25, as recommended in ESC guidance, mitigates bleeding risk without sharply increasing ischemic recurrence when thrombus burden has been adequately managed at the index PCI. Conversely, low-score patients (PRECISE-DAPT <25) with residual thrombotic features—such as high thrombus grade or delayed reperfusion—may merit extended or intensified DAPT. [68,69]

Emerging evidence also supports de-escalation strategies guided by risk. Trials such as TOPIC, TROPICAL-ACS, and TWILIGHT demonstrated that early switch from potent to less potent agents (prasugrel/ticagrelor → clopidogrel) or early aspirin withdrawal after initial stabilization reduces bleeding without excess ischemic harm. Integrating angiographic thrombus evaluation with PRECISE-DAPT could refine de-escalation timing: high thrombus burden warrants potent therapy during the acute phase (first 30 days), while a persistently high PRECISE-DAPT score should trigger step-down once the immediate thrombotic threat resolves. [70–72]

Collectively, the PRECISE-DAPT score offers a useful biological and clinical framework for tailoring $P2Y_{12}$ selection and DAPT duration in STEMI. When interpreted alongside angiographic thrombus burden, it guides clinicians toward an individualized path: start strong for thrombosis suppression, then shorten or de-escalate when bleeding risk dominates the long-term horizon. Such a layered approach bridges procedural insight with systemic patient biology—a crucial advance toward precision antiplatelet therapy. [73,74]

Diabetes mellitus amplifies systemic inflammation, oxidative stress, and platelet reactivity—key mediators of both thrombus formation and elevated PRECISE-DAPT scores. Diabetic STEMI patients typically display diffuse atherosclerosis, greater plaque necrotic core, and delayed endogenous fibrinolysis. These biological and angiographic patterns correspond with higher thrombus burden and impaired reperfusion indices such as reduced myocardial blush grade. Because diabetes also accelerates anemia and renal impairment, both of which increase PRECISE-DAPT, these patients often sit at the intersection of high bleeding and high thrombotic risk. Studies confirm that diabetic STEMI patients

with elevated scores exhibit poorer epicardial flow and higher no-reflow rates, reflecting the mutual reinforcement of systemic metabolic dysfunction and intracoronary thrombus load. [75,76]

Chronic kidney disease (CKD) represents another subgroup in which the dual-risk paradigm becomes evident. Uremic toxins trigger endothelial dysfunction, platelet activation, and procoagulant microparticle release, yet uremic platelet dysfunction also increases bleeding susceptibility. This combination explains why CKD simultaneously elevates ischemic and hemorrhagic risks—precisely what PRECISE-DAPT quantifies. In STEMI registries, patients with moderate-to-severe renal impairment show markedly higher TIMI thrombus grades and more frequent no-reflow despite prompt reperfusion. Such findings indicate that the thrombotic signature of CKD is captured indirectly by the score's renal and hematologic components, confirming its validity as a systemic risk mirror. [77–79]

Elderly patients and those with anemia provide a clinically important population for interpreting PRECISE-DAPT–thrombus relations. Ageing induces endothelial senescence, increased platelet aggregability, and vascular stiffness, while anemia exacerbates tissue hypoxia and sympathetic activation, augmenting shear stress and thrombogenesis. Observational STEMI data reveal that low hemoglobin and advanced age are independent predictors of large thrombus burden and no-reflow. These characteristics also drive high PRECISE-DAPT values, explaining why elderly or anemic patients frequently manifest heavy thrombus, suboptimal blush, and larger infarcts. Tailored antithrombotic regimens—short, potent initial therapy followed by early de-escalation—offer a pragmatic balance in this cohort. [80–83]

Leukocytosis highlights the inflammatory link between systemic and local thrombosis. Elevated white blood cell count, a direct input in PRECISE-DAPT, reflects cytokine release and neutrophil activation. Neutrophil extracellular traps (NETs) have been identified within aspirated coronary thrombi, where they promote fibrin stabilization and microvascular obstruction. Clinical studies correlate admission leukocytosis with higher thrombus grades and lower rates of ST-segment resolution, reinforcing WBC count as a mechanistic and prognostic connector between systemic inflammation and coronary thrombosis. Thus, high WBC simultaneously inflates PRECISE-DAPT and signals heavier thrombus burden. [84–86]

Anterior infarction and delayed presentation are anatomical and temporal subgroups consistently associated with increased thrombus volume. Proximal LAD occlusions generate larger ischemic zones and more turbulent flow, favoring thrombus propagation, while longer ischemic time permits clot maturation and organization. Patients presenting beyond six hours after symptom onset often exhibit TIMI 0 flow with bulky thrombus and reduced myocardial salvage. These patterns correlate strongly with higher PRECISE-DAPT scores, as delayed presenters tend to be older, anemic, and systemically inflamed. Recognition of this overlap enables proactive procedural planning—anticipating high thrombus load while modulating antithrombotic intensity according to bleeding susceptibility. [87–90]

Predictive Performance

The ability of the PRECISE-DAPT score to predict thrombus burden in STEMI extends beyond anecdotal associations and has been examined using standard performance metrics. Across multiple studies, receiver operating characteristic (ROC) analyses show modest but significant discrimination of high thrombus burden, with **area under the curve (AUC)** values ranging between **0.67 and 0.73**. Although originally validated for bleeding prediction, this level of performance suggests that the PRECISE-DAPT score possesses relevant prognostic information regarding thrombotic risk. Its discriminatory power arises from the confluence of clinical and laboratory variables reflecting systemic inflammation, endothelial injury, and coagulation imbalance—all contributors to intracoronary thrombosis. [91,92]

Calibration analyses further demonstrate that the score's predictive ability is consistent across diverse

patient subsets, including diabetic and elderly populations. However, its predictive value for thrombus burden is stronger at higher scores, where biological derangements such as leukocytosis and anemia are most prominent. In regression modeling, each 10-point increase in PRECISE-DAPT independently predicts a 30–40% higher likelihood of high TIMI thrombus grade after adjusting for confounders such as symptom onset-to-balloon time and infarct-related artery location. Importantly, the association persists even after exclusion of patients with overt bleeding diatheses or prior anticoagulant exposure, supporting the concept that the score indirectly captures prothrombotic biology rather than procedural artifact. [93,94]

When compared with other clinical risk tools, such as CRUSADE or DAPT, the PRECISE-DAPT score offers a unique advantage: its inclusion of WBC count and hemoglobin adds sensitivity to inflammatory and hematologic dimensions of thrombus formation. While CRUSADE correlates with bleeding and in-hospital mortality, and DAPT was designed to guide prolonged therapy, neither effectively stratifies intracoronary thrombus risk in STEMI. The GRACE score, though superior for overall mortality prediction, lacks the hematologic and inflammatory inputs present in PRECISE-DAPT. Thus, PRECISE-DAPT bridges a distinctive clinical-biologic gap, encompassing both bleeding and thrombotic predispositions. [95–97]

Advanced statistical modeling combining PRECISE-DAPT with angiographic thrombus grading, Killip class, and baseline biomarkers such as C-reactive protein or fibrinogen significantly improves predictive capacity. Integrated discrimination improvement (IDI) and net reclassification index (NRI) analyses reveal that adding PRECISE-DAPT to conventional angiographic predictors yields an NRI of approximately 0.20–0.25 for identifying patients with heavy thrombus burden or no-reflow. These enhancements underscore its potential for bedside integration within reperfusion protocols and support its use as an adjunct—not a replacement—for direct angiographic assessment. [98–100]

Overall, the PRECISE-DAPT score demonstrates moderate accuracy for predicting high thrombus burden and adverse reperfusion, validated by multiple observational datasets. While not a substitute for angiographic assessment, it serves as an easily obtainable, pre-procedural biomarker of thrombotic load, bridging laboratory risk assessment and interventional decision-making in STEMI. [100]

Conclusions

The interplay between the PRECISE-DAPT score and angiographic thrombus burden in STEMI reveals an important and clinically underexplored convergence of systemic biology and local coronary pathology. Originally designed to estimate bleeding risk, the PRECISE-DAPT score inadvertently captures several dimensions of thrombogenic potential—advanced age, renal impairment, anemia, and systemic inflammation—that collectively shape both hemorrhagic vulnerability and thrombus formation. Across multiple observational studies, higher PRECISE-DAPT values consistently align with greater thrombus load, poorer pre-PCI flow, and more frequent no-reflow phenomena, suggesting that this score mirrors the biological continuum between inflammation, endothelial dysfunction, and coagulation.

Recognizing this dual predictive capacity challenges the conventional separation of “bleeding” and “thrombotic” profiles in STEMI management. It argues instead for a more integrated approach, where systemic risk assessment (via PRECISE-DAPT) complements angiographic grading of thrombus to guide both procedural and pharmacologic decisions. Patients with high scores and heavy thrombus require early potent platelet inhibition, meticulous procedural technique, and vigilant bleeding monitoring—followed by rapid de-escalation once the acute prothrombotic window closes. Conversely, low-score patients may safely sustain extended or intensified DAPT for longer-term ischemic protection.

Beyond immediate clinical implications, this association highlights the need for deeper exploration into the shared pathways of thrombosis and bleeding—particularly inflammation, oxidative stress, and endothelial dysfunction—as common denominators of cardiovascular vulnerability. Future research should validate the predictive accuracy of PRECISE-DAPT for thrombus burden in larger, prospective cohorts and integrate it with imaging and biomarker data to refine risk algorithms.

In summary, the PRECISE-DAPT score transcends its original purpose as a bleeding tool, emerging as

a broader marker of vascular instability and thrombotic propensity in STEMI. Understanding its association with coronary thrombus burden enables clinicians to navigate the delicate balance between ischemic protection and bleeding avoidance, moving closer to a precision-guided, biologically coherent strategy for acute myocardial infarction management.

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