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Comparison of Primary Percutaneous Coronary Intervention Versus Thrombolytic Therapy in ST-Elevation Myocardial Infarction

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Abstract: ST-elevation myocardial infarction (STEMI) is an acute coronary syndrome caused by sudden coronary artery occlusion and requires rapid restoration of myocardial blood flow. Primary percutaneous coronary intervention (PPCI) and thrombolytic therapy are established reperfusion strategies, but their relative effectiveness depends on treatment availability, timing, contraindications, and patient characteristics.The study aimed to compare primary percutaneous coronary intervention with thrombolytic therapy for STEMI and to evaluate their relative effects on mortality, recurrent myocardial infarction, stroke, bleeding, and successful myocardial reperfusion.A comparative clinical evidence-based framework was used to evaluate outcomes associated with PPCI and thrombolytic therapy in patients with STEMI. Evidence concerning mortality, reinfarction, stroke, bleeding complications, recurrent ischemia, and reperfusion success was assessed using randomized trials, systematic reviews, meta-analyses, and contemporary clinical guidelines.PPCI was associated with more reliable coronary reperfusion and lower risks of mortality, reinfarction, recurrent ischemia, and stroke compared with thrombolytic therapy when timely PCI was available. Thrombolytic therapy remained an important alternative when PPCI could not be performed within the recommended time window. Fibrinolysis carried a greater risk of intracranial and other bleeding complications, whereas PPCI

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was associated with procedure-related risks and depended on rapid access to an experienced catheterization laboratory.PPCI generally provides superior clinical outcomes compared with thrombolytic therapy for STEMI when it can be performed promptly. Thrombolytic therapy remains appropriate when timely PPCI is unavailable and can be followed by early angiography and PCI when indicated. The choice of reperfusion strategy should therefore prioritize rapid restoration of coronary blood flow while considering treatment delay, bleeding risk, contraindications, and healthcare-system capabilities.

Key words

ST-elevation myocardial infarction; primary percutaneous coronary intervention; thrombolytic therapy; fibrinolysis; reperfusion; myocardial infarction; coronary revascularization; mortality; stroke.

Introduction

ST-elevation myocardial infarction is a time-critical cardiovascular emergency that usually results from acute thrombotic occlusion of a coronary artery. Prolonged coronary obstruction causes myocardial ischemia, progressive cellular injury, and irreversible myocardial necrosis. Rapid restoration of coronary blood flow therefore represents the central therapeutic objective in STEMI management.Reperfusion can be achieved mechanically through primary percutaneous coronary intervention or pharmacologically through fibrinolytic therapy. PPCI involves urgent coronary angiography followed by balloon angioplasty, stent implantation, or other catheter-based methods to restore vessel patency. Thrombolytic therapy uses fibrinolytic agents to dissolve the obstructing thrombus and restore coronary perfusion without requiring immediate mechanical intervention [1,2].The effectiveness of reperfusion therapy depends strongly on time. The relationship between ischemic duration and myocardial damage means that treatment delay can reduce the benefit of an otherwise effective intervention. Consequently, modern STEMI systems emphasize rapid diagnosis, coordinated emergency transport, and direct transfer to PCI-capable centers when PPCI can be delivered within an appropriate time interval [1].PPCI has become the preferred reperfusion strategy for patients with STEMI when timely treatment is available. Contemporary European guidance recommends PPCI when it can be performed within 120 minutes of STEMI diagnosis. When this cannot be achieved and the patient presents within the appropriate symptom-onset window without contraindications, fibrinolytic therapy is recommended, followed by transfer to a PCI-capable center [1,3].Evidence from randomized clinical trials and meta-analyses demonstrates important advantages of PPCI over fibrinolysis. PPCI has been associated with lower short-term mortality, recurrent myocardial infarction, stroke, and urgent repeat revascularization. These benefits are particularly relevant because fibrinolysis may achieve incomplete or temporary thrombotic dissolution and may fail to restore adequate epicardial coronary flow [4,5].A large comparative meta-analysis including randomized trials and observational studies demonstrated lower short-term mortality with PPCI than fibrinolytic therapy. The analysis also showed reductions in stroke and reinfarction following PPCI, supporting its clinical superiority when rapid mechanical reperfusion is feasible [4].Mortality differences have also been observed across different follow-up periods. A systematic review of randomized controlled trials reported lower in-hospital, short-term, mid-term, and long-term mortality among patients treated with PPCI compared with fibrinolysis [5]. These findings suggest that the advantages of PPCI extend beyond immediate restoration of coronary flow.Stroke represents another important difference between the two strategies. Fibrinolytic therapy exposes patients to systemic fibrinolysis and therefore carries a clinically

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important risk of intracranial hemorrhage. A systematic review comparing prehospital fibrinolysis with PPCI found similar mortality in selected early-treatment populations but a significantly higher risk of any stroke and hemorrhagic stroke with fibrinolysis [6].However, fibrinolysis remains clinically valuable when rapid PPCI is unavailable. Early administration of fibrinolytic therapy can restore coronary flow before a patient reaches a PCI center and may therefore be preferable to waiting for a prolonged transfer when mechanical reperfusion cannot be delivered within the recommended timeframe [1,3].The development of pharmaco-invasive strategies has further strengthened the role of fibrinolysis in selected situations. Patients receiving fibrinolysis can be transferred to a PCI-capable center for angiographic assessment and subsequent intervention when required. Evidence indicates that early PCI after fibrinolysis can reduce reinfarction and recurrent ischemia compared with delayed or ischemia-guided approaches [7].The relative effectiveness of PPCI and thrombolytic therapy therefore depends not only on the intrinsic efficacy of each treatment but also on treatment delay, system organization, patient selection, bleeding risk, and availability of skilled interventional services. The present study compared PPCI with thrombolytic therapy in STEMI and evaluated their major clinical outcomes and practical implications.

Materials and Methods

Study Design

A comparative clinical evidence-based study framework was used to evaluate primary percutaneous coronary intervention and thrombolytic therapy in patients with ST-elevation myocardial infarction.

Study Setting

The study was conducted at Bannu Medical college MTI Bannu for period of 1 year from January 2025 to January 2026.

Study Population

The study population was defined as adults presenting with STEMI who were considered eligible for reperfusion therapy. Patients receiving PPCI and patients receiving thrombolytic therapy were considered as the principal comparative groups.

Inclusion Criteria

Patients were considered eligible when they presented with clinical features consistent with acute myocardial infarction and electrocardiographic evidence of STEMI and were treated with either PPCI or thrombolytic therapy. Patients treated within the recommended acute reperfusion window were considered relevant to the comparative assessment.

Exclusion Criteria

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Patients without confirmed STEMI, patients without sufficient information regarding reperfusion strategy, and patients with conditions in which reperfusion therapy was not clinically indicated were excluded from comparative interpretation.

Primary Percutaneous Coronary Intervention

PPCI was defined as emergency coronary angiography followed by mechanical reperfusion of the infarct-related artery without preceding fibrinolytic treatment. Balloon angioplasty and coronary stent implantation were considered standard components of mechanical reperfusion when clinically indicated.

Thrombolytic Therapy

Thrombolytic therapy was defined as pharmacological fibrinolysis administered to achieve coronary reperfusion. Fibrin-specific agents were considered the preferred pharmacological approach when fibrinolysis was selected. Treatment eligibility was considered according to symptom duration, expected PCI delay, and contraindications.

Outcome Assessment

The principal outcomes included short-term and long-term mortality, recurrent myocardial infarction, recurrent ischemia, stroke, major bleeding, successful reperfusion, and need for urgent or subsequent coronary intervention.

Assessment of Treatment Timing

Treatment timing was assessed as an important modifier of outcome. The comparison considered the interval between symptom onset, first medical contact, diagnosis, administration of fibrinolysis, and restoration of coronary flow through PPCI.

Statistical Analysis

The comparative interpretation focused on the direction and consistency of treatment effects reported in the available evidence. Because original patient-level numerical data were not supplied, no fabricated sample sizes, percentages, p-values, odds ratios, or confidence intervals were generated.

Ethical Considerations

The framework was based on published clinical evidence and guideline recommendations. If applied to an original patient cohort, institutional ethical approval, informed consent where required, confidentiality, and protection of patient information were required.

Results

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The comparative assessment demonstrated that PPCI generally produced more reliable reperfusion and better clinical outcomes than thrombolytic therapy when PPCI was performed without substantial treatment delay. The principal advantages were observed in mortality, recurrent myocardial infarction, stroke, and recurrent ischemia.

Table 1. Comparison of Reperfusion Characteristics

Characteristic	Primary PCI	Thrombolytic therapy	Overall interpretation
Mechanism of reperfusion	Direct mechanical restoration of coronary flow	Pharmacological thrombus dissolution	PPCI directly treats the obstructed coronary artery
Epicardial vessel patency	Generally more reliable	Variable	PPCI provides more consistent reperfusion
Complete coronary reperfusion	More frequently achieved	Less predictable	Mechanical reperfusion generally provides better angiographic results
Treatment availability	Requires PCI-capable facility and trained team	More widely available	Fibrinolysis is advantageous where PCI access is limited
Dependence on transfer systems	High when performed at non-PCI hospitals	Lower for initial treatment	Fibrinolysis can reduce treatment delay in remote settings
Need for subsequent angiography	May still be required for assessment	Frequently required after fibrinolysis	Pharmacoinvasive management is often necessary
Treatment-related delay	May increase with transfer	Can be administered rapidly	Timing determines the relative benefit

PPCI provided more reliable restoration of coronary artery patency than fibrinolysis when it was performed promptly. However, the advantage of PPCI could be reduced when substantial transfer or

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procedural delays occurred. Contemporary guidelines therefore emphasize total ischemic time and recommend fibrinolysis when timely PPCI cannot be achieved [1,3].

Table 2. Major Clinical Outcomes

Clinical outcome	Primary PCI	Thrombolytic therapy	Comparative interpretation
Short-term mortality	Lower	Higher overall	PPCI showed a mortality advantage in comparative evidence
Long-term mortality	Generally lower	Higher	Benefit persisted in randomized evidence
Recurrent myocardial infarction	Lower	Higher	PPCI reduced reinfarction
Recurrent ischemia	Lower	Higher	More complete reperfusion with PPCI reduced recurrent ischemia
Urgent repeat revascularization	Less frequent	More frequent	Fibrinolysis was more likely to require subsequent intervention
Stroke	Lower	Higher	Fibrinolysis carried greater stroke risk
Hemorrhagic stroke	Lower	Higher	Intracranial bleeding was an important fibrinolysis-related concern
Major bleeding	Generally lower systemic bleeding risk	Greater systemic bleeding concern	Bleeding risk favored PPCI in many comparisons

The available evidence consistently favored PPCI for major clinical outcomes when timely intervention was possible. A large meta-analysis reported reductions in short-term mortality and stroke with PPCI

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compared with fibrinolysis, while randomized evidence also demonstrated lower long-term mortality and reinfarction [4]. Another systematic review involving more than 11,000 patients reported higher mortality with fibrinolysis across several follow-up periods [5].

Table 3. Advantages and Disadvantages of Each Reperfusion Strategy

Domain	Primary PCI	Thrombolytic therapy
Reperfusion efficacy	High and generally predictable	Variable and dependent on thrombus response
Mortality outcome	Generally more favorable	Less favorable when compared with timely PPCI
Stroke risk	Lower	Higher, particularly hemorrhagic stroke
Bleeding risk	Lower systemic fibrinolytic exposure	Important systemic bleeding risk
Reperfusion failure	Less common	More frequent
Reinfarction	Lower	Higher
Treatment accessibility	Limited to PCI-capable systems	Widely available
Speed in remote settings	Can be delayed by transfer	Can be administered rapidly
Need for rescue intervention	Lower	More frequent after failed fibrinolysis
Infrastructure requirements	High	Lower

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The results demonstrated that PPCI had important clinical advantages but depended on specialized infrastructure. Thrombolytic therapy provided a practical reperfusion option when patients were distant from PCI centers or when transfer would result in clinically significant treatment delay.

Table 4. Clinical Circumstances Favoring Each Reperfusion Strategy

Clinical circumstance	Preferred strategy	Rationale
STEMI at PCI-capable center with rapid catheterization access	Primary PCI	Provides direct and reliable reperfusion
STEMI at non-PCI center with timely transfer possible	Primary PCI after transfer	Mechanical reperfusion remains preferred when achievable promptly
Expected prolonged delay to PPCI	Thrombolytic therapy when eligible	Avoids prolonged untreated ischemia
Early presentation with large myocardial territory at risk	Strategy determined by reperfusion delay and bleeding risk	Rapid reperfusion is the priority
High bleeding risk or fibrinolysis contraindication	Primary PCI	Avoids systemic thrombolytic exposure
Failed or incomplete fibrinolysis	Rescue PCI	Restores coronary flow mechanically
Successful fibrinolysis	Early angiographic evaluation/PCI strategy	Reduces recurrent ischemia and reinfarction
Limited PCI infrastructure	Fibrinolysis with transfer pathway	Provides immediate reperfusion while preserving access to PCI

Current guideline recommendations support PPCI when it can be delivered within the recommended time window and fibrinolysis when timely PPCI cannot be achieved in eligible patients without contraindications [1,3]. Following fibrinolysis, transfer to a PCI-capable center remains important because subsequent angiography and PCI may be required.

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Discussion

The present assessment demonstrated that primary percutaneous coronary intervention generally provided superior outcomes compared with thrombolytic therapy for STEMI when it was performed promptly. PPCI was associated with lower mortality, reinfarction, recurrent ischemia, and stroke, while thrombolytic therapy remained valuable when rapid mechanical reperfusion was unavailable.The superiority of PPCI is supported by extensive comparative evidence. A Bayesian meta-analysis of randomized trials and observational studies demonstrated lower short-term mortality with PPCI compared with fibrinolysis and also reported substantial reductions in stroke. At longer follow-up, randomized trials demonstrated lower mortality and reinfarction following PPCI [4]. These findings support the use of mechanical reperfusion as the preferred strategy when treatment can be delivered rapidly.A separate systematic review and meta-analysis of randomized trials also demonstrated higher mortality among patients receiving fibrinolysis compared with PPCI across in-hospital, short-term, mid-term, and long-term follow-up [5]. The consistency of these findings across different follow-up periods suggests that the benefits of effective initial reperfusion extend beyond the acute hospitalization.The reduction in reinfarction observed with PPCI is clinically important. Fibrinolysis may produce incomplete thrombus resolution or early reocclusion of the infarct-related artery. PPCI directly addresses the culprit coronary lesion and therefore provides more stable restoration of coronary flow. The lower need for urgent repeat revascularization observed after PPCI is consistent with this mechanism.Stroke represents one of the most important safety differences between the two strategies. A systematic review of prehospital fibrinolysis and PPCI found comparable mortality in selected early-treatment populations but demonstrated a higher risk of any stroke and hemorrhagic stroke with fibrinolysis [6]. This difference reflects the systemic nature of fibrinolytic treatment and its potential to produce intracranial bleeding.Nevertheless, the present findings did not support complete replacement of fibrinolysis by PPCI. The effectiveness of PPCI depends on rapid access to an experienced PCI team. When patients present to hospitals without PCI capability, prolonged transfer can increase total ischemic time and reduce the theoretical advantage of mechanical reperfusion. Current ESC recommendations therefore indicate that fibrinolysis remains appropriate when PPCI cannot be performed within 120 minutes in eligible patients [1,3].Treatment timing is consequently central to the comparison. Contemporary STEMI systems emphasize minimizing patient, emergency medical service, and hospital delays. PPCI is most advantageous when the interval from diagnosis to mechanical reperfusion is short. Conversely, fibrinolysis can be advantageous when it can be administered substantially earlier than catheter-based reperfusion.The role of fibrinolysis has also evolved through pharmaco-invasive treatment strategies. Evidence demonstrated that routine early PCI following fibrinolysis reduced reinfarction and recurrent ischemia compared with standard treatment [7]. Thus, fibrinolysis does not necessarily represent a competing endpoint to PCI; in appropriate settings, it can serve as an initial reperfusion strategy followed by planned angiographic evaluation.However, immediate PCI directly after fibrinolysis is not necessarily beneficial. Evidence comparing immediate intervention with primary PCI showed increased short-term mortality, reinfarction, and major bleeding in some immediate-treatment strategies, whereas appropriately timed early PCI after fibrinolysis provided more favorable outcomes [8]. This distinction supports structured pharmaco-invasive protocols rather than indiscriminate immediate catheterization.The findings also emphasize the importance of patient-specific contraindications. Patients with major bleeding risk or contraindications to fibrinolysis require mechanical reperfusion when feasible. Conversely, patients with substantial expected PCI delays may benefit from early fibrinolytic therapy if they are otherwise eligible. Therefore, treatment selection should be based on the interaction between clinical risk and system-level treatment delay.The evidence from prehospital fibrinolysis further illustrates the importance of timing. In selected patients treated very early, prehospital fibrinolysis produced mortality outcomes comparable with PPCI, although stroke risk remained higher [6]. This suggests that the relative benefit of each strategy can change when the time

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advantage of fibrinolysis is substantial.Modern STEMI management therefore emphasizes regional networks rather than choosing one reperfusion strategy in isolation. Emergency medical services, non-PCI hospitals, and PCI centers should operate through coordinated protocols that minimize treatment delay. Current European guidance recommends immediate transfer to PCI-capable centers after fibrinolysis and emphasizes rapid transfer for patients selected for PPCI [1].Overall, the present comparison supports PPCI as the preferred reperfusion strategy for STEMI when it can be delivered promptly. Thrombolytic therapy remains a valuable alternative when timely PPCI is unavailable, particularly when fibrinolysis can be administered rapidly and without contraindications. The most effective system is therefore one that provides immediate reperfusion by whichever appropriate method minimizes total ischemic time and ensures subsequent access to PCI when required.

Conclusion

Primary percutaneous coronary intervention provides superior reperfusion and generally better clinical outcomes than thrombolytic therapy in patients with ST-elevation myocardial infarction when it can be performed promptly. PPCI is associated with lower mortality, reinfarction, recurrent ischemia, and stroke and provides more reliable restoration of coronary artery patency.Thrombolytic therapy remains an important reperfusion strategy when timely PPCI cannot be achieved. Its principal advantages are rapid administration and broad availability, particularly in healthcare settings without immediate access to catheterization laboratories. However, its use is limited by contraindications, incomplete reperfusion, recurrent ischemia, and increased bleeding and intracranial hemorrhage risk.The optimal strategy should therefore be determined by the expected time to PPCI, symptom duration, bleeding risk, contraindications, and local healthcare infrastructure. When fibrinolysis is administered because timely PPCI is unavailable, patients should be transferred to a PCI-capable center for appropriate angiographic evaluation and further intervention. Rapid diagnosis, coordinated STEMI networks, and minimization of total ischemic time remain essential for improving patient outcomes.

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