



TIMI (Thrombolysis in Myocardial Infarction) Flow Grade in ST Elevation Myocardial Infarction after Primary Percutaneous Intervention: Prevalence and Determinants

Tariq Rahim¹, Mohib Ullah Khan¹, Tariq Shah¹, Jawad Ahmad¹, Kashif Ali Khan¹, Hamad Ali Shah¹, Syed Muzammil Shah¹

¹Department of Interventional Cardiology, Lady Reading Hospital, Peshawar, KP, Pakistan.

ARTICLE INFO

Keywords: STEMI, TIMI Flow Grade, Primary Percutaneous Coronary Intervention, Myocardial Reperfusion, Mortality, Door-to-balloon Time.

Correspondence to: Mohib Ullah Khan, Department of Interventional Cardiology, Lady Reading Hospital, Peshawar, KP, Pakistan.

Email: mohib467@hotmail.com

Declaration

Authors' Contribution

All authors equally contributed to the study and approved the final manuscript

Conflict of Interest: No conflict of interest.

Funding: No funding received by the authors.

Article History

Received: 09-02-2025 Revised: 21-04-2025
Accepted: 12-05-2025 Published: 30-05-2025

ABSTRACT

Background: Optimal coronary reperfusion through PPCI in ST-elevation myocardial infarction (STEMI) is essential for improving outcomes. The Thrombolysis in Myocardial Infarction (TIMI) flow grade remains the definitive standard for evaluating epicardial perfusion success. **Objectives:** To investigate TIMI (0-3) flow grades in a cohort of 500 STEMI patients undergoing PPCI with door-to-balloon (D2B) times of ≥ 90 min and identify clinical, angiographic, and procedural determinants of achieving optimal TIMI (3) flow. **Methods:** This retrospective cohort study examined 500 patients with STEMI and D2B times ≥ 90 min who underwent PPCI over 12 months. Data on clinical, angiographic, and procedural characteristics were collected, and multivariate regression analysis was used to determine the predictors of TIMI (3) flow grade. **Results:** In a cohort of 500 patients (mean age 64.8 ± 11.5 years, 70.4% males), TIMI (3) flow was achieved in 357 patients (71.4%). The TIMI grade distribution was as follows: TIMI (0) in 52 patients (10.4%), TIMI (1) in 43 patients (8.6%), and TIMI (2) in 48 patients (9.6%). A significant inverse correlation existed between in-hospital mortality and TIMI flow grade, with mortality rates of 30.8% for TIMI (0), 20.9% for TIMI (1), 12.5% for TIMI (2), and 4.5% for TIMI (3) ($p < 0.001$). Independent predictors of suboptimal TIMI flow included advanced age (OR 1.04, 95% CI 1.02-1.07), extended D2B time (OR 1.02, 95% CI 1.00-1.04), diabetes mellitus (OR 1.58, 95% CI 1.08-2.31), and Killip Class II-IV (OR 1.72, 95% CI 1.15-2.58). **Conclusions:** In a cohort of 500 STEMI patients with D2B times ≥ 90 min, 71.4% achieved an optimal TIMI grade (3). TIMI grade denotes a key indicator of in-hospital mortality. These findings highlight the need to optimise procedures and implement targeted interventions in high-risk subgroups.

INTRODUCTION

ST-elevation myocardial infarction (STEMI) is the most acute presentation of coronary artery disease, necessitating immediate reperfusion therapy to mitigate myocardial necrosis and enhance survival outcomes. Primary percutaneous coronary intervention (PCI) has become the preferred reperfusion strategy when performed promptly by skilled professionals (Ibanez et al. 2018).

The efficacy of PPCI is conventionally evaluated using the TIMI grading system, which assesses epicardial coronary perfusion on a scale of 0 (no perfusion) to-3 (complete perfusion). The TIMI flow classification system was established by the TIMI Study Group to provide a standardised method for evaluating coronary artery flow during angiography (Appleby et al. 2000). TIMI Grade (0) signifies no perfusion, with no antegrade flow beyond the occlusion. TIMI Grade (1) denotes penetration without perfusion, where the contrast traverses the obstruction

but fails to opacify the coronary bed distal to the occlusion. TIMI Grade (2) reflects partial perfusion, with contrast moving past the obstruction at a reduced velocity compared to normal flow. TIMI Grade (3) indicates full perfusion with normal antegrade flow and contrast clearance (Stone et al. 2001).

Achieving TIMI (3) flow post-PPCI is associated with significantly improved clinical outcomes, including reduced mortality, lower incidence of heart failure, and better preservation of left ventricular function. Contemporary studies report TIMI (3) flow achievement rates ranging from 80-96% in patients with STEMI undergoing primary PCI within optimal time frames (Shah et al. 2022).

However, in real-world practice, many patients present with D2B times exceeding 90 min, necessitating careful evaluation of the outcomes in this population. Understanding contemporary patterns of TIMI flow in patients with prolonged D2B times is essential for

optimising PPCI outcomes in real-world settings (McNamara et al. 2006).

This study aimed to evaluate the prevalence of TIMI flow grades in a large cohort of 500 STEMI patients with D2B times ≥ 90 min and to determine the independent clinical, angiographic, and procedural factors associated with optimal TIMI (3) flow.

METHODOLOGY

This retrospective cohort study examined 500 consecutive patients with STEMI who underwent PPCI at Lady Reading Hospital, Peshawar, from 1 February 2024 to 31 January 2025. This study followed the STROBE guidelines for observational research and focused on patients with D2B times of ≥ 90 min, reflecting real-world institutional practice patterns.

The inclusion criteria involved patients aged ≥ 18 years diagnosed with STEMI, characterised by typical chest pain, specific electrocardiographic changes (ST-elevation ≥ 1 mm in ≥ 2 contiguous leads), and elevated cardiac biomarkers, who underwent PPCI within 12 h of symptom onset, with a D2B time ≥ 90 min.

The exclusion criteria comprised individuals with a history of coronary artery bypass grafting, those experiencing cardiogenic shock necessitating mechanical circulatory support, incomplete angiographic or clinical records, known terminal illness with a life expectancy of < 6 months, and a door-to-balloon time of < 90 min.

Data encompassing comprehensive clinical, angiographic, and procedural aspects were systematically gathered from electronic health records, catheterisation

laboratory reports, and hospital databases using a standardised data extraction form. Clinical variables comprised patient demographics, cardiovascular risk factors, presentation characteristics, and laboratory values. The GRACE risk score was computed for risk stratification.

Continuous variables were characterised using means and standard deviations, and categorical variables were described using frequencies and percentages. A multivariate logistic regression analysis was conducted using backward elimination, with a significance level set at $p < 0.05$. All statistical analyses were performed using SPSS (version 29.0).

This study followed the Declaration of Helsinki principles and received Institutional Review Board approval.

RESULTS

Study Population and Baseline Characteristics

The baseline characteristics and clinical presentation data provided significant insights into patients with TIMI 3 flow compared to those with non-TIMI 3 flows. The observed differences in these characteristics may indicate potential risk factors and the implications of failing to achieve optimal TIMI 3 flow in clinical settings. Notably, the mean age differed significantly between the two groups, with patients in the non-TIMI 3 flow group being older on average (68.5 years) than those in the TIMI 3 flow group (63.2 years), suggesting that age is a potential factor influencing blood flow post-intervention.

Table 1

Baseline Characteristics and Clinical Presentation (N=500)

| Characteristic | Overall (N=500) | TIMI 3 Flow (N=357) | Non-TIMI 3 Flow (N=143) | p-value |
|--|------------------|---------------------|-------------------------|---------|
| Demographics | | | | |
| Age (years), mean \pm SD | 64.8 \pm 11.5 | 63.2 \pm 10.9 | 68.5 \pm 12.3 | <0.001 |
| Male sex, n (%) | 352 (70.4) | 258 (72.3) | 94 (65.7) | 0.145 |
| Cardiovascular Risk Factors | | | | |
| Hypertension, n (%) | 298 (59.6) | 208 (58.3) | 90 (62.9) | 0.342 |
| Diabetes mellitus, n (%) | 158 (31.6) | 102 (28.6) | 56 (39.2) | 0.023 |
| Dyslipidemia, n (%) | 247 (49.4) | 178 (49.9) | 69 (48.3) | 0.742 |
| Current smoking, n (%) | 175 (35.0) | 128 (35.9) | 47 (32.9) | 0.537 |
| Clinical Presentation | | | | |
| Killip Class I, n (%) | 368 (73.6) | 275 (77.0) | 93 (65.0) | 0.008 |
| Killip Class II, n (%) | 95 (19.0) | 62 (17.4) | 33 (23.1) | |
| Killip Class III, n (%) | 27 (5.4) | 15 (4.2) | 12 (8.4) | |
| Killip Class IV, n (%) | 10 (2.0) | 5 (1.4) | 5 (3.5) | |
| Angiographic Characteristics | | | | |
| LAD as infarct-related artery, n (%) | 225 (45.0) | 162 (45.4) | 63 (44.1) | 0.793 |
| RCA as infarct-related artery, n (%) | 175 (35.0) | 125 (35.0) | 50 (35.0) | |
| LCx as infarct-related artery, n (%) | 75 (15.0) | 52 (14.6) | 23 (16.1) | |
| Left main as infarct-related artery, n (%) | 25 (5.0) | 18 (5.0) | 7 (4.9) | |
| Procedural Characteristics | | | | |
| Door-to-balloon time (min), mean \pm SD | 105.2 \pm 16.8 | 103.8 \pm 15.9 | 108.5 \pm 18.7 | 0.005 |
| Radial access, n (%) | 368 (73.6) | 268 (75.1) | 100 (69.9) | 0.234 |

(LAD) = left anterior descending artery; **(RCA)** = right coronary artery; **(LCX)** = left circumflex artery.

The prevalence of diabetes mellitus was higher in the non-TIMI 3 flow group (39.2%) than in the TIMI 3 flow group (28.6%), with a p-value indicating statistical significance ($p=0.023$). Hypertension was slightly more prevalent in the non-TIMI 3 flow group (62.9%) than in the TIMI 3 flow group (58.3%); however, this difference was not statistically significant ($p=0.342$). Those with non-TIMI 3 flow also presented with worse Killip class, with a greater number in classes II-IV ($p=0.008$). The D2B time was

longer in the non-TIMI 3 flow group (108.5 vs. 103.8 min, $p=0.005$). Independent predictors of suboptimal TIMI flow included advanced age (OR 1.04 per year), longer D2B time (OR 1.02 per minute), diabetes mellitus (OR 1.58), and Killip class II-IV (OR 1.72). An inverse correlation was observed between TIMI flow grade and in-hospital mortality, with TIMI 0, 1, 2, and 3 associated with 30.8%, 20.9% mortality, TIMI 2 with 12.5%, and TIMI 3 with 4.5% mortality, respectively.

TIMI Flow Grade Distribution and Prevalence

The table demonstrates notable enhancements in blood flow after PPCI, as assessed by (TIMI) flow grades. Prior to PPCI, 92% of patients exhibited suboptimal blood flow (TIMI grades 0-2), with only 8% attaining the optimal TIMI-3 grade.

Table 2

TIMI Flow Grade Distribution (N=500)

| TIMI Flow Grade | Pre-PCI n (%) | Post-PCI n (%) |
|----------------------------|---------------|----------------|
| TIMI 0 | 315 (63.0) | 52 (10.4) |
| TIMI 1 | 89 (17.8) | 43 (8.6) |
| TIMI 2 | 56 (11.2) | 48 (9.6) |
| TIMI 3 | 40 (8.0) | 357 (71.4) |
| Optimal flow (TIMI 3) | 40 (8.0) | 357 (71.4) |
| Suboptimal flow (TIMI 0-2) | 460 (92.0) | 143 (28.6) |

Following PPCI, there was a substantial increase in the proportion of patients achieving TIMI-3 grade, rising to 71.4% from 8%, thereby underscoring the efficacy of PPCI in restoring coronary artery blood flow. Nonetheless, 28.6% of patients continued to experience suboptimal flow post-PPCI.

Clinical Outcomes by TIMI Flow Grade

The clinical outcomes associated with TIMI flow grade, as delineated in Table 3, demonstrated significant variations across several conditions, including in-hospital mortality, heart failure, and left ventricular ejection fraction (LVEF), contingent upon the TIMI flow grade attained post-coronary intervention. The data revealed a pronounced disparity in mortality rates among the different TIMI flow grades. Patients with TIMI 0 exhibited the highest in-hospital mortality rate of 30.8%, which was markedly higher than that in patients with TIMI 3 grade, who showed a mortality rate of merely 4.5%.

Table 3

Clinical Outcomes by TIMI Flow Grade (N=500)

| Outcome | TIMI 0 (N=52) | TIMI 1 (N=43) | TIMI 2 (N=48) | TIMI 3 (N=357) | p-value |
|------------------------------|---------------|---------------|---------------|----------------|---------|
| In-hospital mortality, n (%) | 16 (30.8) | 9 (20.9) | 6 (12.5) | 16 (4.5) | <0.001 |
| Heart failure, n (%) | 28 (53.8) | 18 (41.9) | 15 (31.3) | 58 (16.2) | <0.001 |
| Reinfarction, n (%) | 3 (5.8) | 2 (4.7) | 2 (4.2) | 8 (2.2) | 0.185 |
| Stroke, n (%) | 2 (3.8) | 1 (2.3) | 1 (2.1) | 4 (1.1) | 0.235 |
| Major bleeding, n (%) | 5 (9.6) | 4 (9.3) | 4 (8.3) | 26 (7.3) | 0.652 |
| LVEF (%), mean ± SD | 36.2 ± 8.8 | 38.9 ± 9.2 | 42.8 ± 9.1 | 47.9 ± 8.6 | <0.001 |

(LVEF)= left ventricular ejection fraction

The incidence of heart failure was inversely correlated with the TIMI flow grade. Patients with TIMI 0 flow experienced a 53.8% occurrence of heart failure, which progressively decreased to 16.2% in TIMI 3. These outcomes did not exhibit significant variation across TIMI grades, with reinfarction rates being marginally higher at lower flow grades (TIMI 0, 5.8%; TIMI 3, 2.2%) but not achieving statistical significance (p = 0.185). Similarly, the stroke rates remained relatively low across all groups and did not differ significantly. The incidence of major bleeding was relatively consistent across different flow grades, indicating that although the TIMI flow grade significantly

influenced mortality and heart failure, it did not substantially impact the bleeding risk (p = 0.652). The enhancement in LVEF with improved TIMI flow was evident. TIMI 0 had the lowest mean LVEF at 36.2%, whereas TIMI 3 had a significantly higher LVEF at 47.9% (p < 0.001).

Independent Predictors of Suboptimal TIMI Flow

Table 4 outlines several key factors contributing to this condition. The analysis indicated that age, D2B time, diabetes mellitus, and Killip Class II-IV were significant predictors of suboptimal TIMI flow in patients who underwent PPCI for acute myocardial infarction.

Table 4

Analysis of factors predicting poor TIMI flow (≤2) using multivariate logistic regression (N=500)

| Variable | Adjusted Odds Ratio | 95% Confidence Interval | p-value |
|--|---------------------|-------------------------|---------|
| Age (per year increase) | 1.04 | 1.02-1.07 | 0.001 |
| Door-to-balloon time (per minute increase) | 1.02 | 1.00-1.04 | 0.032 |
| Diabetes mellitus | 1.58 | 1.08-2.31 | 0.018 |
| Killip Class II-IV | 1.72 | 1.15-2.58 | 0.008 |

Model Statistics: C-statistic: 0.74 (95% CI: 0.69-0.79), Hosmer-Lemeshow p-value: 0.186, Nagelkerke R²: 0.19, CI = confidence interval

The likelihood of experiencing suboptimal TIMI flow increased by 4% for each additional year of age. An increase in D2B time was associated with a 2% increase in the odds of suboptimal flow per minute of delay. Patients with diabetes mellitus exhibited a 58% higher likelihood of suboptimal TIMI flow than non-diabetic individuals. Furthermore, being classified as Killip Class II-IV significantly elevated the odds of impaired blood flow post-PCI by 72%, with this classification serving as an important determinant of TIMI flow prognosis.

Temporal Factors and Clinical Outcomes

The mean D2B time was 105.2 ± 16.8 min, with a range of 90–145 min. Within this constrained timeframe, patients who experienced shorter door-to-balloon times demonstrated improved outcomes. Specifically, patients with reperfusion times between 90 and 100 min achieved TIMI 3 flow in 75.8% of cases, in contrast to 66.2% of those with times exceeding 110 min (p=0.012).

DISCUSSION

This extensive retrospective cohort study, which included 500 STEMI patients with D2B time ≥90 min, yielded several important findings. The present findings substantiate the assertion that advanced age is a significant risk factor for impaired coronary flow following intervention, underscoring the necessity of timely medical intervention to achieve optimal outcomes. Furthermore, diabetes is a critical cardiovascular risk factor that affects blood flow during emergencies. These findings contribute to the identification of high-risk individuals who may benefit from more intensive monitoring and prompt intervention to mitigate the impact of these risk factors on TIMI flow outcomes (Elakabawi et al. 2020; Maruszak et al. 2023).

Understanding these predictors can enhance clinical decision-making and patient management strategies in emergency cardiology. Although hypertension is a prevalent comorbidity, it does not independently predict suboptimal TIMI flow (Proietti et al. 2025). The proportion of current smokers was comparable between the two groups, indicating that smoking did not significantly influence the TIMI flow outcomes in this dataset. Higher TIMI flow grades were associated with a decreased incidence of heart failure and enhanced left ventricular ejection fraction (Wei et al. 2017). Even when D2B times were ≥ 90 min, achieving TIMI 3 flow was associated with significantly improved clinical outcomes. These findings underscore the critical importance of attaining optimal TIMI 3 flow in patients with STEMI undergoing primary PCI, even in instances of prolonged D2B times (Bradley et al. 2006).

The Killip classification serves as an essential prognostic tool, ranging from Killip Class I (no heart failure) to Class IV (cardiogenic shock). Research indicated that Higher Killip class was associated with poorer clinical outcomes (Riaz et al. 2025). The observed correlation between increased age and suboptimal coronary flow was consistent with the existing literature, which attributed this relationship to the presence of more complex coronary pathology and reduced vascular adaptability (Khan et al. 2022).

Hyperglycaemia induced by diabetes, a prevalent condition among patients with diabetes, has been associated with adverse clinical outcomes, including suboptimal initial TIMI flow, potentially explaining the discrepancies observed in our study (Stalikas et al. 2022). Other modifiable factors, such as thrombus burden and baseline TIMI flow, have been shown to exert a more direct influence on flow outcomes (Duman et al. 2015). Conversely, a p -value of 0.235 suggested that variations in blood flow impact different clinical outcomes variably, with bleeding more likely attributable to procedural or patient-related factors rather than solely to reperfusion success (Kim et al. 2022). The Left Ventricular Ejection Fraction (LVEF) metric underscored the efficacy of achieving TIMI 3 flow in preserving cardiac function,

thereby potentially influencing long-term cardiac outcomes positively (Jiang et al. 2024).

Integrating clinical presentation data with procedural characteristics provides a framework for predicting outcomes and tailoring treatment strategies. The post-intervention TIMI flow grade significantly influenced clinical outcomes, particularly in-hospital mortality, heart failure, and left ventricular ejection fraction (LVEF). Achieving TIMI 3 flow improved these results. Although reinfarction, stroke, and bleeding rates showed no significant variation with TIMI flow, optimal blood flow remains essential for patient outcomes.

The analysis of baseline characteristics revealed the interplay of demographic and clinical factors affecting coronary blood flow and outcomes post-primary percutaneous coronary intervention (PPCI), with age and diabetes mellitus as critical factors.

The limitations of this study include its retrospective design, single-centre setting, and specific focus on patients experiencing prolonged door-to-balloon times. In addition, the study did not evaluate the TIMI myocardial perfusion grade or other indicators of microvascular function.

Future research should prioritise the development of targeted interventions for patient subgroups identified as being at high risk. Additionally, it is imperative to investigate the correlation between TIMI flow grade and long-term outcomes in patients with extended D2B time.

CONCLUSIONS

Integrating clinical presentation data with procedural characteristics provides a framework for predicting outcomes and tailoring treatment. The post-intervention TIMI flow grade significantly influenced clinical outcomes, particularly mortality, heart failure, and left ventricular ejection fraction (LVEF). Achieving TIMI 3 flow improved these results. While reinfarction, stroke, and bleeding rates showed no variation with TIMI flow, optimal blood flow remained essential. Analysis of the baseline characteristics revealed that demographic and clinical factors affected coronary flow and outcomes post (PPCI), with age and diabetes as critical factors.

REFERENCES

- Appleby, M. A., Michaels, A. D., Chen, M., & Michael, C. G. (2000). Importance of the TIMI frame count: Implications for future trials. *Trials*, 1(1).
<https://doi.org/10.1186/cvm-1-1-031>
- Bradley, E. H., Herrin, J., Wang, Y., Barton, B. A., Webster, T. R., Mattern, J. A., Roumanis, S. A., Curtis, J. P., Nallamothu, B. K., Magid, D. J., McNamara, R. L., Parkosewich, J., Loeb, J. M., & Krumholz, H. M. (2006). Strategies for reducing the door-to-Balloon time in acute myocardial infarction. *New England Journal of Medicine*, 355(22), 2308-2320.
<https://doi.org/10.1056/nejmsa063117>
- Duman, H., Çetin, M., Durakoğul, M. E., Değirmenci, H., Hamur, H., Bostan, M., Karadağ, Z., & Çiçek, Y. (2015). Relation of Angiographic thrombus burden with severity of coronary artery disease in patients with ST segment elevation myocardial infarction. *Medical Science Monitor*, 21, 3540-3546.
<https://doi.org/10.12659/msm.895157>
- Elakabawi, K., Huang, X., Shah, S. A., Ullah, H., Mintz, G. S., Yuan, Z., & Guo, N. (2020). Predictors of suboptimal coronary blood flow after primary angioplasty and its implications on short-term outcomes in patients with acute anterior STEMI. *BMC Cardiovascular Disorders*, 20(1).
<https://doi.org/10.1186/s12872-020-01673-0>
- Ibanez, B., James, S., Agewall, S., Antunes, M. J., Bucciarelli-Ducci, C., Bueno, H., Caforio, A. L., Crea, F., Goudevanos, J. A., Halvorsen, S., Hindricks, G., Kastrati, A., Lenzen, M. J., Prescott, E., Roffi, M., Valgimigli, M., Varenhorst, C., Vranckx, P., & Widimský, P. (2018). 2017 ESC guidelines for the management of acute myocardial infarction in patients presenting with ST-segment elevation. *Kardiologia Polska*, 76(2), 229-313.
<https://doi.org/10.5603/kp.2018.0041>
- Jiang, Y., Chen, X., Zhang, X., Dong, S., & Liu, Y. (2024). Dynamic trajectories of left ventricular ejection fraction in heart failure with improved ejection fraction. *BMC Cardiovascular Disorders*, 24(1).

- <https://doi.org/10.1186/s12872-024-04288-x>
Khan, A., Latif, A., S., Khalil, M. S., Parvez, M., & Ikram, Z. (2022). Predictors of Suboptimal coronary blood flow during primary percutaneous intervention. *Pakistan Journal of Medical and Health Sciences*, 16(10), 908-910.
<https://doi.org/10.53350/pjmhs221610908>
- Kim, Y. H., Her, A., Jeong, M. H., Kim, B., Hong, S., Kim, S., Ahn, C., Kim, J., Ko, Y., Choi, D., Hong, M., & Jang, Y. (2021). Two-year clinical outcomes according to Pre-PCI TIMI flow grade and Reperfusion timing in Non-STEMI after newer-generation drug-eluting stents implantation. *Angiology*, 73(2), 152-164.
<https://doi.org/10.1177/00033197211012537>
- Maruszak, N., Pilch, W., Januszek, R., Malinowski, K. P., Surdacki, A., & Chyrchel, M. (2023). Risk factors of Suboptimal coronary blood flow after a percutaneous coronary intervention in patients with acute anterior wall myocardial infarction. *Journal of Personalized Medicine*, 13(8), 1217.
<https://doi.org/10.3390/jpm13081217>
- McNamara, R. L., Wang, Y., Herrin, J., Curtis, J. P., Bradley, E. H., Magid, D. J., Peterson, E. D., Blaney, M., Frederick, P. D., & Krumholz, H. M. (2006). Effect of door-to-Balloon time on mortality in patients with ST-segment elevation myocardial infarction. *Journal of the American College of Cardiology*, 47(11), 2180-2186.
<https://doi.org/10.1016/j.jacc.2005.12.072>
- Proietti, R., Palazzolo, M. G., Ruff, C. T., Lip, G. Y., & Giugliano, R. P. (2025). Long-term visit-to-visit blood pressure variability and risk of cardiovascular and bleeding events: Insights from the ENGAGE AF-TIMI 48 trial. *Hypertension Research*, 48(4), 1613-1618.
<https://doi.org/10.1038/s41440-024-02083-x>
- Riaz, G., Khan, N., Haq, E. U., Kumari, S., Hussain, I., & Zada, S. (2025). Mortality predictors and in-hospital outcomes in high Killip class STEMI patients: Insights from a tertiary cardiac center. *Pakistan Heart Journal*, 58(1), 51-58.
<https://doi.org/10.47144/phj.v58i1.2765>
- Shah, S. D., Shah, A. A., Qasim, A., Khan, M. S., Ahmed, F., & Wahid, A. (2022). Association between TIMI risk score and in-hospital mortality in acute STEMI patients undergoing primary PCI. *Pakistan Journal of Medical and Health Sciences*, 16(11), 158-160.
<https://doi.org/10.53350/pjmhs20221611158>
- Stalikas, N., Papazoglou, A. S., Karagiannidis, E., Panteris, E., Moysidis, D., Daios, S., Anastasiou, V., Patsiou, V., Koletsa, T., Sofidis, G., Sianos, G., & Giannakoulas, G. (2022). Association of stress induced hyperglycemia with angiographic findings and clinical outcomes in patients with ST-elevation myocardial infarction. *Cardiovascular Diabetology*, 21(1).
<https://doi.org/10.1186/s12933-022-01578-6>
- Stone, G. W., Cox, D., Garcia, E., Brodie, B. R., Morice, M., Griffin, J., Mattos, L., Lansky, A. J., O'Neill, W. W., & Grines, C. L. (2001). Normal flow (TIMI-3) before mechanical Reperfusion therapy is an independent determinant of survival in acute myocardial infarction. *Circulation*, 104(6), 636-641.
<https://doi.org/10.1161/hc3101.093701>
- Wei, X., Liu, Y., He, P., Jiang, L., Zhou, Y., Chen, J., Tan, N., & Yu, D. (2016). Additive prognostic value of left ventricular ejection fraction to the TIMI risk score for in-hospital and long-term mortality in patients with ST segment elevation myocardial infarction. *Journal of Thrombosis and Thrombolysis*, 43(1), 1-6.
<https://doi.org/10.1007/s11239-016-1407-7>