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Zwolle Risk Score as a Predictor of In-Hospital Mortality in Post Primary Percutaneous Coronary Intervention St-Elevation Myocardial Infarction Patients

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ABSTRACT

Objective: To determine the Zwolle Risk Score's (ZRS) prediction accuracy during coronary angiography for clinical outcome in post PCI patients with ST-elevation myocardial infarction keeping in-hospital mortality as primary endpoint.
Study Design: Analytical Cross sectional study.
Place and Duration of Study: Adult Cardiology, Armed Forces Institute of Cardiology (AFIC/NNIHD) Rawalpindi, Pakistan from May to Nov 2025.
Methodology: Four hundred six STEMI patients of both sexes were enrolled, with age between 18 to 80 years using the non-probability consecutive sampling technique. Patients with NSTEMI, unstable angina, history of PCI or CABG, patients with incomplete clinical data were excluded. ZRS was calculated before the coronary angiography and a score >6 categorized as positive predictor of in-hospital mortality. Every patient was followed up by 72 hours to record mortality outcomes. The parameters of the diagnostic accuracy were determined.
Results: out of Four hundred six patients 311(76.6%) participants were men. Mean age was 38.75±13.07 years. We analyzed that 95(23.4%) patients were categorized as high risk on the basis of ZRS score while actual in-hospital mortality was counted as 43(10.6%). The study's sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy were 81.4%, 83.5%, 36.8%, 97.4%, and 83.3%, respectively.
Conclusion: The ZRS has a satisfactory diagnostic accuracy in predicting early in-hospital mortality in patients with STEMI who underwent PPCI, with a high sensitivity and negative predictive value. Its ability to repeatedly rule out the risk of early death makes it a practical tool in first-line triage and overall risk selection in acute heart care.

Keywords: In-hospital Mortality, Percutaneous coronary intervention, ST-elevation myocardial infarction, Zwolle Risk Score.

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INTRODUCTION

ST-segment elevation myocardial infarction (STEMI) is a critical cardiac emergency resulting from sudden blockage of a coronary artery, which compromises blood supply to the myocardium and leads to irreversible myocardial injury if not promptly treated.[1] According to the 2019 Global Burden of Disease study, Pakistan has a high cardiovascular disease burden, with an age-standardized incidence of 918.18 per 100,000 and a mortality rate of 357.88 per 100,000 to which STEMI contributes substantially.[2,3]

Early reperfusion using primary percutaneous coronary intervention (PPCI) or thrombolytic therapy is critical for restoring coronary blood flow and preserving threatened myocardial tissue. Timely re-perfusion with PPCI is associated with improved outcomes.[4,5]

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Patients presenting with STEMI have conventionally required management in an intensive care setting due to the risk of serious, life-threatening complications. With the widespread use of timely reperfusion through thrombolysis or primary PCI, the need for routine ICU admission may be reduced. Stable STEMI patients now experience fewer in-hospital complications, suggesting that intensive care resources may be over utilized in this group.[6] The Zwolle Risk Score (ZRS) is a simple risk assessment tool used to identify STEMI patients adequate for safe discharged within 72 hours.[7] This study was designed to assess the risk of complications in STEMI patients following percutaneous coronary intervention. The ZRS is based on six variables including Killip class, post-PCI thrombolysis in myocardial infarction (TIMI) flow, age, presence of three-vessel disease, anterior wall infarction, and ischemic time. The ZRS values indicate that a more severe myocardial damage correlates with a worse short-term prognosis. The score has been validated for identifying low-risk

STEMI patients suitable for early discharge; however, limited studies have evaluated its usefulness in guiding ward-based care instead of ICU admission after primary PCI.[6,7,8]

Predictive value of ZRS in local studies has yet to be evaluated. Due to variations in demographics, comorbidities, and healthcare accessibility, local validation is essential. This study was carried out to evaluate the predictive accuracy of ZRS for clinical outcomes in our local STEMI population following PPCI. Findings of this study will not only help to gather more data on the subject but would also guide tailored risk classification that will eventually help to improve post-PCI management.

METHODOLOGY

The Analytical Cross Sectional study was conducted at the Armed Forces Institute of Cardiology and National Institute of Heart Diseases in Rawalpindi; Pakistan, during six months after obtaining the ethical clearance, using non-probability consecutive sampling over a six-month period from May to November 2025 following approval of the study synopsis from the Institutional Ethical Review Board (IERB) under letter number (9/2/R&D/2025/356; Dated: 27 May, 2025).

The sample size was computed using the sensitivity specificity sample size calculator keeping sensitivity 87.5%,[10] specificity of 72.92%,[10] an estimated prevalence of 10.6%,[11] a confidence level of 95% and precision of 10%, calculated sample size was 397, a total of 406 patients recruit to increase power of study.

Inclusion Criteria: Patients aged 18–80 years regardless of gender presenting with STEMI were included in the study.

Exclusion Criteria: Patients with NSTEMI, unstable angina, percutaneous coronary intervention or coronary artery bypass graft surgery within 6 months, a terminal illness, malignancy or incomplete clinical records were excluded.

After informed consent, every eligible patient was thoroughly assessed which included a thorough history taking, physical examination, electrocardiography and biomarker testing. During the coronary angiography, the trainee researcher estimated the ZRS, which included age, Killip class, anterior infarction, ischemic time, TIMI flow after the procedure, and the number of diseased vessels; a score above six was considered as high-risk of in-hospital mortality 9 and a score of six or less as low-risk. A consultant cardiologist with above three years of teaching experience carried out coronary angiography and primary percutaneous coronary intervention. In-hospital mortality, or death within 72 hours of admission, was noted along with all demographic and clinical variables on a structured proforma.

Statistical Package for the Social Sciences Statistics version 23 was used to perform statistical analyses. Quantitative variables, including age and ischemic time, were summarized as median (IQR) as Shapiro-Wilk test was used to test distributional normality of quantitative variables and they were not normally distributed. All qualitative variables (gender, family history, comorbidities and results of diagnostic accuracy in terms of true positive, false positive, true negative, false negative) were presented in terms of frequencies and percentages. A contingency table of 2x 2 was designed to calculate sensitivity, specificity, positive predictive value, negative predictive value and general diagnostic accuracy of the ZRS based on available formulae. Stratification was done to address potential confounders (age, gender, family history of myocardial infarction, comorbidities, and delay in presentation) and recalculated post-stratification diagnostic accuracy in each subgroup.

RESULTS

We enrolled 406 patients for this study and analysis of the data revealed that mean age of the population was 43(24-53) years; while more than half of these patients belonged to age group <40 years. Study population was male dominant with 311(76.6%) males. Family history of MI was reported in 78(19.2%) total population. Mean time to presentation was 9(7-9) hours where 76.4% patients presented after 6 hours of onset of symptoms. It was noticed that 156(38.4%) of patients were smoker while hypertension and diabetes was positive in 150(36.9%) and 111(27.3%) of total study subjects respectively. Detailed analysis of qualitative variables is presented in Table-I.

Stratification analysis illuminated that ZRS has higher PPV among female 46.2% as compared to male and misclassification rate in both sexes was low with very less false negative rate. ZRS score found to be highly sensitive (88.9%) for patients with age between 18-40 years however specificity remained excellent for both age subgroups. ZRS accuracy was nearly similar among patients with family history of MI and those who don't have the family history of MI. However, ZRS reported a decent predictive strength in smokers, hypertensive and diabetic patients with sensitivity

ranges from 76-92% and specificity greater than 80%. Detailed stratification analysis for all the effect modifiers is presented in Table-II.

Table-I: Baseline Characteristics of Study Population (n = 406)

Variable(s)	Categories	Median (IQR)
Age (years)	Years	43 (24-53)
		Frequency (%)
	18–40 Years	207 (51.0%)
	41–60 Years	199 (49.0%)
Gender	Male	311 (76.6%)
	Female	95 (23.4%)
Family History of IHD	Yes	78 (19.2%)
	No	328 (80.8%)
Hypertension		150 (36.9%)
Diabetes Mellitus		111 (27.3%)
Smoking		156 (38.4%)
ZRS Mortality Prediction	Positive (High risk)	95 (23.4%)
	Negative (Low risk)	311 (76.6%)
In-Hospital Mortality	Yes	43 (10.6%)

IQR: Interquartile Range, IHD: Ischemic Heart Disease, ZRS: Zwolle Risk Score

Table-II: Diagnostic Accuracy of Zwolle Risk Score for Predicting In-Hospital Mortality (Stratification for all the Effect Modifiers) (n = 406)

Variable(s)		Sensitivity %	Specificity %	PPV %	NPV %	Accuracy %
Gender	Female	75.0%	92.0%	46.2%	97.6%	90.5%
	Male	82.9%	80.8%	35.4%	97.4%	81.0%
Age (Years)	18–40	88.9%	84.7%	35.6%	98.8%	85.0%
	41–60	76.0%	82.2%	38.0%	96.0%	81.9%
Family History	No	78.8%	84.1%	35.6%	97.3%	83.5%
	Yes	90.0%	80.9%	40.9%	98.2%	82.1%
Hypertension	No	76.9%	82.2%	32.8%	96.9%	81.6%
	Yes	88.2%	85.7%	44.1%	98.3%	86.0%
Diabetes	No	76.7%	84.2%	35.4%	97.0%	83.4%
	Yes	92.3%	81.6%	40.0%	98.8%	83.8%
Smoking	No	78.1%	82.6%	39.7%	96.3%	82.0%
	Yes	90.9%	84.8%	31.3%	99.2%	85.3%

Positive Predictive Value: PPV, Negative Predictive Value: NPV

Out of total 95(23.4%) of patients were categorized as high risk based on ZRS score while actual in-hospital mortality was counted as 43(10.6%). Analysis of the study findings further elaborated that sensitivity, specificity, PPV, NPV and overall accuracy of the study was 81.4%, 83.5%, 36.8%, 97.4% and 83.3% respectively (Table-III).

Table-III: Diagnostic Accuracy of Zwolle Risk Score for Predicting In-Hospital Mortality (n = 406)

	In-Hospital Mortality Frequency (%)		Total
	Yes	No	
ZRS Positive	35(8.6%) (TP)	60(14.7%) (FP)	95(23.3%)
ZRS Negative	8(1.9%) (FN)	303(74.6%) (TN)	311(76.6%)
Total	43(10.6%)	363(89.4%)	406(100.0%)

Sensitivity= 81.4%; Specificity =83.5%; Positive Predictive Value (PPV)= 36.8%; Negative Predictive Value (NPV) = 97.4%; Overall Accuracy= 83.3%

The receiver operating characteristic (ROC) analysis showed that the ZRS Score had an area under the curve (AUC) of 0.846, indicating good diagnostic accuracy for predicting the outcome. The *p*-value < 0.001 demonstrates that the predictive ability of the score is significantly better than chance, as shown in Figure.

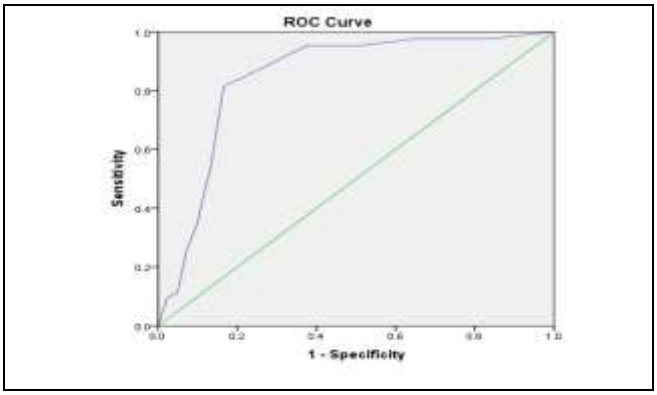

Figure: Receiver operating characteristic curve of Zwolle Risk Score for in-hospital mortality.

DISCUSSION

Our study results demonstrated that Zwolle Risk Score (ZRS) maintains a high level of sensitivity, an excellent level of specificity, and an acceptable overall accuracy over a wide clinical range which prove that it's a reliable and practical risk stratification score. Our findings are consistent with the global literature that determines ZRS as an effective early indicator of unfavorable outcomes in ACS especially because it combines easily accessible clinical and ECG variables. The current study also augments this fact by providing a stratified analysis in several demographic and clinical subgroups that are encountered in routine cardiology practice. In a recent study, Wang C *et al*, calculated the sensitivity and specificity of ZRS score (>6) as 87.5% and 72.92% respectively for the predicting the clinical outcome in STEMI patients treated with primary PCI.[10] Cordero A *et al.*, in another study reported that in-hospital mortality was 10.6% among STEMI patients who undergo PCI.[11]

ZRS score found equally sensitive across gender subgroups with slightly higher PPV in female, which is in line with the literature indicating that women can present with more severe or atypical ischemic physiology despite similar treatment.[12] The specificity in both sexes suggests that ZRS does not exaggerate death risk in either gender, which, in turn, justifying its relevance in a wide range of patients.

Stratification by age showed that the predictive value was high in all age subgroups. However, there was greater sensitivity in younger patients of age up to 40 years, which is expected, as myocardial ischemia in younger patients often indicates heavy thrombus burden and broad ST-segment changes which are important predictors in the ZRS model. Conversely, the slight decrease in sensitivity of older persons with age >40 years, is aligned with the occurrence of atypical presentations and baseline conduction abnormalities in this group, which may change the scoring of ECG.[13,14] However, the large specificity in both age groups highlights the strength of ZRS to reduce false -positive mortality projections.

The score also exhibited a strong performance in high-risk subgroups such as those with hypertension, diabetes and active smoking conditions which are known to high risk and severity of STEMI.[15,16] The sensitivity was still high in diabetics which supports the fact that diabetic patients tend to have extensive myocardial injury and high short-term mortality which is well represented by ZRS. On the same note, hypertensive patients showed the same trend, a fact that depicts that ZRS manages to integrate hemodynamic as well as electrophysiological disturbances that are common in this population.[17,18]

These results highlight several critical clinical implications. To start with, ZRS may be confidently used as a fast, bedside, non-invasive instrument to determine high-risk STEMI patients, who should be subjected to aggressive follow-up, early angiography, and hemodialysis. The high negative predictive value (>97 % among the subgroups) indicates that patients with a low-risk rating by ZRS are not likely to die in-hospital, thus allowing clinicians to better manage resource utilization, which is very important in resource-limited settings. Lastly, the fact that it is stable even with delayed presenters supports the applicability of ZRS in peripheral or rural locations where the timely reperfusion can be disrupted.

LIMITATIONS OF STUDY

There are a variety of limitations in this research. The results may not be generalized due to the conduction of this study in a single center. The sample size is sufficient to allow diagnostic analysis but might not be sufficient to detect rare ECG pattern variations or interactions between comorbidities. Our study analyzed only in-hospital mortality and long-term mortality and outcomes missing. Moreover, ZRS was assessed at presentation without correcting it with variations of subsequent treatment, which can confound outcome relationships. Lastly, no external validation was carried out with other risk scores (e.g., TIMI, GRACE) an activity which could have also provided comparative information.

CONCLUSION

ZRS is reliable, practical, and clinically relevant in prediction of an early in-hospital mortality in the patients arriving with STEMI and treated with PPCI. It is characterized by decent sensitivity, strong specificity and a high NPV, thus providing a fair accuracy in detecting patients with low mortality rates early in their lives and making it highly desirable as a means of quick-triage and prioritization of treatment. Although its PPV is small thereof representing an overestimation of the risk of mortality in some patients.

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Authors' Contribution

Following authors have made substantial contributions to the manuscript as under:

SAZ & ANK: Data acquisition, data analysis, critical review, approval of the final version to be published.

AA & AA: Study design, data interpretation, drafting the manuscript, critical review, approval of the final version to be published.

UA & NN: Conception, data acquisition, drafting the manuscript, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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