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Hearts under fire: acute myocardial infarction care during Sudan's humanitarian crisis

Abstract

Background: Acute myocardial infarction (AMI) poses a significant health threat globally, particularly in low-middle income countries (LMICs). Amidst challenges such as armed conflict, percutaneous coronary interventions (PCI) may not always be feasible, necessitating reliance on thrombolysis therapy as a reperfusion strategy. This study aims to evaluate the short-term outcomes of thrombolysis in patients with ST-segment elevated MI during the Sudanese humanitarian crisis.

Methods: A retrospective cohort study was conducted enrolling patients admitted to the Medani Heart Center during the Sudanese conflict. Data encompassing demographic details, laboratory findings, risk factors, echocardiographic assessments, and outcomes. Logistic regression analyses were employed to discern predictors of failed thrombolysis, adverse events, and mortality.

Results: Of the 72 patients, 69.4% were male, with a mean age of 59.9 years. Most presented with anterior STEMI, and the mean time from symptom onset to presentation was 4.8 hours. Notably, failed thrombolysis occurred in 49% of cases, with predictors including decreased high-density lipoprotein cholesterol levels, ejection fraction (EF) less than 50%, and regional wall motion abnormalities (RWMA). Adverse events were observed in 66.5% of cases, primarily heart failure (47.2%). The mortality rate stood at 9.7%, with predictors being reduced EF and RWMA.

Conclusion: Thrombolysis has a comparable outcome as a primary modality of coronary reperfusion in resource-limited practice. Failed thrombolysis significantly increased the risk of mortality, providing crucial insights into the application of thrombolytic therapy in STEMI within low-middle-income countries.

Keywords: acute ST-elevation myocardial infarction, thrombolysis, outcomes, low-middle income countries, Sudan

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Introduction

Myocardial infarction (MI) is the acute death of myocardial cells following inadequate perfusion, confirmed by abnormal cardiac biomarkers.[1] Early ischemic changes include reduced glycogen, myofibril relaxation, and sarcolemma disruption within 10 to 15 minutes.[2] ST-segment elevation (STEMI) on an electrocardiogram (ECG) requires persistent blood flow blockage in acute thrombotic coronary events.[3] Ruptured coronary plaques from atherosclerosis or high-risk thin cap fibroatheromas (TCFAs) induce platelet activation, aggregation, and thrombus formation.[3,4] Necrosis progression from the sub-endocardium (Green to the sub-epicardium is influenced by collateral blood flow, reduced oxygen intake, and intermittent occlusion with reperfusion, possibly protective if preconditioned.[5] Timely reperfusion therapy is the gold standard for the management to save the remaining viable tissues.[6]

Acute coronary syndrome (ACS); STEMI, non-ST-elevation MI (NSTE-MI), and unstable angina, causes MI with an annual universal incidence of over 3 million STEMI and 4 million NSTE-MI cases, and it affects both developed and developing nations.[7-9] Despite reduced overall mortality, MI-related heart failure (HF) remains a major concern, causing significant morbidity and mortality.[10,11] In the United States (US), HF impacts around 6 million people annually, resulting in 300,000 deaths and a financial burden exceeding $40 billion.[12] MI poses a substantial economic strain, contributing to 1.1 million hospitalizations and $450 billion in direct costs in the US in 2010.[13]

Reperfusion therapy, percutaneous coronary intervention (PCI), is the treatment of choice for STEM according to the guidelines.[14,15] However, logistical and financial challenges limit global access to this procedure; making fibrinolytic therapy the standard alternative.[16] Combining fibrinolytic therapy with early invasive procedures like coronary angiography and possible PCI, offers a balance between speed and reliability, although less extensively studied.[17] In resources challenged continents, primary PCI is not very available, thus, understanding the outcomes of the alternative reperfusion options is crucial for optimizing STEMI care and counseling the patients.[18] Here by, we are proving a real world from a single center in Sudan during the war crisis studying the outcomes of the medical reperfusion therapy for STEMI.

Situation in low-middle income countries

The burden of cardiovascular disease, especially acute STEMI, is rising in low-middle-income countries (LMICs) where 80% of the world's population reside.[19] An estimated 3 million STEMI cases are reported each year in LMICs, impacting younger people of working age and having significant economic ramifications.[19,20] A major implementation gap, a complex and multidimensional issue, is the reason why LMICs continue to have unsatisfactory results even though evidence-based treatments have significantly improved STEMI outcomes in affluent nations. In LMICs such as Sudan, a surge in cardiovascular disease, particularly STEMI, has resulted in suboptimal outcomes due to insufficient resources.[20] It is urgent to address this growing issue since 80% of cardiovascular fatalities occur in LMICs per the world health organization.[21,22]

Local reperfusion strategies in Sudan

The lack of uniform STEMI care stems in Sudan creates many barriers, notably the absence of regional systems for STEMI care.[23] The cardiac catheterization labs do not meet the demands of cardiac events. Moreover, most of the labs are in the capital while much more populations resides in the countryside.[19] Limited access to these labs is compounded by poor transportation infrastructure and inadequately trained or equipped paramedics and ambulances, further hindering timely access to invasive care, this would make medical reperfusion options vital.[20] With only eight state cardiac catheterization laboratories—more than half of which are based in Khartoum, the country's capital—the cardiac healthcare system in Sudan faces formidable obstacles. However, the recent armed conflict has resulted in the sudden closure of nearly 80% of these critical facilities. The conflict within the capital has resulted in logistical and financial disruptions, impeding the flow of essential medical supplies from the national medical supplies funds to peripheral healthcare centers. Moreover, the cardiac centers and PCI capable centers were in shortage of the stents and machine maintenance equipment. This conflict, coupled with the loss of the primary catheter supplier to peripheral labs, has rendered essential healthcare centers like the Wad Madani Heart Center inactive and left the patients of STEMI predominantly dependent on thrombolysis. This study seeks to investigate the short-term outcomes among individuals who exclusively received thrombolysis as a therapeutic intervention.

Methods

Study design

We conducted a retrospective cohort study at the Medani Heart Center located in the Wad-Medani district of Gezira state, east-central Sudan. The study encompassed the patients diagnosed with acute ST elevation myocardial infarction between May and June 2023, all of whom were initially considered candidates for PCI. However, due to feasibility and practical constraints associated with PCI, these patients exclusively received thrombolysis. Data collection was executed by (AA, IE, NM) and meticulously recorded in an Excel spreadsheet. Subsequently, the analysis was conducted (IM) and validated by a second, independent author (HA).

Data was collected retrospectively from May to June 2023. We reported the demographic data (Table 1), the risk factors, and outcomes (Table 2). The primary outcome of interest was in-hospital mortality. Successful thrombolysis which was defined as a significant alleviation of symptoms, and resolution of 50% of the STEMI in the ECG. A complete case analysis was conducted to handle missing data and any patients with missing valuable data or variable have been excluded from the final analysis. The thrombolysis has been used was streptokinase 1.5 million units intravenous for all patients, infused over 60 minutes.

Table 1 Baseline characteristics

Baseline data		
Age	59.9 +/- 12.7	
Gender	69.4% males	
DM-II	41.7%	
Cholesterol levels	172.04 +/- 38.1	
HTN	18.1%	
Unknown comorbidities	40.3%	
Pain to ED presentation	4.8 +/- 2.2 hours	
Pain to needle time	10 +/- 2.1 hours	
	Anterior STEMI	45.8%
	Anterolateral STEMI	20.8%
Pattern of STEMI	Inferior with posterior extension	18.1%
	Inferior STEMI	11.1%
	Lateral STEMI	4.2%
	≤ 40%	N= 51.4%
EF	41 – 49%	N= 15.3%
	≥ 50%	N= 33.3%

DM, diabetes mellites type II; ED, emergency department; HTN, hypertension; LVEF, ejection fraction; STEMI, ST-segment elevated myocardial infarction.

Table 2 Post thrombolysis outcomes

Outcomes	
Successful thrombolysis	52.9%
EF 5 days after thrombolysis	41.7% -/+ 12.4
event-free recovery	33.3%
HF	47.2%
Cardiogenic Shock	4.2%
Arrythmias	5.6%
Mortality	9.7%

HF, heart failure; LVEF, Left ventricular ejection fraction.

Ethical clearance (Ethical Committee No: 16-23) was obtained from the Institutional Review Board of the Faculty of Medicine, University of Gezira, Wad Medani, Sudan, on April 22nd, 2023. The proposal adhered to medical ethics principles and received official approval.

Inclusion and exclusion criteria

We included all patients presented at the center with STEMI and met the guidelines indication for thrombolysis. We excluded all patients with unstable angina and NSTEMI. Also, patients with STEMI who have contraindications to thrombolysis revascularization.

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Statistical analysis

Statistical analysis was done using SPSS version 27. Numerical data are presented in either mean and standard deviations or median and interquartile range. Logistic regression analyses were employed to discern predictors of failed thrombolysis, adverse events, and mortality.

Results

The current study comprised a cohort of 72 patients who presented with acute ST-elevation myocardial infarction (STEMI) at the emergency department (ED) (Table 1). The mean age of the participants was 59.9 years (SD=12.68). The average time from symptom onset to ED arrival was 4.83 hours (SD=2.214). Furthermore, the mean ejection fraction after 5 days was 41.65% (SD=12.37%). The average time from symptom onset to thrombolysis administration was 10.01 hours (SD=2.112). Most of the study participants were males, constituting 69.4% of the sample. Among them, 41.7% had diabetes mellitus (DM), while 18.1% had hypertension (HTN). The mean of total cholesterol was found to be 172 ± 38 mg/dl and HDL-c was 31±9.1 mg/dl. The remaining 40.3% had no clear past medical history as they have not seen a primary care physician due to low socioeconomic status (Table 1).

Successful thrombolysis was achieved in 52.9% of the patients. Echocardiography at 5 days revealed that 62.5% exhibited regional wall abnormalities and hypokinesia, 6.9% had an akinetic wall, and the remaining 30.6% had normal wall motion. In terms in adverse events, 47.2% of patients experienced heart failure prior to discharge, 5.6% had arrythmia, and 4.2% had cardiogenic shock (Supplementary figure 1). Event-free recovery occurred in 33.3% of cases, while 9.7% resulted in mortality (Table 1). There were significant association was found between the medical reperfusion successfulness and DM, HTN, STEMI pattern nor total cholesterol, however, elevated HDL-c was significantly associated with thrombolysis successfulness (Supplement Table 1). Moreover, neither symptoms to ED nor PTN was difference among both successful and failed thrombolysis groups (Supplementary Table 2)

Discussion

In this study, we investigated the outcomes of using thrombolysis alone in patients with STEMI who are candidates for PCI in the setting of PCI unavailability. The center of the study serves a large community. During the crisis, the influx of the patients from the surrounding areas overwhelmed the already exhausted center. Moreover, the cardiac center has ceased the procedures due to the absence of resources like stents during the crisis. To our knowledge, this is the first study in Sudan and in the region to evaluate the outcomes of medical reperfusion alone for STEMI in the era of PCI.

The majority of patients under study complicated by heart failure (47.2%) which is significantly higher than the study done by Iqbal et. al. which was 20.3%.[24] This can be explained by the fact that there was a significantly higher door-to-needle (DNT) time (mean =5 hours versus 1.5 hours in the Iqbal et al study) which in turns put the patients at greater risk of developing complications. Furthermore, all patients in this study had a pain-to-needle time of more than 3 hours which is notably higher than that in Iqbal's' study which was the case in about 75% of their study participants.[24] Gender exhibited a strong association with outcome, with males experiencing higher rates of complications than females. Our study's findings regarding the success rate of thrombolysis were consistent with previous studies conducted by Harvey et al. and Bhatia et al.[25,26] However, contrary to the existing literature, our study revealed that females exhibited better outcomes than males. One possible explanation for this discrepancy could be the smaller effect size within the female group, which may be attributed to their relatively smaller sample size.

Moreover, in contrast to our study, Murat et al. found that females had higher HDL levels than males, but exhibited poorer outcomes and lower ejection fractions.[27] It is worth noting that the patients in the Murat study were treated with either PCI or thrombolysis, whereas our study focused solely on thrombolysis, which might have influenced the outcome. Although both the Murat study and our study showed higher HDL levels in females compared to males, there were differences in outcomes between the genders. It is plausible that these differences could be potentially influenced by ethnicity.[27,28] Another study conducted by El Amrawy et al. demonstrated that normal HDL levels were associated with lower in-hospital outcomes. These findings underscore the significance of future studies that aim to investigate the monitoring of patient risk factors that may be potentially associated with outcomes.[29]

There is a significant difference in door-to-needle time but there is no such difference in time from onset to ED arrival. Similarly, both pain to needle (PNT) and DNT are negatively correlated with ejection fraction. Furthermore, PNT, DNT, and HDL are significantly different between those with successful and failed thrombolysis but not the time from onset to ED arrival. This significantly denotes that the outcome is directly impacted by how fast interventions are being delivered. In the present study the mean DNT is 5 hours which is significantly longer than that in the Igbal study in which it was around 1.5 hours.[24] Given this in mind, this does not make policy makers and prehospital care provider neglect the time before arriving to the hospital because prompt recognition will make taking actions more efficient and beneficial as "Time is muscle".

While our study discovered no connection between the pattern of STEMI and the outcome, this finding contradicts existing evidence, which could be explained by the relatively smaller sample size compared to other studies conducted globally. However, it is worth noting that our study is distinct in that it examines the short-term effects, an aspect that has not been extensively explored in studies worldwide.[30]

On the contrary, this study has revealed the significance of both HDL levels and pain-to-needle time in relation to short-term outcomes in STEMI patients who undergo thrombolysis alone. For example, an increase of one unit in HDL levels is associated with a higher likelihood of successful thrombolysis (OR = 1.24, 95% CI: 1.016 - 1.511). Likewise, for every unit increase in pain-to-needle time, there is a decreased probability of successful thrombolysis (OR = 0.16, 95% CI: 1.016 - 1.511).

In conclusion, this study highlighted the challenges of using thrombolysis alone in STEMI patients during a war when PCI was unavailable. Longer door-to-needle and pain-to-needle times contributed to higher complication rates, including heart failure. Gender differences were observed, with females having higher HDL levels and better outcomes. HDL levels and pain-to-needle time emerged as significant predictors of successful thrombolysis. These findings emphasize the importance of prompt intervention, monitoring, and further investigation into gender disparities in outcomes.

Limitation

The findings of this study should be interpreted within the context of several limitations. Firstly, the retrospective study design employed

in this research introduces inherent limitations, including potential biases and incomplete data stemming from reliance on existing medical records. Moreover, the restricted sample size of 72 patients might restrict the generalizability of the findings. It is noteworthy that the present study exclusively focused on the use of streptokinase for thrombolysis and did not assess long-term outcomes. Unfortunately, we could not obtain the LDL levels. These limitations highlight the importance of exercising caution when interpreting the findings and emphasize the need for future research adopting prospective study designs, larger sample sizes, multicenter approaches, and comprehensive evaluations of both short and long-term outcomes. Addressing these limitations will contribute to a more comprehensive understanding of the effectiveness of thrombolysis and provide valuable insights for clinical decision-making.

Recommendations

This study's findings yield several significant recommendations for future research and clinical practice in acute STEMI management. Firstly, it is crucial for governmental authorities to allocate resources and expand the number of catheter laboratories in healthcare institutions. This expansion would enable timely and accessible thrombolysis administration, optimizing patient outcomes. Secondly, future investigations should employ a multicenter study design to encompass a broader patient cohort, capturing diverse clinical practices and outcomes. This approach would enhance research generalizability. Additionally, efforts must be made to raise public awareness and healthcare professional education regarding the pivotal role of prompt thrombolysis initiation in reducing adverse STEMI outcomes. Health education campaigns should emphasize early symptom recognition and swift treatment initiation. Furthermore, future studies should comprehensively assess long-term outcomes, including recurrence rates, quality of life measures, and functional outcomes, to obtain a nuanced understanding of thrombolysis' overall impact on patient well-being. Lastly, larger sample sizes should be targeted in future research to ensure representation of diverse demographics, comorbidities, and treatment responses, bolstering the robustness and applicability of findings. Adhering to these recommendations will advance acute STEMI understanding and management, ultimately enhancing patient care and outcomes.

Conclusion

In summary, this research provided valuable insights into the short-term outcomes of thrombolysis in STEMI patients, particularly in a war setting without access to PCI. Timely interventions and monitoring were crucial, as longer delays increased the risk of complications. Gender differences in HDL levels and outcomes were evident, suggesting influences of ethnicity and treatment modalities. Further research is needed to optimize thrombolytic therapy, address gender disparities, and improve care in resource-constrained environments. Overall, a comprehensive understanding of risk factors and tailored approaches are essential for enhancing STEMI management and patient outcomes.

Declaration

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