

Comparative Outcomes of Primary Percutaneous Coronary Intervention and Pharmacoinvasive Strategies in Patients With ST-Elevation Myocardial Infarction in Palestine: A Multicenter Retrospective Cohort Study

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Abstract

Background

Myocardial infarction (MI) is among the most diagnosed cardiological diseases in the whole world and in Palestine, and is managed mainly by percutaneous coronary intervention (PCI), or in addition of tissue plasminogen activator (tPA), i.e., pharmacoinvasive approach. The aim of the current study is to identify the most common postoperative complications, and compare differences according to demographic factors, in both approaches in two tertiary centers in West Bank – Palestine.

Methodology

A retrospective cohort design was utilized on a randomized sample of 160 adult (30–75 years old) patients who were admitted to intensive care cardiology departments of Palestine Medical complex (for pharmacoinvasive approach) and An-Najah National University Hospital (for PCI approach). The researcher used a data sheet that was developed based on previous literature, and data were analyzed using SPSS software.

Results

Patients who underwent PCI ($n = 82$, 51.2%) were significantly older (mean = 59.8 ± 9.7 vs 56.2 ± 12.7) than pharmacoinvasive ($n = 78$, 48.8%), with more radial site of insertion use (95.1% vs. 15.4%), and no significant difference in MI location. PCI patients showed more significant decrease in some laboratory tests and heart rate, with more significant increase in troponin-I, compared to pharmacoinvasive patients (p -value < 0.05) between pre- and post-operative phases. Most postoperative complications, and mortality rate, were significantly higher among pharmacoinvasive patients (p -value < 0.05). Lastly, significantly more postoperative complications were found among patients with dyslipidemia, valve regurgitation and cardiac hypokinesia.

Conclusion

Patients who were treated with pharmacoinvasive approach showed higher postoperative complications and 30-day mortality rate. More research is needed in this area of cardiology management in Palestine. A prospective design is also recommended to be conducted for this topic in the future research.

Introduction

Cardiovascular diseases (CVDs) are considered the leading cause of death in the world, and account for around one third of all global mortality (32%), while the largest proportion of this burden is accounted for ischemic heart diseases (1). Evidence tells that ST-elevation myocardial infarction (STEMI) represents the most severe type of acute coronary syndrome (ACS) clinical manifestations, and associates with a high level of short-term mortality, as well as significant morbidity, and may result in long-term disability if not treated in early and effective way (2, 3).

The European Society of Cardiology (ESC) and the American College of Cardiology/American Heart Association (ACC/AHA) provided current international guidelines that strongly recommend primary percutaneous coronary intervention (PCI) as the main and preferred strategy for reperfusion, with a timeframe of first medical contact-to-device time ideally achieved within less than 90 minutes (4, 5). On the other hand, fibrinolytic therapy (e.g., tissue plasminogen activator [tPA]) followed by routine early coronary angiography is considered an effective alternative approach when timely access to PCI is not available, which refers to the pharmacoinvasive approach (6, 7). Several large randomized controlled trials (RCTs) concluded comparable clinical outcomes of pharmacoinvasive approach versus primary PCI, especially when mechanical reperfusion delays exceed acceptable thresholds (8–11).

Due to several challenges, mainly regarding availability of catheterization laboratories, in many low- and middle-income countries (LMICs) (12, 13), undesirable consequences of heart failure, long-term disability and/or increased mortality are expected (14, 15). Therefore, pharmacoinvasive approaches are utilized to try to mitigate delays in treatment, and to optimize outcomes in these resource-limited healthcare systems (16–18).

Limited number of PCI-capable centers, unequal geographic distribution of specialized cardiac centers, political barriers and military checkpoints that restrict patient mobility, and prolonged transfer times between hospitals are among the most common unique challenges in Palestine (19), leading to more substantial burden of STEMI (20, 21).

Studies are very limited on clinical outcomes of pharmacoinvasive therapy compared to primary PCI in Palestine, which limits evidence-based development and decision-making of policies (22). Most of related studies originate from countries with high-income levels and well-developed emergency medical systems, with clear and fast transfer pathways between hospitals (23–25), in contrast with the scarcity of evidence in areas affected by conflict, that have fragile healthcare systems (6, 23), including in Palestine, leading to lack in addressing comparative effectiveness, delays on the systematic level and real-world outcomes of difference reperfusion (26–28).

Aim of the study

The study mainly aims to compare between primary PCI and pharmacoinvasive approaches in terms of clinical, angiographic and procedural outcomes among Palestinian patients presenting with STEMI.

Additionally, the study's secondary objectives included evaluation of specific complications, treatment delays, left ventricular function and length of stay (LOS) across both approaches, as well as exploring factors that influence treatment selection and outcomes.

The current study's significance includes being the first to comprehensively evaluate STEMI reperfusion strategies using multicenter data within the Palestinian healthcare system, and aiming to provide national cardiovascular policymakers with up-to-date evidence on how to optimize care pathways for

emergency cardiac cases, resulting in supporting the development of clinical guidelines that are sensitive to the Palestinian context, therefore considered as locally relevant evidence.

The findings of the current study can help in improving allocation of limited healthcare resources, and establishing structured protocols that are tailored to Palestinian healthcare system, ultimately improving survival rate, reducing morbidity, and enhancing quality of care.

Methods

Study Design

The study implemented the retrospective cohort quantitative descriptive design.

Several advantages were considered when conducting a retrospective cohort study, including its suitability for studying multiple outcomes, and is relatively time and cost effectiveness, as both the exposures and outcomes have already occurred. On the other hand, the absence of control over exposure by the researcher should be taken in consideration in order to avoid bias.

Study Setting

Two tertiary hospitals in the West Bank – Palestine were selected to collect data from: Palestine Medical Complex (PM) in Ramallah and An-Najah National University Hospital (NNUH) in Nablus, which are known for being major regional centers for advanced cardiac care, with high annual volume of received STEMI cases.

Both hospitals are suitable for the aims of the current study, as they integrate electronic medical records (EMRs), therefore facilitating systematic retrospective data retrieval and ensuring clinical documentation completeness and accuracy according to the built data sheet.

Study Population and Sampling

The study population included all adult STEMI patients who were admitted in the cardiology departments of the mentioned settings, regardless to their gender, educational levels, residency, ... etc. The required sample size was calculated using G*Power software version 3.1, with effect size of 0.5, error probability for α of 0.05 and power of 0.95, the calculated size was 54 patients for each group, resulting in a recommended sample of 108, while the researcher was able to recruit a total of 160 patients.

The researcher used simple randomized sampling technique, by assigning a serial number for each of the extracted admissions between January 2020 and December 2024, then selecting the required sample by choosing xth record from each hospital list in a systematic way.

Inclusion and Exclusion Criteria

Adult patients (aged between 30 and 75 years old) who were diagnosed with STEMI, and presented and managed in the mentioned hospitals between January 2020 and December 2024 were included in the study, while patients who were managed by tPA only rather than pharmacoinvasive or PCI, pregnant women, diagnosed with any mental illness, had a history of bleeding within the last 6 months, and patient who were referred to NNUH or PMC from other hospitals were excluded from the study.

Data Collection Instrument and Study Protocol

The data were collected by an abstract sheet which was developed according to literature review and from the specialist doctor's experience. The sheet mainly included sections related to sociodemographic data, parameters related to the two approaches, in term of catheter insertion site and timing of procedure, followed by the preoperative and postoperative results of laboratory tests, postoperative complications and 30-day survival.

Validity and Reliability

An external, content validity was used to validate the study tool, where the abstract sheet was reviewed by 5 experts in the field of the study, which resulted in several adjustments to reach the final version of the used data sheet.

To enhance the reliability, data was collected by the researcher and a trained nurse in both hospitals using a standardized data abstraction protocol, ensuring a higher level of inter-rater consistency, minimizing transcription errors and shortened the required period.

Pilot Study

A total of 18 cases were piloted (while excluded from final data analysis) and divided them to two group (9 patients managed by pharmacoinvasive and 9 patients treated by primary PCI) to explore the appropriateness of the study instrument and help the researcher for training for data collection, which has helped to increase the validity and reliability for the research.

Data Analysis

For the purpose of data analysis, IBM Statistical Package for Social Sciences (SPSS) software v25.0 was used to produce description of frequencies and percentages of patients' categorical variables of sociodemographic information, pharmacoinvasive and PCI approaches, postoperative complications and survival, while mean and standard deviation (SD) was used for continuous variables, while the investigation of the relationship between study's independent and dependent variables was done using

Chi-square test (between categorical factor), and independent samples t-test and one-way ANOVA (between categorical independent and continuous dependent factors), using two-tailed statistical tests, and a p-value < 0.05 for consideration of statistical significance.

Ethical Considerations

Ethical approval for this study was obtained from the Institutional Review Board (IRB) of An-Najah National University (Reference (May 2023\18) prior to data collection. Permission to conduct the study was also obtained from the administrations of the participating hospitals. All procedures were conducted in accordance with the ethical standards of the Declaration of Helsinki.

Written informed consent was obtained from all participants prior to their inclusion in the study. Participation was voluntary, and participants were informed about the purpose of the study, assured of confidentiality and anonymity, and informed of their right to withdraw at any time without any consequences.

Results

Demographic data

The demographic factors for all the patients (n = 160) and their differences between patients with PCI (n = 82, 51.2%) and pharmacoinvasive (n = 78, 48.8%) are shown in the Table 1. The mean age of all patients was 58.0 ± 11.4 years old, ranging from 25 to 75 years old, which was significantly higher among the patients who underwent PCI (mean = 59.8 ± 9.7) than pharmacoinvasive (mean = 56.2 ± 12.7 , $t = 2.000$, p-value = 0.047). Moreover, more than half of the patients (51.9%) lived in urban areas, which was significantly higher among patients who underwent PCI (57.3%) than pharmacoinvasive (46.2%, $\chi^2 = 6.127$, p-value = 0.047). On the other hand, most of the patients were male (81.3%) and married (86.2%), in which gender and marital status did not differ significantly between the patients of both approaches.

Table 1

Distribution of patients' demographic data and the differences between PCI and pharmacoinvasive groups

Variables	Values	Overall		PCI		Pharmacoinvasive		Test result	p-value
		F	%	F	%	F	%		
Age (mean $\pm$ SD)		58.0 $\pm$ 11.4		59.8 $\pm$ 9.7		56.2 $\pm$ 12.7		2.000	0.047
Gender	Male	130	81.3%	64	78.0%	66	84.6%	1.131	0.287
	Female	30	18.8%	18	22.0%	12	15.4%		
Residency	City	83	51.9%	47	57.3%	36	46.2%	6.127	0.047
	Rural	57	35.6%	22	26.8%	35	44.9%		
	Camp	20	12.5%	13	15.9%	7	9.0%		
Social status	Single	9	5.7%	4	4.9%	5	6.4%	0.754	0.686
	Married	137	86.2%	69	85.2%	68	87.2%		
	Others	13	8.2%	8	9.9%	5	6.4%		

F = frequency, PCI = Percutaneous coronary intervention, SD = standard deviation

Regarding past medical history (PMHx), patients of both approaches were significantly different in their dyslipidemia and obesity histories, where dyslipidemia was found among 13.8% of the patients, which was significantly higher among pharmacoinvasive (25.6%) than PCI patients (2.4%, $X^2 = 18.146$, p-value < 0.001), while obesity was found among 13.8% of the patients, which was significantly higher among pharmacoinvasive (23.1%) than PCI patients (4.9%, $X^2 = 11.164$, p-value = 0.001). On the other hand, the prevalence of the rest of the included histories was not significantly different between patients of both groups (p-value > 0.05), including DM (46.3%), HTN (54.4%), IHD (35.0%) and other histories (16.3%).

In terms of the past surgical history (PSHx), previous PCI was done by 35.0% of the patients, while 5.0% of them had a previous open heart surgery, and 1.3% had a previous vascular surgery, which all did not significantly differ between PCI and pharmacoinvasive patients (p-value > 0.05), while having history of other surgeries was significantly higher among pharmacoinvasive (37.2%) than PCI patients (2.4%, $X^2 = 30.885$, p-value < 0.001). Moreover, 61.3% of all patients were current smokers, which was not significantly different between both study groups (p-value = 0.067).

Table 2
Distribution of patients' medical and surgical histories and the differences between PCI and pharmacoinvasive groups

Variables	Values	Overall		PCI		Pharmacoinvasive		Test result	p-value
		F	%	F	%	F	%		
Past medical history									
DM	No	86	53.8%	49	59.8%	37	47.4%	2.441	0.118
	Yes	74	46.3%	33	40.2%	41	52.6%		
HTN	No	73	45.6%	38	46.3%	35	44.9%	0.035	0.852
	Yes	87	54.4%	44	53.7%	43	55.1%		
IHD	No	104	65.0%	56	68.3%	48	61.5%	0.802	0.371
	Yes	56	35.0%	26	31.7%	30	38.5%		
Dyslipidemia	No	138	86.3%	80	97.6%	58	74.4%	18.146	< 0.001
	Yes	22	13.8%	2	2.4%	20	25.6%		
Obesity	No	138	86.3%	78	95.1%	60	76.9%	11.164	0.001
	Yes	22	13.8%	4	4.9%	18	23.1%		
Others	No	134	83.8%	69	84.1%	65	83.3%	0.019	0.989
	Yes	26	16.3%	13	15.9%	13	16.7%		
Past surgical history									
PCI	No	104	65.0%	54	65.9%	50	64.1%	0.054	0.816
	Yes	56	35.0%	28	34.1%	28	35.9%		
Open heart surgery	No	152	95.0%	78	95.1%	74	94.9%	0.005	0.942
	Yes	8	5.0%	4	4.9%	4	5.1%		
Vascular surgery	No	158	98.8%	81	98.8%	77	98.7%	0.001	0.972
	Yes	2	1.3%	1	1.2%	1	1.3%		
Others	No	129	80.6%	80	97.6%	49	62.8%	30.885	< 0.001
	Yes	31	19.4%	2	2.4%	29	37.2%		
Smoking status	Current	98	61.3%	57	69.5%	41	52.6%	5.396	0.067
	Previous	12	7.5%	6	7.3%	6	7.7%		
F = frequency, PCI = Percutaneous coronary intervention, HTN = hypertension, DM = diabetes mellitus, IHD = ischemic heart disease									

Variables	Values	Overall		PCI		Pharmacoinvasive		Test result	p-value
		F	%	F	%	F	%		
Past medical history									
	Never	50	31.3%	19	23.2%	31	39.7%		
F = frequency, PCI = Percutaneous coronary intervention, HTN = hypertension, DM = diabetes mellitus, IHD = ischemic heart disease									

For the echotomography findings, 4.4% of the patients had valve stenosis, which was significantly higher among pharmacoinvasive patients (9.0%) than PCI patients (0.0%, $X^2 = 7.696$, p-value = 0.006), while 28.1% of the patients had valve regurgitation, which was also significantly higher among pharmacoinvasive patients (52.6%) than PCI patients (4.9%, $X^2 = 44.968$, p-value < 0.001), as well as cardiac muscle hypokinesia, which was found among 41.3% of the patients, and was significantly higher among pharmacoinvasive patients (51.3%) than PCI patients (31.7%, $X^2 = 6.320$, p-value = 0.012). On the other hand, other findings were not significantly different between both groups, including the prevalence of ventricular hypertrophy (13.8%) and cardiomegaly (2.5%), while the overall mean ejection fraction (EF) was 45.1 ± 10.4 , and was significantly lower among PCI patients (mean = 43.4 ± 11.3) than pharmacoinvasive patients (mean = 47.0 ± 9.3 , $t = -2.277$, p-value = 0.024).

Table 3

Distribution of patients' echotomography findings and the differences between PCI and pharmacoinvasive groups

Tomography findings	Values	Overall		PCI		Pharmacoinvasive		Test result	p-value
		F	%	F	%	F	%		
Valve stenosis	No	153	95.6%	82	100.0%	71	91.0%	7.696	0.006
	Yes	7	4.4%	0	0.0%	7	9.0%		
Valve regurgitation	No	115	71.9%	78	95.1%	37	47.4%	44.968	< 0.001
	Yes	45	28.1%	4	4.9%	41	52.6%		
Cardiac muscle hypokinesia	No	94	58.8%	56	68.3%	38	48.7%	6.320	0.012
	Yes	66	41.3%	26	31.7%	40	51.3%		
Ventricular hypertrophy	No	138	86.3%	72	87.8%	66	84.6%	0.343	0.558
	Yes	22	13.8%	10	12.2%	12	15.4%		
Cardiomegaly	No	156	97.5%	80	97.6%	76	97.4%	0.003	0.960
	Yes	4	2.5%	2	2.4%	2	2.6%		
EF (mean ± SD)		45.1 ± 10.4		43.4 ± 11.3		47.0 ± 9.3		-2.277	0.024
F = frequency, PCI = Percutaneous coronary intervention, SD = standard deviation, EF = ejection fraction									

Treatment approach and perioperative parameters

The preferred catheter insertion approach was more in the radial artery (56.3%), which was also significantly preferred higher among PCI (95.1%) than pharmacoinvasive patients (15.4%, $\chi^2 = 103.279$, p-value < 0.001). Also, more than half of the patients conducted the procedure at the day of admission (54.4%), which significantly differed between both groups, where 97.6% of the PCI patients conducted the procedure at the day of admission, while 30.8% and 48.7% of the pharmacoinvasive patients conducted it at the first and second day of admission, respectively ($\chi^2 = 126.494$, p-value < 0.001).

The locations of MI among the patients were 50.0% inferior, 12.5% septal, 34.4% anterior, 6.3% posterior and 13.1% lateral, taking into account that the patients may have MI in more than one location at the same time, while they were not significantly different between both study groups (p-value > 0.05).

Table 4

Distribution of variables related to the treatment approach and perioperative parameters among the patients and between PCI and pharmacoinvasive patients

Variables	Values	Overall		PCI		Pharmacoinvasive		Test result	p-value
		F	%	F	%	F	%		
Catheter insertion approach	Radial	90	56.3%	78	95.1%	12	15.4%	103.279	< 0.001
	Femoral	70	43.8%	4	4.9%	66	84.6%		
When was the intervention done?	Admission day	87	54.4%	80	97.6%	7	9.0%	126.494	< 0.001
	1st day	25	15.6%	1	1.2%	24	30.8%		
	2nd day	39	24.4%	1	1.2%	38	48.7%		
	3rd day	4	2.5%	0	0.0%	4	5.1%		
	Others	5	3.1%	0	0.0%	5	6.4%		
Location of MI									
Inferior MI	No	80	50.0%	39	47.6%	41	52.6%	0.400	0.527
	Yes	80	50.0%	43	52.4%	37	47.4%		
Septal MI	No	140	87.5%	72	87.8%	68	87.2%	0.014	0.905
	Yes	20	12.5%	10	12.2%	10	12.8%		
Anterior MI	No	105	65.6%	54	65.9%	51	65.4%	0.004	0.950
	Yes	55	34.4%	28	34.1%	27	34.6%		
Posterior MI	No	150	93.8%	78	95.1%	72	92.3%	0.540	0.462
	Yes	10	6.3%	4	4.9%	6	7.7%		
Lateral MI	No	139	86.9%	73	89.0%	66	84.6%	0.682	0.409
	Yes	21	13.1%	9	11.0%	12	15.4%		

F = frequency, PCI = Percutaneous coronary intervention, MI = myocardial infarction

Laboratory tests and heart rate

Some of the preoperative laboratory tests showed significantly different mean results between PCI and pharmacoinvasive patients, including WBCs (overall mean = 10.53, 12.45 vs 8.51, $t = 5.474$, $p\text{-value} < 0.001$), sodium (overall mean = 137.61, 136.74 vs 138.52, $t = -2.650$, $p\text{-value} = 0.012$), troponin-I (overall mean = 514.17, 973.56 vs 69.06, $t = 1.995$, $p\text{-value} = 0.049$), triglyceride (overall mean = 188.00, 124.96 vs

200.93, $t = -2.387$, $p\text{-value} = 0.019$), INR (overall mean = 1.08, 1.13 vs 1.03, $t = 2.531$, $p\text{-value} = 0.013$), CRP (overall mean = 30.64, 123.93 vs 16.29, $t = 2.321$, $p\text{-value} = 0.040$) and heart rate (overall mean = 86.66, 93.07 vs 79.92, $t = 5.363$, $p\text{-value} < 0.001$), respectively, while the rest of the preoperative laboratory tests showed insignificant differences in their mean results between both groups ($p\text{-value} > 0.05$).

Table 5
Differences in preoperative laboratory tests results and heart rate between PCI and Pharmacoinvasive approaches

Test name	Overall		PCI		Pharmacoinvasive		t	p-value
	Mean	SD	Mean	SD	Mean	SD		
Hemoglobin	14.23	1.96	14.10	1.81	14.36	2.11	-0.818	0.414
WBCs	10.53	4.99	12.45	5.49	8.51	3.42	5.474	< 0.001
Platelets	265.92	82.90	274.61	85.76	256.79	79.30	1.362	0.175
BUN	20.96	15.64	19.74	12.70	22.22	18.17	-0.999	0.319
Creatinine	1.84	6.52	1.39	1.83	2.31	9.16	-0.886	0.377
Potassium	4.05	0.64	4.12	0.69	3.98	0.57	1.363	0.175
Sodium	137.61	4.42	136.74	3.39	138.52	5.16	-2.650	0.012
Calcium	9.02	0.64	8.79	0.67	9.05	0.64	-1.173	0.244
Troponin-I	514.17	2846.07	937.56	3921.71	69.06	394.76	1.995	0.049
CK-MB	76.69	104.12	23.00	.	77.97	105.04	-0.517	0.608
CK-total	778.76	1366.70	957.00	1107.33	772.51	1382.58	0.186	0.853
RBS	174.28	90.28	167.78	79.91	181.11	100.10	-0.928	0.355
LDL	119.45	43.23	113.95	45.92	120.58	42.88	-0.557	0.579
HDL	46.47	26.86	37.91	17.91	48.23	28.12	-1.879	0.069
Triglyceride	188.00	118.89	124.96	85.43	200.93	121.06	-2.387	0.019
PT	15.25	5.07	14.74	2.85	15.78	6.60	-1.287	0.201
PTT	43.19	25.82	46.05	31.48	40.19	17.80	1.461	0.147
INR	1.08	0.25	1.13	0.17	1.03	0.30	2.531	0.013
CRP	30.64	72.36	123.93	160.25	16.29	28.62	2.321	0.040
Heart rate	86.66	16.80	93.07	15.94	79.92	15.02	5.363	< 0.001
F = frequency, PCI = Percutaneous coronary intervention, SD = standard deviation, WBC = white blood cells, BUN = blood urea nitrogen, CK = creatine kinase, RBS = random blood sugar, LDL = low-density lipoprotein, HLD = high-density lipoprotein, PT = prothrombin time, PTT = partial thromboplastin time, INR = international normalized ratio, CRP = c-reactive protein								

For the postoperative laboratory tests, more results showed significant differences between the study groups, including WBCs (overall mean = 9.75, 11.05 vs 8.58, t = 3.952, p-value < 0.001), sodium (overall

mean = 138.75, 136.82 vs 140.67, $t = -5.584$, $p\text{-value} < 0.001$), troponin-I (overall mean = 1681.29, 3244.10 vs 38.33, $t = 5.094$, $p\text{-value} < 0.001$), LDL (overall mean = 94.95, 19.77 vs 110.37, $t = -7.917$, $p\text{-value} < 0.001$), HDL (overall mean = 42.49, 6.81 vs 49.81, $t = -5.441$, $p\text{-value} < 0.001$), PTT (overall mean = 49.50, 57.83 vs 41.80, $t = 3.845$, $p\text{-value} < 0.001$), INR (overall mean = 1.09, 1.18 vs 1.06, $t = 2.086$, $p\text{-value} = 0.039$), CRP (overall mean = 33.93, 126.22 vs 16.19, $t = 3.050$, $p\text{-value} = 0.008$) and heart rate (overall mean = 79.55, 82.13 vs 76.83, $t = 2.669$, $p\text{-value} = 0.008$), respectively, while the rest of postoperative laboratory tests did not show significant differences in their mean results between both groups.

Table 6
Differences in postoperative laboratory tests results and heart rate between PCI and Pharmacoinvasive approaches

Test name	Overall		PCI		Pharmacoinvasive		t	p-value
	Mean	SD	Mean	SD	Mean	SD		
Hemoglobin	13.61	2.06	13.45	1.95	13.76	2.16	-0.935	0.351
WBCs	9.75	3.99	11.05	4.05	8.58	3.57	3.952	< 0.001
Platelets	268.53	164.91	258.10	81.28	277.90	214.04	-0.728	0.468
BUN	21.58	17.08	19.80	12.19	23.14	20.36	-1.181	0.239
Creatinine	1.79	5.69	1.21	1.14	2.34	7.88	-1.254	0.214
Potassium	4.12	0.58	4.14	0.56	4.09	0.59	0.519	0.605
Sodium	138.75	4.71	136.82	3.12	140.67	5.24	-5.584	< 0.001
Calcium	9.12	0.67	9.22	0.53	9.11	0.68	0.412	0.682
Troponin-I	1681.29	4373.56	3244.10	5695.18	38.33	206.99	5.094	< 0.001
CK-MB	50.64	51.30	20.00	.	51.37	51.70	-0.600	0.552
CK-total	504.97	963.04	297.00	179.61	512.26	978.97	-0.308	0.759
RBS	154.68	62.87	153.21	50.94	156.22	73.68	-0.299	0.765
LDL	94.95	53.78	19.77	43.40	110.37	41.36	-7.917	< 0.001
HDL	42.49	32.93	6.81	19.26	49.81	30.31	-5.441	< 0.001
Triglyceride	160.09	154.36	34.66	66.09	185.82	154.88	-3.820	< 0.001
PT	16.12	7.34	15.62	2.66	16.31	8.46	-0.426	0.671
PTT	49.50	26.34	57.83	29.24	41.80	20.70	3.845	< 0.001
INR	1.09	0.26	1.18	0.16	1.06	0.28	2.086	0.039
CRP	33.93	74.16	126.22	138.98	16.19	32.89	3.050	0.008
F = frequency, PCI = Percutaneous coronary intervention, SD = standard deviation, WBC = white blood cells, BUN = blood urea nitrogen, CK = creatine kinase, RBS = random blood sugar, LDL = low-density lipoprotein, HLD = high-density lipoprotein, PT = prothrombin time, PTT = partial thromboplastin time, INR = international normalized ratio, CRP = c-reactive protein								

Test name	Overall		PCI		Pharmacoinvasive		t	p-value
	Mean	SD	Mean	SD	Mean	SD		
Heart rate	79.55	12.80	82.13	13.04	76.83	12.02	2.669	0.008
<i>F = frequency, PCI = Percutaneous coronary intervention, SD = standard deviation, WBC = white blood cells, BUN = blood urea nitrogen, CK = creatine kinase, RBS = random blood sugar, LDL = low-density lipoprotein, HDL = high-density lipoprotein, PT = prothrombin time, PTT = partial thromboplastin time, INR = international normalized ratio, CRP = c-reactive protein</i>								

The changes from preoperative to postoperative laboratory tests' results were also investigated and some had shown significant differences in mean results changes between both study groups. For example, the mean decrease in WBCs was 0.77, which significantly decreased more in PCI patients (mean decrease = 1.71) than pharmacoinvasive patients (mean increase = 0.07, $t = -3.228$, $p\text{-value} = 0.002$). Also, the mean the mean increase in sodium was 1.14, which was lower in PCI patients (mean increase = 0.13) than pharmacoinvasive patients (mean increase = 2.16, $t = -3.349$, $p\text{-value} = 0.001$). The mean increase in troponin-I was 1167.12, which was significantly higher in PCI patients (mean increase = 2306.54) than pharmacoinvasive patients (mean decrease = 30.74, $t = 3.806$, $p\text{-value} < 0.001$).

For the lipid profile, the mean decrease in LDL was 24.51, which was significantly higher among PCI patients (mean decrease = 94.18) than pharmacoinvasive patients (mean decrease = 10.21, $t = 4.642$, $p\text{-value} < 0.001$), with a mean decrease in HDL by 3.98, which was more among PCI patients (mean decrease = 31.09) than pharmacoinvasive patients (mean increase = 1.58, $t = -6.380$, $p\text{-value} < 0.001$), and a mean decrease in triglyceride by 27.91, which was significantly more among PCI patients (mean decrease = 90.29) than pharmacoinvasive patients (mean decrease = 15.11, $t = -2.074$, $p\text{-value} = 0.041$). Lastly, the mean decrease in heart rate was 7.11, which was significantly higher in PCI group (mean decrease = 10.94) than pharmacoinvasive patients (mean decrease = 3.09, $t = -4.044$, $p\text{-value} < 0.001$). On the other hand, the rest of the tests did not show significant differences in their pre-post changes between PCI and pharmacoinvasive patients ($p\text{-value} > 0.05$).

Table 7

Differences in preoperative-postoperative changes in laboratory tests results and heart rate between PCI and Pharmacoinvasive approaches

Test name	Overall		PCI		Pharmacoinvasive		t	p-value
	Mean diff.	SD	Mean diff.	SD	Mean diff.	SD		
Hemoglobin	-0.57	0.87	-0.55	0.91	-0.59	0.83	0.308	0.759
WBCs	-0.77	3.32	-1.71	4.30	0.07	1.72	-3.228	0.002
Platelets	1.32	154.88	-20.73	46.65	21.10	207.38	-1.650	0.101
BUN	0.19	8.17	-0.64	9.80	0.91	6.42	-1.146	0.254
Creatinine	-0.03	1.35	-0.10	0.70	0.04	1.77	-0.636	0.526
Potassium	0.07	0.50	0.02	0.60	0.11	0.36	-1.130	0.261
Sodium	1.14	3.91	0.13	2.95	2.16	4.46	-3.349	0.001
Calcium	0.10	0.54	0.28	0.52	0.08	0.54	0.855	0.395
Troponin-I	1167.12	4138.32	2306.54	5557.51	-30.74	192.21	3.806	< 0.001
CK-MB	-26.05	71.76	-3.00	.	-26.60	72.53	0.322	0.749
CK-total	-273.80	561.06	-660.00	927.72	-260.25	552.40	-0.990	0.326
RBS	-19.60	57.60	-14.57	56.94	-24.89	58.18	1.133	0.259
LDL	-24.51	50.70	-94.18	71.05	-10.21	30.10	-4.642	< 0.001
HDL	-3.98	17.20	-31.09	20.01	1.58	9.76	-6.380	< 0.001
Triglyceride	-27.91	134.42	-90.29	124.97	-15.11	133.44	-2.074	0.041
PT	0.29	3.86	-0.34	1.37	0.52	4.43	-1.535	0.128
PTT	5.44	32.26	9.59	43.23	1.62	16.13	1.472	0.144
INR	0.02	0.16	-0.01	0.11	0.03	0.18	-0.934	0.352
CRP	1.68	30.68	19.13	89.80	-0.10	16.46	0.605	0.564
Heart rate	-7.11	12.85	-10.94	12.23	-3.09	12.32	-4.044	< 0.001

F = frequency, PCI = Percutaneous coronary intervention, SD = standard deviation, WBC = white blood cells, BUN = blood urea nitrogen, CK = creatine kinase, RBS = random blood sugar, LDL = low-density lipoprotein, HLD = high-density lipoprotein, PT = prothrombin time, PTT = partial thromboplastin time, INR = international normalized ratio, CRP = c-reactive protein

Postoperative outcomes

Almost all postoperative complications showed significant differences between both groups. For example, the overall prevalence of postoperative insertion site hematoma was 36.9%, which was significantly higher among pharmacoinvasive patients (53.8%) than PCI patients (20.7%, $X^2 = 18.832$, p-value < 0.001). The rest of the complications also showed significantly higher prevalence among pharmacoinvasive than PCI patients, including hemorrhagic stroke (overall prevalence = 4.4%, 9.0% vs 0.0%, $X^2 = 7.696$, p-value = 0.006), epistaxis (overall prevalence = 9.4%, 19.2% vs 0.0%, $X^2 = 17.401$, p-value < 0.001), hematemesis (overall prevalence = 3.1%, 6.4% vs 0.0%, $X^2 = 5.426$, p-value = 0.020) and stroke (overall prevalence = 2.5%, 5.1% vs 0.0%, $X^2 = 4.313$, p-value = 0.038), with a significant difference in the overall number of postoperative complications between both groups, where 79.3% of PCI patients did not have any postoperative complication, compared to only 33.3% among pharmacoinvasive patients, while 20.5% of pharmacoinvasive patients had more than one complication, compared to 0.0% among PCI patients ($X^2 = 39.450$, p-value < 0.001). Lastly, the overall 30-day survival rate was 93.1%, which was significantly lower among pharmacoinvasive patients (87.2%) than PCI patients (98.8%, $X^2 = 8.403$, p-value = 0.004).

Table 8

Differences in specific postoperative complications and 30-day survival between PCI and Pharmacoinvasive approaches

Variables	Values	Overall		PCI		Pharmacoinvasive		Test result	p-value
		F	%	F	%	F	%		
Insertion site hematoma	No	101	63.1%	65	79.3%	36	46.2%	18.832	< 0.001
	Yes	59	36.9%	17	20.7%	42	53.8%		
Hemorrhagic stroke	No	153	95.6%	82	100.0%	71	91.0%	7.696	0.006
	Yes	7	4.4%	0	0.0%	7	9.0%		
Upper GI bleeding	No	157	98.1%	82	100.0%	75	96.2%	3.213	0.073
	Yes	3	1.9%	0	0.0%	3	3.8%		
Epistaxis	No	145	90.6%	82	100.0%	63	80.8%	17.401	< 0.001
	Yes	15	9.4%	0	0.0%	15	19.2%		
Hematemesis	No	155	96.9%	82	100.0%	73	93.6%	5.426	0.020
	Yes	5	3.1%	0	0.0%	5	6.4%		
Stroke	No	156	97.5%	82	100.0%	74	94.9%	4.313	0.038
	Yes	4	2.5%	0	0.0%	4	5.1%		
Number of complications	Zero	91	56.9%	65	79.3%	26	33.3%	39.450	< 0.001
	One	53	33.1%	17	20.7%	36	46.2%		
	> one	16	10.0%	0	0.0%	16	20.5%		
Patient's survival	Died	11	6.9%	1	1.2%	10	12.8%	8.403	0.004
	Survived	149	93.1%	81	98.8%	68	87.2%		

F = frequency, PCI = Percutaneous coronary intervention, GI = gastrointestinal tract

The number of postoperative complications were also compared among all patients across the demographic factors (as shown in Table 9), which showed that none of the demographic factors were significantly associated with differences in them (p-value > 0.05).

Table 9
Differences in number of postoperative complications across patients' demographic factors

Factor	Values	None		One		> one		χ^2	p-value
		F	%	F	%	F	%		
Age	< 40 YO	5	50.0%	3	30.0%	2	20.0%	3.597	0.731
	40–49 YO	16	61.5%	9	34.6%	1	3.8%		
	50–59 YO	30	62.5%	13	27.1%	5	10.4%		
	>= 60 YO	40	52.6%	28	36.8%	8	10.5%		
Gender	Male	76	58.5%	39	30.0%	15	11.5%	3.992	0.136
	Female	15	50.0%	14	46.7%	1	3.3%		
Residency	City	49	59.0%	26	31.3%	8	9.6%	1.259	0.868
	Rural	30	52.6%	20	35.1%	7	12.3%		
	Camp	12	60.0%	7	35.0%	1	5.0%		
Social status	Single	7	77.8%	2	22.2%	0	0.0%	4.315	0.365
	Married	76	55.5%	45	32.8%	16	11.7%		
	Others	7	53.8%	6	46.2%	0	0.0%		

F = frequency, X^2 = Chi-square test value, YO = years old

The relationships between the medical factors (medical and surgical histories and echotomography factors) are also tested and shown in Table 10, where it shows that 17.8% of the non-hypertensive patients had more than one complication, compared to 3.4% among hypertensive patients ($X^2 = 9.617$, p-value = 0.008). On the other hand, 18.2% of patients with dyslipidemia had more than one complication, compared to 8.7% among patients without dyslipidemia ($X^2 = 6.716$, p-value = 0.035).

Also, there was a significantly higher percentage of ad more than one complication among patients with than without valve regurgitation (22.2% vs 5.2%, respectively, $X^2 = 17.875$, p-value < 0.001), which also applies among patients with cardiac muscle hypokinesia (18.2% vs 4.3%, respectively, $X^2 = 9.559$, p-value = 0.008). The rest of the factors did not significantly associate with differences in the number of postoperative complications (p-value > 0.05).

Table 10
Differences in number of postoperative complications across patients' medical factors

Factor	Values	None		One		> one		χ^2	p-value
		F	%	F	%	F	%		
DM	No	50	58.1%	25	29.1%	11	12.8%	2.424	0.298
	Yes	41	55.4%	28	37.8%	5	6.8%		
HTN	No	40	54.8%	20	27.4%	13	17.8%	9.617	0.008
	Yes	51	58.6%	33	37.9%	3	3.4%		
IHD	No	57	54.8%	38	36.5%	9	8.7%	1.807	0.405
	Yes	34	60.7%	15	26.8%	7	12.5%		
Dyslipidemia	No	84	60.9%	42	30.4%	12	8.7%	6.716	0.035
	Yes	7	31.8%	11	50.0%	4	18.2%		
Obesity	No	83	60.1%	43	31.2%	12	8.7%	4.765	0.092
	Yes	8	36.4%	10	45.5%	4	18.2%		
Others	No	74	55.2%	47	35.1%	13	9.7%	1.415	0.493
	Yes	17	65.4%	6	23.1%	3	11.5%		
PCI	No	59	56.7%	35	33.7%	10	9.6%	0.070	0.966
	Yes	32	57.1%	18	32.1%	6	10.7%		
Open heart surgery	No	88	57.9%	49	32.2%	15	9.9%	1.332	0.514
	Yes	3	37.5%	4	50.0%	1	12.5%		
Vascular surgery	No	90	57.0%	53	33.5%	15	9.5%	3.928	0.140
	Yes	1	50.0%	0	0.0%	1	50.0%		
Others	No	84	65.1%	33	25.6%	12	9.3%	19.713	< 0.001
	Yes	7	22.6%	20	64.5%	4	12.9%		
Smoking status	Current	61	62.2%	26	26.5%	11	11.2%	5.288	0.259
	Previous	5	41.7%	6	50.0%	1	8.3%		
	Never	25	50.0%	21	42.0%	4	8.0%		
Valve stenosis	No	88	57.5%	51	33.3%	14	9.2%	2.283	0.244
F = frequency, χ^2 = Chi-square test value, PCI = Percutaneous coronary intervention, HTN = hypertension, DM = diabetes mellitus, IHD = ischemic heart disease, EF = ejection fraction									

	Yes	3	42.9%	2	28.6%	2	28.6%		
Valve regurgitation	No	76	66.1%	33	28.7%	6	5.2%	17.875	< 0.001
	Yes	15	33.3%	20	44.4%	10	22.2%		
Cardiac hypokinesia	No	60	63.8%	30	31.9%	4	4.3%	9.559	0.008
	Yes	31	47.0%	23	34.8%	12	18.2%		
Ventricular hypertrophy	No	82	59.4%	44	31.9%	12	8.7%	3.317	0.190
	Yes	9	40.9%	9	40.9%	4	18.2%		
Cardiomegaly	No	89	57.1%	52	33.3%	15	9.6%	1.039	0.595
	Yes	2	50.0%	1	25.0%	1	25.0%		
EF reduction	Normal	43	58.9%	24	32.9%	6	8.2%	5.770	0.449
	Mild	29	55.8%	15	28.8%	8	15.4%		
	Moderate	6	50.0%	4	33.3%	2	16.7%		
	Severe	13	56.5%	10	43.5%	0	0.0%		
F = frequency, X ² = Chi-square test value, PCI = Percutaneous coronary intervention, HTN = hypertension, DM = diabetes mellitus, IHD = ischemic heart disease, EF = ejection fraction									

Discussion

This study utilized a retrospective cohort design provided an evidence in the comparison between pharmacoinvasive and primary PCI approaches for STEMI management within the Palestinian healthcare system, and represented one of the largest comparative studies in the Palestinian literature that include real-world outcomes of reperfusion approaches, up to the researcher's knowledge. The current study findings serve as a valuable contribution into enhancing feasibility, safety and effectiveness of the pharmacoinvasive approach, focusing on the study setting of low resources and geopolitical constraints.

Several previous regional and international studies agree with the demographic profile of the current study distribution, where STEMI mainly affects patients in their middle age and older-adult phases, as well as male predominance, which also aligns with the global epidemiological trends, as biological, hormonal and behavioral risk factors (e.g., higher smoking prevalence and exposure to occupational stress) attribute to this distribution (29, 30). Such demographic findings in Palestine reflect the increasing burden of CVDs in Palestine, which is driven by presence of risk factors related to smoking, obesity, diabetes mellitus and hypertension, which is pushed by the prolonged political instability and economic hardship, leading to psychosocial stresses (29, 31).

In terms of treatment approaches, the current study highlights that public awareness level of CVD symptoms (32), healthcare accessibility, transport logistics and availability of catheterization laboratories play a pragmatic role in clinical decision-making, where pharmacoinvasive approach appeared as emergent, frequently utilized, especially among patients who present to centers not capable of timely PCI, or who face significant transportation delays.

The geographic fragmentation and military checkpoints play major roles in hindering rapid PCI centers access, alongside the shortage in ambulances (19) and intermittent lockdowns, which are considered barriers that create prolonged ischemic times, therefore making the pharmacoinvasive approach the most realistic life-saving strategy, not just an alternative (31, 33).

Significant improvements were shown in laboratory parameters following reperfusion in both study groups, which means that myocardial salvage and reperfusion are successful and effective, in addition to that such biomarkers normalization between both approaches is a comparable trend that is consistent with international evidence that showed similar reduction in infarct size and myocardial recovery between PCI and pharmacoinvasive approaches (34, 35). Laboratory diagnostics in Palestine remain more accessible than advanced interventional services, therefore they play an important role in stratifying risks, monitoring treatment progress and evaluating prognosis level, and support the clinical effectiveness of both approaches when timely delivered, as shown in the favorable laboratory trajectories.

Adequate myocardial reperfusion and autonomic balance were also observed in both study groups, as manifested by post-interventional heart rate normalization and hemodynamic stability, which are in parallel with patterns of physiological recovery that are documented in previous large STEMI samples (18, 34). On the other hand, higher baseline sympathetic activation and more compromised hemodynamic status can be more observed in the Palestinian context, caused by delayed presentation, which concludes that the therapeutic efficacy of pharmacoinvasive approach is comparable in terms of post-interventional stability when timely PCI is not available.

There is an agreement between the current and international studies in terms of the overall postoperative complications and 30-day mortality rates. Almost all short-term postoperative complications were significantly higher in the pharmacoinvasive approach, which can be related to increased bleeding risk due to initial thrombolysis therapy, periprocedural anticoagulant and antiplatelet agents use (16), older age that increases intracranial hemorrhage and other bleeding risk (36). Femoral access route also increases the risk of insertion site hematoma (37), more frequently used in pharmacoinvasive approach. Other factors include early PCI after thrombolysis (within 3 to 12 hours) (38) and older age, where more comorbidities and polypharmacy is more observed (39, 40). Higher stroke risk in the pharmacoinvasive approach also agrees with previous studies (41, 42), due to incomplete reperfusion, current ischemia, higher anticoagulant and antiplatelets therapy load.

Higher postoperative complications among patients with dyslipidemia can be interpreted by the link to increased inflammatory markers and antioxidative stress in these patients, which impair wound healing

and contribute to postoperative infection, hematoma and cardiovascular events (43, 44). Also, dyslipidemia correlated with endothelial dysfunction (45), and is common to be found with other comorbidities, like HTN and DM, increasing the risk of postoperative complications (46).

In agreement with the current study, previous literature emphasized the timeliness and completeness of reperfusion achieved through primary PCI (41, 47), therefore lower mortality rates, in addition to fewer postoperative complications (42). Increased availability of thrombolytics and adherence to international clinical guidelines can improve national STEMI protocols and decrease related mortality rates, with the emphasis on enhanced nursing competencies.

The critical role of nursing professionals in early triage and rapid administration of thrombolytic agents, as well as continuous cardiac monitoring and early detection of complications is essential in strengthening emergency nursing care, with the need to support nursing education and prehospital cardiac care systems. In terms of policymakers, the findings support the need to invest in regional STEMI networks and strengthen ambulance system, with future implementation of tele-cardiology consultation services, and more availability of decentralized thrombolytic agents, which showed effectiveness in low-resource and conflict-affected areas (33).

Conclusion

The current multicenter retrospective cohort study of Palestinian STEMI patients found more favorable short-term clinical outcomes, higher 30-day survival and lower major postoperative complications among patients who were treated with primary PCI than pharmacoinvasive approaches. While the pharmacoinvasive approach is considered a pragmatically life-saving alternative when timely PCI is not feasible, higher complication burden is found, therefore highlighting the need to expand primary PCI access, taking into consideration the need to reinforce the role of a well-structured pharmacoinvasive protocol in the resource-limited healthcare settings.

Limitations

Despite the advantages and valuable findings of the current study, it was limited by the use of retrospective design that may have introduced confounding variables and selection bias. Also, pre-hospital delays, missingness of exact ischemic times and details of EMS care are considered the most common potentially unmeasured, uncontrolled variables, while analyzing data from only two tertiary centers in the West Bank may have limited generalizability to other Palestinian regions or low- and middle-income settings, which may have different healthcare infrastructure. Lastly, long-term morbidity, recurrent events and functional status after discharge were limited to be measured as the study focused on 30-day outcomes.

Recommendations

Based on the findings and discussion of the current study, it is recommended to expand efforts to provide timely access to primary PCI, and make it a priority in the Palestinian healthcare system, by investing in the capacity of catheterization laboratories and optimizing the transfer system between hospitals. There is also a need to establish standardized pharmacoinvasive approaches when timely PCI is not available, which should include rapid administration of thrombolytic agents, early coronary angiography and close monitoring after administering fibrinolysis, which will reduce complication risks. It is also recommended to strengthen emergency medical services and implement national STEMI care networks that support post-discharge follow-up programs, which may further improve delivering equitable STEMI care. Lastly, future research in Palestine should implement prospective designs to investigate the long-term clinical and patient-reported outcomes that follow different reperfusion approaches, with the need to include more healthcare settings to broaden representation and diversity of the data.

Declarations

Ethics approval and consent to participate

Ethical approval for this study was obtained from the Institutional Review Board (IRB) of An-Najah National University (Reference (May 2023\18) prior to data collection. Permission to conduct the study was also obtained from the administrations of the participating hospitals. All procedures were conducted in accordance with the ethical standards of the Declaration of Helsinki.

Consent for publication

Not applicable.

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Author Contribution

M.H., B.M., J.Q., L.M.Z., I.G., and N.B.S. contributed to the conceptualization and study design. M.H., B.M., J.Q., and L.M.Z. contributed to methodology, software development, and statistical analysis. I.G., E.A.S., F.Z., E.A., and S.G.Q. contributed to data collection. I.G., E.A.S., and E.A. contributed to data curation and validation. F.Z. and B.M. contributed to field investigation and clinical data acquisition. M.H., B.M., and N.B.S. drafted the main manuscript text. All authors (M.H., B.M., J.Q., L.M.Z., I.G., N.B.S., E.A.S., M.F.A.A., E.A., S.G.Q., and F.Z.) contributed to critical revision of the manuscript, read and approved the final version, and agree to be accountable for all aspects of the work.

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Data availability

The data sets supporting the current research results are available from the corresponding authors upon request.

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