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Research article

The impact of war on ACS admissions and triage – a single center experience

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A B S T R A C T

Introduction: Contemporary data regarding the impact of war on cardiovascular disease is scarce. The Israel-Gaza war that erupted on October 7th, 2023, provided a tragic opportunity to explore the effect of war on the epidemiology, characteristics, and management of patients with acute coronary syndrome (ACS) living in areas of active armed conflict.

Methods: All patients admitted with ACS to our medical center, between October 7th, 2023, and January 6th, 2024, were retrospectively included. Crucial time intervals in the management of individuals with ACS were collected in a predetermined spreadsheet. In-hospital and 30-day outcomes were obtained from the medical records and contrasted with ACS cases admitted in the period preceding the war.

Results: A total of 449 individuals (102 females [22.7 %]) with a diagnosis of ACS were recruited, 358 patients (144 STEMI and 214 NSTEMI) were admitted during the 9 months before October 7th and 91 patients (42 STEMI and 49 NSTEMI) in the 3 months after October 7th. Compared to the control period, a significant reduction in ACS admissions per month was noted (38.91 vs. 28.79, $p < 0.001$) driven by fewer cases of both STEMI and NSTEMI (15.65 vs. 13.29, $p = 0.011$ and 23.26 vs. 15.5, $p < 0.001$, respectively). In patients with STEMI, the total ischemic time was similar before and after the war (179 min vs. 187 min, $p = 0.849$).

Conclusions: War has a dramatic impact on cardiovascular incidence and outcomes which, however, are not necessarily linked to higher admission rates. Nevertheless, with the adoption of systematic approach and increased awareness, patients with ACS can be managed effectively even at times of extremely limited resources such as war.

1. Introduction

The impact of war on public health is profound and multifaceted, affecting individuals and communities both during and long after conflicts have ended [1,2]. Nevertheless, data on the specific effects of active armed conflicts on cardiovascular disease (CVD) are limited [3,4]. Multiple studies have shown that war is strongly linked to psychological stress, an independent risk factor for heart diseases, including coronary artery disease (CAD) [4–7]. The psychological insults are further exacerbated by exposure to images of violence through social and conventional media [8]. Consequently, areas affected by mass disasters or armed conflicts suffer from higher rates of acute coronary syndrome (ACS), in-hospital complications, and unfavorable consequences. These poor outcomes are attributed to delayed presentation and reduced access to urgent reperfusion treatment [3,9–13]. Indeed, a prolonged total ischemic time (TIT) - the time interval from chest pain (CP) onset to restoration of coronary blood flow - remains a pivotal determinant of poor

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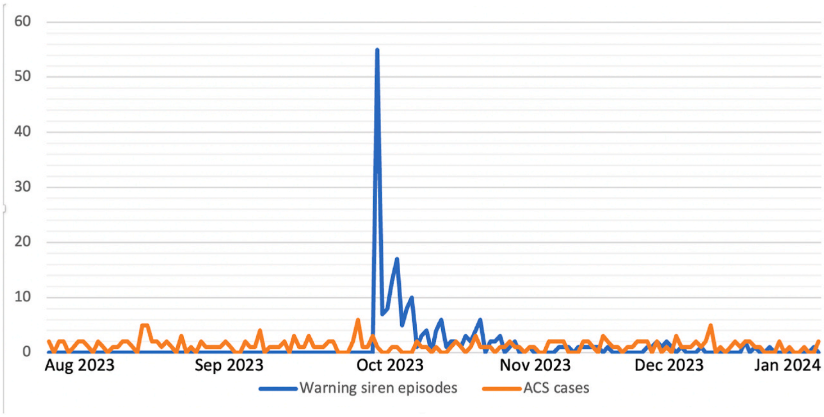

Fig. 1. ACS cases arriving at Barzilai ER in reference to rocket barrages fired at the city of Ashkelon during the Israel-Gaza war.

outcomes in ACS [14,15]. Notably, in patients with ST elevation myocardial infarction (STEMI), the risk of 1-year mortality is increased by 7.5 % for each 30-min delay [16]. Likewise, all-cause mortality and cardiac death are significantly higher among patients with non-ST elevation myocardial infarction (NSTEMI) and delayed revascularization (≥24 h), especially in the presence of complex coronary lesions [17]. Numerous war-related circumstances can delay timely coronary reperfusion, either individually or collectively. Limited community health services, patient reluctance to seek medical care for fear of acts of violence, impediments in transportation to the hospital due to ongoing rocket attacks, damage to essential hospital infrastructure from acts of war, or delays in emergency department (ED) transit time due to staffing shortage and\or overwhelming increase in workload, all significantly extent the TIT, exacerbating the prognosis for ACS patients [3,10,13].

In the current study, we aim to explore the incidence, in-hospital management and short-term outcomes of patients admitted with acute coronary syndrome, including STEMI and NSTEMI\unstable angina (UA) presented to our medical center during active armed conflict, from October 7th, 2023, to January 6th, 2024, and to propose a model for the initial management of patients with ACS in times of large-scale crisis.

2. Methods

2.1. Study design and population

The study was performed at Barzilai medical center, a 600-bed district general hospital, in Ashkelon area in southern Israel. The hospital area was declared an active war zone during the Israel-Gaza war that erupted on October 7th, 2023. During the first 3 months of conflict, thousands of rockets were fired from Gaza to towns and cities in southern Israel, causing casualties among civilians and substantial damage to essential facilities, including within the hospital (Fig. 1). Hence, life-saving procedures, such as emergent coronary catheterization, had to be transferred from the conventional catheterization lab to a protected catheterization lab in a reinforced saferoom that is routinely dedicated for electrophysiology procedures and treatments. Consequently, during the war, all cardiac procedures were performed in a single catheterization lab.

For this single center retrospective study, we included all patients 18 years of age or older admitted with ACS, including STEMI and NSTEMI/UA from January 7th, 2023, to October 6th, 2023, before the war, and during the first 3 months of the conflict, between October 7th, 2023, and January 6th, 2024. We hypothesized that the effects of the conflict on ACS admissions would be greatest during the initial phases of the war. For each patient with STEMI, we calculated the total ischemic time (TIT) using a predetermined time report spreadsheet. TIT intervals and delays assessment were simplified by dividing TIT into 3 consecutive stages: 1) from symptoms onset to first medical contact (FMC), 2) FMC to ECG and 3) ECG to coronary balloon inflation [18]. Prehospital data was provided by the emergency medical services (EMS) upon patient arrival. Initial evaluation and ECG were performed by the nursing staff and recorded in the spreadsheet. Upon STEMI diagnosis the on-call cardiologist was notified and arrived to the ED for further patient evaluation. If a decision to proceed to primary PCI was made, the cath lab team is activated and the on-call cardiologist assumes the responsibility of recording the time interval information into the time report spreadsheet. When a STEMI diagnosis is known prior to hospital arrival, the cardiologist is informed in advance to wait for the patient at the ED. If the cath lab is available and vacant, the patient is transferred for primary percutaneous coronary intervention (PPCI) directly by the EMS, bypassing the ED. Finally, at the end of the percutaneous intervention, the timeline report spreadsheet is revised and signed by the chief interventional cardiologist. Importantly, during the time of active conflict further measures were taken to mitigate potential time delays and expedite percutaneous intervention in STEMI. For instance, a senior interventional cardiologist was available for in-person consultations, 24 h a day, 7 days a week for the entire first month of the conflict. In addition, elective coronary procedures were cancelled leaving the cath lab available for urgent cases only.

The diagnosis and management of patients, including invasive and pharmacologic treatments, were in accordance with the European society of cardiology (ESC) guidelines for ACS [19,20]. Demographic and clinical data were retroprospectively and

Table 1
Comparison of STEMI cases arriving in Barzilai ER before and after the commencement of the Israel-Gaza war.

Variable		Before war n = 144	During war n = 42	P value
Age (Mean ± SD)		62.47 ± 13.62	60.4 ± 12.94	0.386
Sex (n,%)	Female	37, 25.7 %	7, 16.7 %	0.226
	Male	107, 74.3 %	35, 83.3 %	
BMI (Median, Q1-Q3)		27.1, 24.3–31.2	27.6, 25.4–31	0.532
Hypertension (n,%)		77, 53.5 %	23, 54.8 %	0.821
Smoking (n,%)		69, 47.9 %	27, 64.3 %	0.074
Diabetes (n,%)		53, 36.8 %	11, 26.2 %	0.203
Ischemic heart disease (n,%)		28, 19.4 %	7, 16.7 %	0.685
Peripherial vascular disease (n,%)		3, 2.1 %	1, 2.4 %	1
COPD (n,%)		6, 4.2 %	3, 7.1 %	0.429
Troponin (Median, Q1-Q3)		44.5, 18-155	38, 15-222	0.805
EF, % (Median, Q1-Q3)		45, 37-50	45, 36-50	0.981
Cardiogenic shock (n,%)		10, 6.9 %	4, 9.5 %	0.693
Arrhythmias (n,%)		14, 9.7 %	8, 19 %	0.1
Hospital mortality (n,%)		5, 3.5 %	4, 9.5 %	0.118
Mortality within 30 days		6, 4.2 %	4, 9.5 %	0.237
Door to balloon time, minutes (Median, Q1-Q3)		48, 29-80	53.5, 36-85	0.421
Time from symptoms onset to FMC, minutes (Median, Q1-Q3)		101, 50-171	105, 45-285	0.807
FMC-to-ECG time, minutes (Median, Q1-Q3)		7, 5–11.5	6, 3-12	0.579
First ECG to balloon time, minutes (Median, Q1-Q3)		71, 57.5–95.5	76, 62-107	0.234
TIT, minutes (Median, Q1-Q3)		183, 125-300	198, 119-353	0.849

COPD chronic obstructive pulmonary disease; BMI body mass index; EF ejection fraction: STEMI ST-elevation myocardial infarction; FMC first medical contact; ECG electrocardiogram; ER emergency medicine; TIT total ischemic time.

Table 2
Comparison of NSTEMI cases arriving in Barzilai ER before and after the commencement of the Israel-Gaza war.

Variable		Before war *n=214*	During war *n=49*	P value
Age (Mean ± SD)		65.44 ± 11.17	64.9 ± 12.83	0.764
Sex (n,%)	Female	48, 22.4 %	10, 20.4 %	0.85
	Male	166, 77.6 %	39, 79.6 %	
BMI (Median, Q1-Q3)		28.1, 25–31.8	28.1, 25.5–31.3	0.928
Hypertension (n,%)		137, 64 %	38, 77.6 %	0.07
Smoking (n,%)		90, 42.1 %	24, 49 %	0.378
Diabetes (n,%)		103, 48.1 %	26, 53.1 %	0.533
Ischemic heart disease (n,%)		74, 34.6 %	20, 40.8 %	0.411
Peripherial vascular disease (n,%)		16, 7.5 %	3, 6.1 %	0.741
COPD (n,%)		12, 5.6 %	4, 8.2 %	0.5
Door to balloon, Minutes (Median, Q1-Q3)		1099, 568-2935	1957, 481-4001	0.305
Troponin (Median, Q1-Q3)		89, 45-204	64, 34.5–160.5	0.181
EF, % (Median, Q1-Q3)		50, 40-60	48.5, 40–56.5	0.888
Hospital mortality (n,%)		2, 0.9 %	1, 2 %	0.463
Mortality within 30 days		2, 0.9 %	1, 2 %	0.463

COPD chronic obstructive pulmonary disease; BMI body mass index; EF ejection fraction.

anonymously documented in an electronic case report form (eCRF). The study protocol adhered to the declaration of Helsinki and was approved by the institutional review board of Barzilai Medical Center (BRZ-104-23) with the exemption from informed consent.

2.2. Statistical methods

Patients' characteristics were presented as numbers (%) for categorical variables, and mean ± standard deviation (SD) or median and interquartile range (Q1-Q3) for normal and non-normal distributed continuous variables respectively. Comparison of categorical variables was done by Chi-squared test and Fisher's exact tests. Student *t*-Test and Mann-Whitney tests were performed for comparison of normally and non-normally distributed continuous variables, respectively.

All tests were two-sided. $P < 0.05$ was considered statistically significant. Analyses were carried out using SPSS Statistics for Windows, Version 26.0. (IBM Corp, Armonk, NY, USA).

3. Results

3.1. Baseline characteristics

A total of 449 patients with ACS were included in the analysis. Median age was 64 [interquartile range (IQR): 56–72] and 102 (22.7

Table 3
Acute coronary syndrome admissions per month before and after the commencement of the Israel-Gaza war.

Variable	Before war	During war	P value
ACS	38.91 ± 11.14	28.79 ± 19.56	<0.001
STEMI	15.65 ± 4.39	13.29 ± 7.58	0.011
NSTEMI\UA	23.26 ± 7.94	15.5 ± 12.26	<0.001

Values are mean ± SD; STEMI ST-elevation myocardial infarction; NSTEMI\UA Non-ST-elevation myocardial infarction; ACS acute coronary syndrome.

%) were female. The group of patients was divided according to the period of admission, 358 patients during the 9 months before the conflict and 91 patients during the first 3 month of the conflict. There were no statistically significant differences between the two periods of admission regarding age, gender, and comorbidities. Baseline characteristics of STEMI and NSTEMI patients stratified by the admission period are present in Tables 1 and 2, respectively. ACS admissions per month (mean ± SD) are reported in Table 3.

3.2. Main ACS diagnoses on admission

Overall, there were 186 cases of STEMI (44 females [23.6 %]) and 263 cases of NSTEMI (58 females [22 %]). During the conflict we observed a significant decrease in mean ACS monthly admissions compared to the control period (38.91 ± 11.14 vs. 28.79 ± 19.56, $p < 0.001$). Fewer cases of STEMI and NSTEMI per month were admitted during the conflict compared to the pre-conflict period (15.65 ± 4.39 vs. 13.29 ± 7.58, $p = 0.011$ and 23.26 ± 7.94 vs. 15.5 ± 12.26, $p < 0.001$, respectively) (Table 3).

3.3. Time intervals

In patients with STEMI, the median interval from symptom onset to FMC, obtained during history taking in the ED and/or from the EMS report, accounted for 101 min (IQR 50–171 min) before the war and 105 min (IQR 45–285 min) afterwards ($p = 0.807$). The median FMC to ECG timeframe was 7 min (IQR 7–11.5 min) before the conflict compared to 6 min (IQR 3–12 min) after the conflict ($p = 0.579$). The median time periods from first ECG to balloon before and after the war were 71 min (IQR 57.5–95.5 min) and 76 min (IQR 62–107 min), respectively ($p = 0.234$). Overall, the median TIT in the period before the war was not significantly different from the median TIT during the war (183 min [IQR 125–300 min] vs 198 min (IQR 119–353 min) $p = 0.849$]. The median time to PCI in patients with NSTEMI was 18.3 h or 1099 min (IQR 568–2935) before the war and 32.6 h or 1957 min (IQR 481–4001) after the war ($p = 0.305$). The crucial time intervals are presented in Table 1 for STEMI and Table 2 for NSTEMI.

3.4. In-hospital complications and 30-day mortality

In patients with STEMI (Table 1), we observed a similar rate of cardiogenic shock (6.9 % vs 9.5 %, $p = 0.118$) and arrhythmias (9.7 % vs 19 %, $p = 0.1$). Before the commencement of the conflict, we observed a total of 14 (9.7 %) arrhythmic events [8 ventricular fibrillation (VF); 6 ventricular tachycardia (VT)] and compared to 8 (19 %) events [4 VF; 3 VT; 1 complete atrio-ventricular block (CAVB)] during the war. Furthermore, there were no statistically significant differences between the two periods of admission regarding in-hospital (3.5 % vs 9.5 %, $p = 0.118$) and 30-day mortality (4.2 % vs 9.5 %, $p = 0.237$). Likewise, no differences were observed in in-hospital (0.9 % vs 2 %, $p = 0.463$) and 30-day mortality (0.9 % vs 2 %, $p = 0.463$) among patients with NSTEMI (Table 2).

4. Discussion

The main findings of our study were: 1) during the first 3 months of conflict the number of patients presenting with ACS was substantially lower compared to the pre-conflict period 2) Fewer cases of STEMI and NSTEMI were admitted during the conflict; 3) Crucial time intervals in patients with STEMI and NSTEMI were similar across the entire study period; 4) A trend towards higher rate of ventricular arrhythmias has been documented in patients with STEMI during the conflict; 5) There were no differences in in-hospital and 30-day mortality in individuals with STEMI and NSTEMI during the periods of monitoring.

Armed conflicts are associated with increased incidence of ACS that are responsible, at least in part, to the excess cardiovascular morbidity and mortality seen during times of war [3].

Recently, a study that evaluated the occurrence of ACS during the Israel-Gaza war reported a substantial increase in the incidence of STEMI [21]. The evidence of higher rates of myocardial infarctions is not surprising given the well-established relationship between emotional stress and coronary heart diseases [22]. In the current study, the psychological insult was particularly intense, stemming not only from the freight of losing one's life but also from the profound worry about the potential loss of one's country. Intense and/or repetitive psychological insults can precipitate a dysfunctional stress reaction that results in sympathetic overstimulation, dysregulation of the hypothalamus-pituitary-adrenal axis, abnormal immune-inflammatory response, endothelial dysfunction, and behavioral changes such as higher smoking rates [23–26]. However, while the specific mechanisms by which stress precipitates ACS are not entirely elucidated, experiments show that stress-induced leukocyte recruitment in atherosclerotic plaques and increased fibrous cap extracellular matrix breakdown are central in promoting plaque destabilization, in particular plaque rupture, the principal underlying

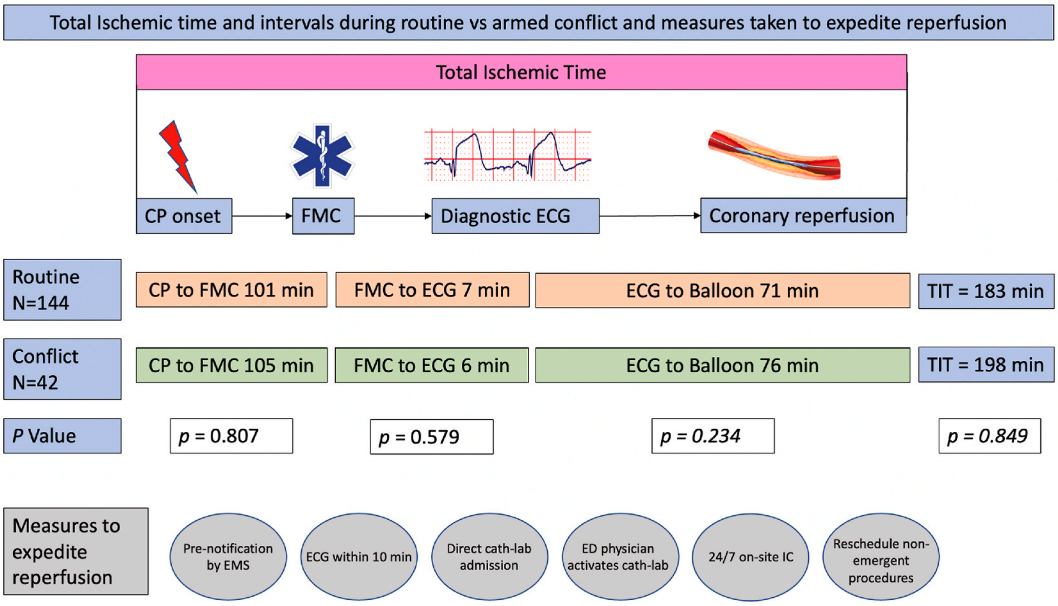

Fig. 2. Crucial time intervals in STEMI before and during the conflict and local measures taken to minimize the total ischemic time.
CP chest pain; FMC first medical contact; ECG electrocardiogram, TIT total ischemic time; EMS emergency medical services; ED emergency department; IC interventional cardiologist.

mechanism in STEMI [27–29]. Interestingly, the higher incidence of heart diseases reported during war is not necessarily translated into higher admission rates. Shortage in healthcare resources, increased perception of danger due to acts of violence and civilian migration can translate into reduced care seeking among civilians [13,30,31], as demonstrated by our findings. We hypothesize that the short distance (~20 Km) between our medical center and the actual combat zone, the multiple rocket barrages fired at the hospital and its surroundings (Fig. 1) and the mobilization of civilians away from the conflict area were the main reasons for the dramatic reduction in ACS admissions during the first 3 months of the conflict compared to the pre-conflict period (Table 3) driven by fewer cases per month of both STEMI (15.65 vs. 13.29, $p = 0.011$) and NSTEMI (23.26 vs. 15.5, $p < 0.001$). Surprisingly, there was no significant differences in crucial time intervals between the study periods. In individuals presented with STEMI, we invested major efforts to expedite coronary reperfusion and to reduce the door to balloon time (Table 1). We believe that these efforts (Fig. 2) had a substantial contribution in minimizing the TIT. It is plausible that the comparable time intervals before and during the conflict were responsible for the invariable short-term outcomes noted during the study. In patients presenting with NSTEMI, an early invasive strategy within 24 h of presentation was adopted, in accordance with the ESC guidelines recommended timeframe [19]. However, compared to patients with STEMI, longer reperfusion times were recorded in patients with NSTEMI undergoing reperfusion (Table 2), although statistical significance was not demonstrated. Notwithstanding, patient with NSTEMI admitted during the war did not have an increased risk of in-hospital mortality compared to those who were admitted in the pre-war period (2 % vs. 0.9 %, $p = 0.463$). In contrast, we observed a trend toward a higher in-hospital mortality rate among patients with STEMI following the onset of the conflict (3.5 % vs. 9.5 %. $p = 0.118$). While this finding may be attributable to chance, the low event rate during the relatively short study period could also contribute to this result. Notably, contemporary studies assessing short-term fatality rates among STEMI cases during armed conflicts have reported no significant change in in-hospital mortality between the pre- and post-war periods [21,32]. Finally, a trend towards a higher rate of ventricular arrhythmias was observed during the conflict in patients presenting with STEMI (9.7 % vs 19 %, $p = 0.1$). The association between emotional stress and adverse cardiac events, including ventricular arrhythmias, is well documented [33], and the psychological distress associated with war may have contributed to these findings.

Our study possesses several limitations: (1) It was conducted within a singular medical center, inherently prone to referral bias. (2) This analysis focused solely on short-term mortality rates and was confined to the initial three months of the conflict. (3) Our medical facility is situated at a short distance from the active battle zone and encountered multiple rocket attacks during the war in contrast to regions distant from the combat area. (4) Since the studied population had been repeatedly exposed to rocket barrages in previous years, we cannot exclude the contribution of chronic stress, in addition to the acute stress induce by the war, to our findings. (5) We compared outcomes in the period before the war (winter, spring, and summer) to the period after the commencement of the war (autumn and winter) that may potentially have influenced our results. (6) Our analysis primarily centered on overall in-hospital and 30-day mortality rather than cardiovascular-specific mortality.

5. Conclusion

War has a dramatic impact on cardiovascular outcomes which are likely linked, at least in part, to delayed coronary recanalization.

Thus, minimizing the ischemic time is paramount to potentially improve outcomes in ACS. With increased awareness and the adoption of systematic approach (Fig. 2), patients with ACS can be managed effectively even in resource-limited setting such as war.

CRediT authorship contribution statement

Sharon Bruoha: Writing – review & editing, Writing – original draft, Methodology, Data curation, Conceptualization. **Tatiana Stolichny:** Resources, Data curation. **Vladimir Chitoroga:** Resources, Data curation. **Michael Shilo:** Validation, Software, Resources, Formal analysis, Data curation. **Michael Friger:** Validation, Software, Resources, Formal analysis, Data curation. **Jamal Jafari:** Visualization, Supervision, Methodology, Investigation. **Evgeny Chernogoz:** Software, Resources, Methodology, Investigation, Formal analysis. **Maggie Cohen Grisaru:** Validation, Software, Resources, Methodology, Investigation, Data curation. **Amos Katz:** Writing – review & editing, Visualization, Methodology, Formal analysis, Conceptualization. **Chaim Yosefy:** Writing – review & editing, Visualization, Supervision, Conceptualization. **Gili Givaty:** Visualization, Resources, Project administration, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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