ORIGINAL ARTICLE

CONTENTS

Predictors of complicated course of acute myocardial infarction with ST-segment elevation in patients with obesity, overweight and normal body weight

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ABSTRACT

Aim: The aim of the study was to clarify the influence of smoking and other risk factors (RFs) on the occurrence of complications in patients with normal body weight, overweight (OW) and obesity.

Materials and Methods: Patients (n=158) with acute ST-segment elevation myocardial infarction (STEMI) were divided into 3 groups depending on body mass index (BMI): Group I included 52 patients with normal body weight (mean age - 60.83±11.94 years); Group II - 51 patients with OW (mean age - 62.04±8.55 years); Group III - 55 patients with obesity of I-III degree (mean age - (0.96±11.31 years) (p>0.05).

Results: The most common RFs were hypertension (88.46-94.55%), dyslipidemia (DLP) (50.00-76.36%), smoking (69.23-69.09%). The relative risk of acute left ventricular aneurysm in Group I with DLP is 2.08 times higher (RR=2.08 [0.37; 11.62], p=0.029), and among smokers, this risk increases by 25% (RR=1.25 [0.22; 7.18], p=0.049).

The relative risk of major complications in Group II in the presence of 5-6 RFs is 1,5 times higher (RR=1.58 [0.61; 10.94], p=0.016). The relative risk of all complications in Group III in the presence of DLP is 1.23 times higher (RR=1.23,

with 95% CI from 0.91 to 1.65, p=0.017), and in the presence of smoking is 8.37 times higher RR=8.37 [2.11; 33.16], p<0.001).

Conclusions: Complications are observed three times more often in obese patients and about twice as often in overweight patients. Significant predictors of complications are smoking, dyslipidemia, simultaneous exposure to 5-6 risk factors.

Smoking increases the risk of complications by 8 times in obese patients.

KEY WORDS: acute myocardial infarction, overweight, obesity, risk factors, smoking

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INTRODUCTION

Obesity is one of the major risk factors and predictors of coronary heart disease (CHD) and premature death. Individuals with mild obesity have a life expectancy 3–5 years shorter than those with normal body weight, while severe obesity can reduce life expectancy by up to 15 years [1–4]. The 26-year Framingham study involving 5209 participants established a clear relationship between obesity and the development of cardiovascular diseases (CVD). Researchers note that obesity is an independent risk factor (RF) for cardiovascular events, especially in women [5]. The distribution of adipose tissue is important in the development of cardiometabolic diseases. For example, according to the results of an American study that included 2683 postmenopausal women with a normal BMI (from 18.5 to 24.9 kg/m2) without CVD at the beginning of the study, it was found that women with a higher amount of adipose tissue in the abdominal area and a lower level in the thigh area have an increased risk of developing CVD [6]. These findings highlight the importance of fat distribution in specific body areas in the development of CVD.

One of the most aggressive risk factors for acute myocardial infarction (AMI) is smoking [7]. The great number of studies demonstrate a causal relationship between smoking and CVD occurrence'. It has been proven that each cigarette smoked increases the risk of non-fatal AMI by 5.6% [8]. Smoking one pack of cigarettes per day for 20 years leads to the intake of approximately 2 kg of various chemicals (sulfur, chlorine, calcium, potassium) and heavy metals (cadmium, lead, chromium, iron, manganese, strontium, nickel, zinc) enter the body [9]. The effect of passive smoking on the human body is no less dangerous [10]. The combination of smoking with

obesity and arterial hypertension (AH) is particularly dangerous. When smoking is combined with abdominal obesity, cardiovascular risk increases by 5.5 times [11]. In particular, one study examining the long-term consequences of ST-segment elevation AMI (STEMI) found that smoking was the strongest predictor of secondary cardiovascular events in individuals under 35 years of age. The association with obesity significantly increases this risk [12].

Since AMI in the context of obesity remains an important issue in modern medicine, a detailed study of the influence of various risk factors—primarily smoking—on the course of this combined pathology may form the basis for identifying key pathogenetic mechanisms and contribute to the development of pathogenetically based treatments [13,14].

AIM

The aim of our study was to determine the influence of smoking and other risk factors on the occurrence of complications in the early post-infarction period in patients with overweight (OW) and obesity.

MATERIALS AND METHODS

158 patients with STEMI aged 32 to 86 years who were hospitalized at the Department of Cardiology and Reperfusion Therapy of the Lviv Territorial Medical Association «Multidisciplinary Clinical Hospital of Intensive Care and Emergency Medical Care» were examined. The inclusion criteria were: men and women over the age of 18 years diagnosed with STEMI. The clinical diagnosis of STEMI was established on the basis of clinical, laboratory and instrumental studies, in accordance with the recommendations of the Ukrainian Association of Cardiologists (2021) and the European Society of Cardiology (2023) [15]. Also, the patient's informed consent to participate in the study was mandatory. Exclusion criteria included hereditary syndromes associated with obesity, as well as secondary, diencephalic, and mixed forms of obesity.

All patients with AMI were divided into three groups: the first Group consisted of 52 patients with AMI with normal body weight (BMI – 18.5-24.9 kg/m2), the second Group – 51 patients with AMI with OW (BMI – 25.0-29.9 kg/m2), the third Group – 55 patients with AMI and obesity of I-III degrees (BMI ≥30.0 kg/m2). In all cases, the patients were comparable between the groups in terms of age and sex.

According to the criteria of the American BRFSS system (The Behavioral Risk Factor Surveillance System), smokers were considered to be people who smoke daily, sometimes or are exposed to passive tobacco smoke. When classifying the status of a smoker, the following criteria were used:

1) smokers – persons who smoke daily or occasionally and have smoked 100 or more cigarettes in their lifetime;

2) former smokers – persons who have quit smoking and now do not smoke at all, but have smoked more than 100 cigarettes in their lifetime;

3) non-smokers – persons who have not smoked 100 cigarettes in their lifetime.

The survey recorded the number of cigarettes smoked per day and the duration of smoking (in years).

Statistical analysis of the obtained results was performed using both descriptive and analytical methods. Medico-statistical analysis of the received data was produced by descriptive and analytical methods using Microsoft Excel 2016, Statistica 10 and IBMSPSS Statistics 20 programs. A Gaussian distribution was established, which allowed us to determine the standard deviation (SD) and error (M±m) for each of the studied mean values (Mean). Comparison of two sets of mean values was carried out using the unpaired Student's t-test (t). Pearson's $\chi 2$ test was used to compare two sets of categorical variables and frequencies. The calculation of the correlational dependence between the studied parameters was carried out using the Pearson linear correlation method (r). Averages (Mean) were presented as the arithmetic mean and its standard error (M±m). Comparison of 2 groups of mean values was performed using the unpaired Student's t-test. To describe relative values, percentages and their errors ($P \pm m_p$, %) were calculated. The calculation of the correlational interdependence between the studied indicators was carried out using the Spearman method. The results were considered reliable at a minimum significance level of $p<0.05$. To compare the magnitude of the influence of risk factors in the studied groups, the relative risk indicator (RR) was calculated.

During the study, all ethical standards were upheld in accordance with the principles of the World Medical Association's Declaration of Helsinki, the Council of Europe's Convention on Human Rights and Biomedicine, ICHGCP, and current regulatory legal acts of Ukraine. The set of diagnostic procedures was approved by the Bioethical Commission of the State non-profit enterprise «Danylo Halytsky National Medical University in Lviv». The main source of information was the inpatient medical record (form 003/0). No violations were identified during the study (protocol No. 2, dated 09/26/2022).

RESULTS

The prevalence of STEMI risk factors was analyzed across the three patient groups (Table 1). Along with hyper-

Table 1. Prevalence of the main risk factors in patients with STEMI depending on BMI ($P\pm m_p$, %)

Indicators	Group I (n=52)	Group II (n=51)	Group III (n=55)
	$P\pm m_p$, %	$P\pm m_p$, %	$P\pm m_p$, %
Hypertension	88.46±4.43	92.16±3.76	94.55±3.06
DLP	50.00±6.93	62.75±6.77	76.36±5.73##
T2DM	17.31±5.25	31.37±6.5	47.27±6.73##
Smoking	69.23±6.40	56.86±6.94	69.09±6.23
Excessive alcohol consumption	40.38±6.80	43.14±6.94	32.73±6.33
Hereditary factors	19.23±5.47	25.49±6.10	36.36±6.49#
Occupational hazards	32.69±6.51#	25.49±6.10	16.36±4.99
PIC*	25.00±6.00	15.69±5.09	16.36±4.99

Note: #– p<0.05, ##– p<0.01, significance of the difference between the indicators of Groups I and III; *–Type 2 diabetes mellitus;
Source: compiled by the authors of this study

Table 2. Relative risk (RR) of complications depending on the presence of risk indicators

Indicators	RR value [95% CI]		
	Group I	Group II	Group III
60-69 years	1.02 [0.65-1.60]	1.09 [0.74-1.62]	1.45[0.77-2.73] *
≥70 years	0.87 [0.67-1.13]	1.08 [0.79-1.46]	1.28[0.07-1.2] *
VAI>1.1**	0.91[0.82-1.0]	0.86 [0.22-3.45]	1.12[0.99-1.26] *
Hypertension	1.19 [0.16-9.09]	1.14 [0.94-1.38]	0.56 [0.05-5.8]
T2DM	1.04 [0.74-1.46]	1.09 [0.74-1.62]	1.37[0.83-2.28] *
Dyslipidemia	1.00 [0.50-1.99]	1.42 [0.87-2.32] *	1.23 [0.91-1.65]
Smoking	1.48 [0.77-2.82] *	1.23 [0.73-2.06]	8.37[2.11-3.16] *
LDL-C >1.4 mmol/l	1.22 [0.80-1.87] *	1.42 [0.87-2.32] *	1.43[0.91-2.26] *
HDL-C <1.0 mmol/l	1.61 [0.73-3.55] *	1.51 [0.69-3.26] *	1.54[0.96-2.49] *
GFR<60 ml/min/1.73 m^2	1.43 [0.38-5.39] *	1.42 [0.87-2.32] *	1.56 [0.84-2.89] *
hospitalization after 12 hours	1.16 [0.75-1.78]	1.61 [0.89-2.93] *	1.51[0.97-2.36]
5-6 FR simultaneously	1.43[0.19-10.57] *	1.58 [0.61-10.94] *	1.39 [1.08-1.8] *

Note: *– p<0,05; **–visceral adiposity index
Source: compiled by the authors of this study

tension and dyslipidemia (DLP), smoking was found to be one of the most common risk factors among the surveyed individuals. Daily active or passive smoking was observed in 69.23±6.40% of patients in Group I, 56.86±6.94% of patients in Group II, and 69.09±6.23% of patients in Group III (p>0.05). The duration of smoking was analyzed, no significant difference was found between the studied groups (22.42±0.9 years (I), 23.86±1.29 years (II), 23.26±1.34 years (III), p>0.05). It was found that patients of Group I smoked a slightly larger number of cigarettes per day (21.33±0.96 pcs.), compared to individuals of Groups II and III (18.45±0.94 pcs. (II), 20.00±0.63 pcs. (III), p_{1-2}=>0.05, $p_{1-3>}$0.05, p_{2-3}>0.05), although there was no significant difference either. It was also found that only 2 individuals in Group II were exposed to the harmful effects of passive smoking, while the remaining patients were active smokers.

The frequency of complications during the hospital period of AMI was analyzed. The highest proportion of patients with complicated AMI was recorded in the obese group (52.73±6.73%), compared with OW (39.22±6.84%) and patients with normal (19.23±5.47%) body weight (p_{1-2}=0.026, p_{1-3}<0.001) (Fig. 1). In particular, the course of AMI was complicated by the formation of acute LV aneurysm (p_{1-3}=0.005, p_{2-3}=0.028) three times more frequently in obese patients and approximately twice as often in overweight patients, compared with patients with normal body weight. A similar trend was observed in the groups regarding the occurrence of acute heart failure (Killip Class III-IV) (p_{1-3}=0.049).

Rhythm and conduction disturbances were observed across all groups, but occurred three times more fre-

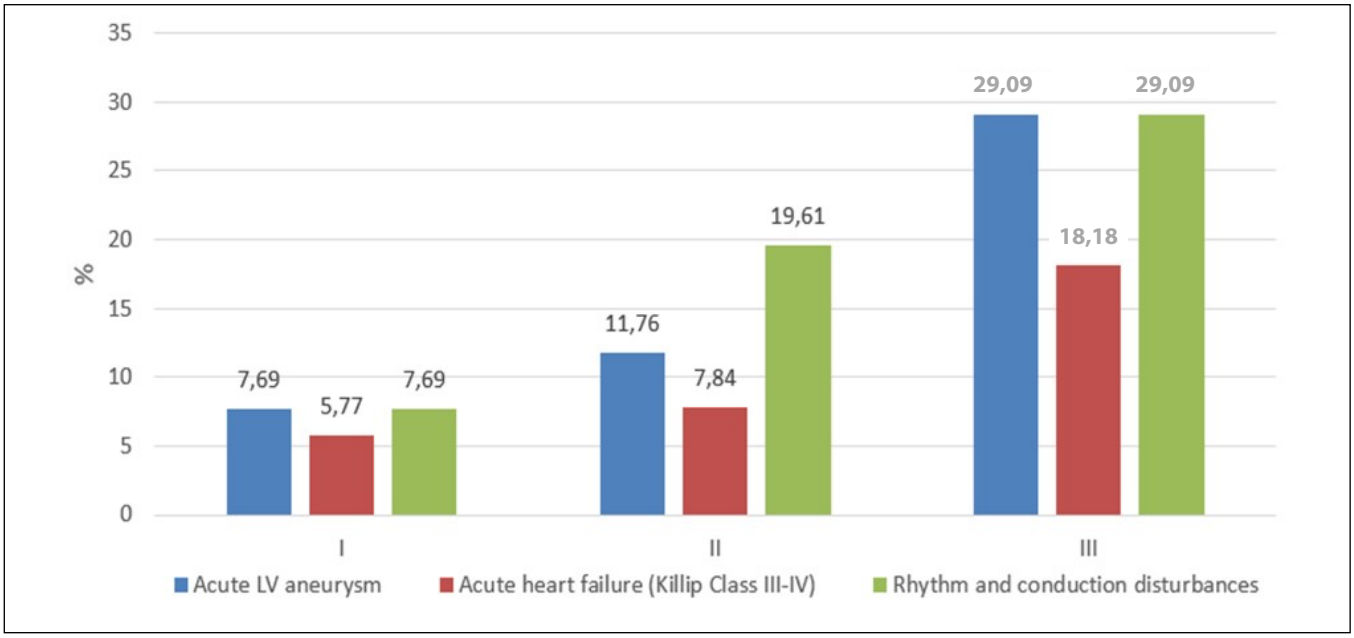

Fig. 1. Complications during the hospital period STEMI (P±mp, %)
Picture taken by the authors

quently in obese patients (Group III) ($p_{1-3=}$0.005) and approximately twice as often in overweight patients compared to patients with normal body weight. In particular, ventricular fibrillation (VF) with successful defibrillation was diagnosed in 1.92±0.9% of persons in Group I, 1.96±0.9% of persons in Group II and 5.45±2.06% of persons in Group III. Other rhythm disturbances (such as atrial fibrillation and ventricular tachycardia) were observed in 6 patients (10.91±4.2%) in Group III, 4 patients (7.84±3.76%) in Group II and 1 patient (1.92±0.9%) in Group I (p>0.05). Conduction disorders were noted in 3.85±1.67% of patients in Group I, 9.8±4.16% of patients in Group II, and among patients of III Group – in 12.73±4.49%.

We analyzed the impact of individual risk factors on the likelihood of adverse events during the early post-infarction period in patients with different body weights (Table 2). It was found (p=0.014) that the relative risk of major STEMI complications in smokers with normal body weight (Group I) is 1.48 times higher than among non-smokers (RR=1.48, with a 95% confidence interval (CI) of 0.77 to 2.82). In Group I, the presence of 5–6 risk factors (RFs) increased the complication risk by 43% (RR=1.43[0.19; 10.57], p=0.021), with LDL-C level>1.4 mmol/l – by 22% (RR=1.22 [0.80; 1.87], p=0.048), with HDL-C level<1.0 mmol/l – by 61% (RR=1.61 [0.73; 3.55], p=0.016), and with GFR<60 ml/min – by 43% (RR=1.43 [0.38; 5.39], p=0.035) (Table 2).

We analyzed the impact of individual RFs on the risk of developing major complications of AMI in each of the patient groups. In particular, it was reliably established (p=0.038) that the relative risk of acute LV aneurysm in patients with STEMI and normal body weight (Group I) who have DLP is 2.08 times higher (RR=2.08 [0.37; 11.62], p=0.029), furthermore, among smokers, this risk increases by 25% (RR=1.25 [0.22; 7.18], p=0.049). Risk of acute LV aneurysm increases by 3.33 times (RR=3.33 [0.61; 18.29], p=0.006) with late hospitalization in these patients. The relative risk of rhythm and conduction disturbances occurrence in smokers with STEMI and normal body weight (Group I) is 1.42 times higher than in patients who do not smoke (RR=1.42 [0.52; 3.84], p=0.038). Thus, in patients with normal body weight (Group I) the dominant RFs are smoking, DLP and late hospitalization.

The relative risk of major complications in patients with STEMI and OW (Group II) in the presence of 5-6 FRs is one and a half times higher (RR=1.58 [0.61; 10.94], p=0.016). A similar situation is observed in patients hospitalized after 12 hours (RR=1.61 [0.89; 2.93], p=0.046). In particular, the relative risk of acute LV aneurysm in patients of Group II doubles in the presence of T2DM (RR=2.00 [0.32; 12.55], p=0.040), a similar trend is observed in DLP (RR=2.00 [0.63; 6.32], p=0.011). This risk is also two and a half times higher with HDL-C levels <1.0 mmol/l (RR=2.53 [0.41; 15.66], p=0.022) and with GFR <60 ml/min/1.73 m^2 (RR=2.40 [0.39; 14.88], p=0.026).

Analysis of the prerequisites for the acute left ventricular failure (Killip class III-IV) occurrence in patients with STEMI and OW (Group II) showed that the risk is 2.64 times higher in the presence of DLP (RR=2.64 [0.48; 14.58], p=0.010). A similar relative risk of acute left ventricular failure (Killip class III-IV) in Group II is associated with smoking, and is 2.38 times higher in

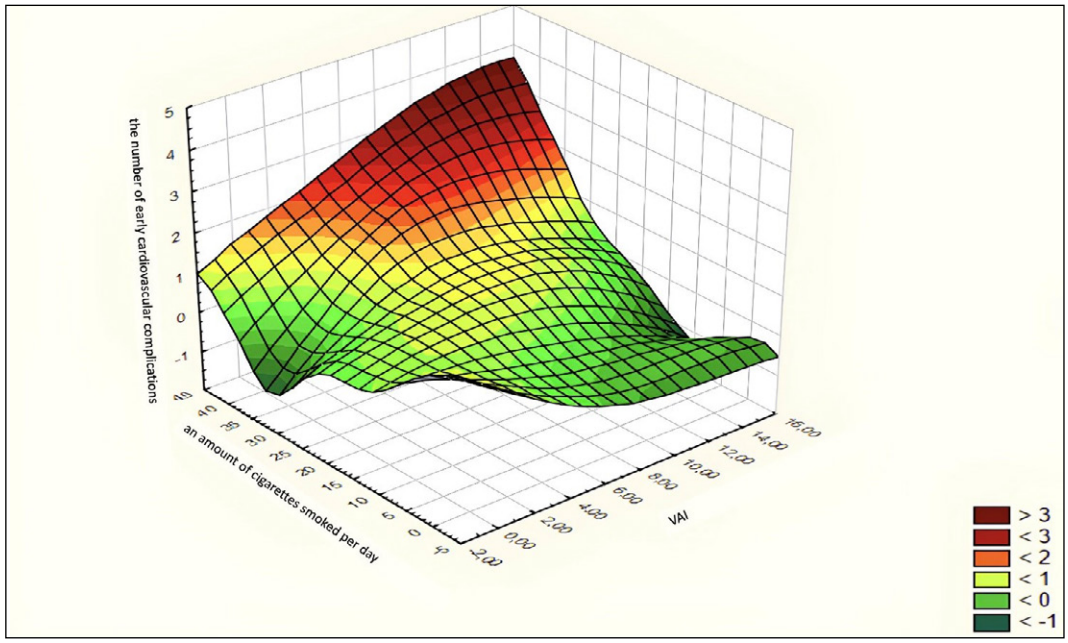

Fig. 2. Dependence of the number of early cardiovascular complications in patients with STEMI, an amount of cigarettes smoked per day and VAI
Picture taken by the authors

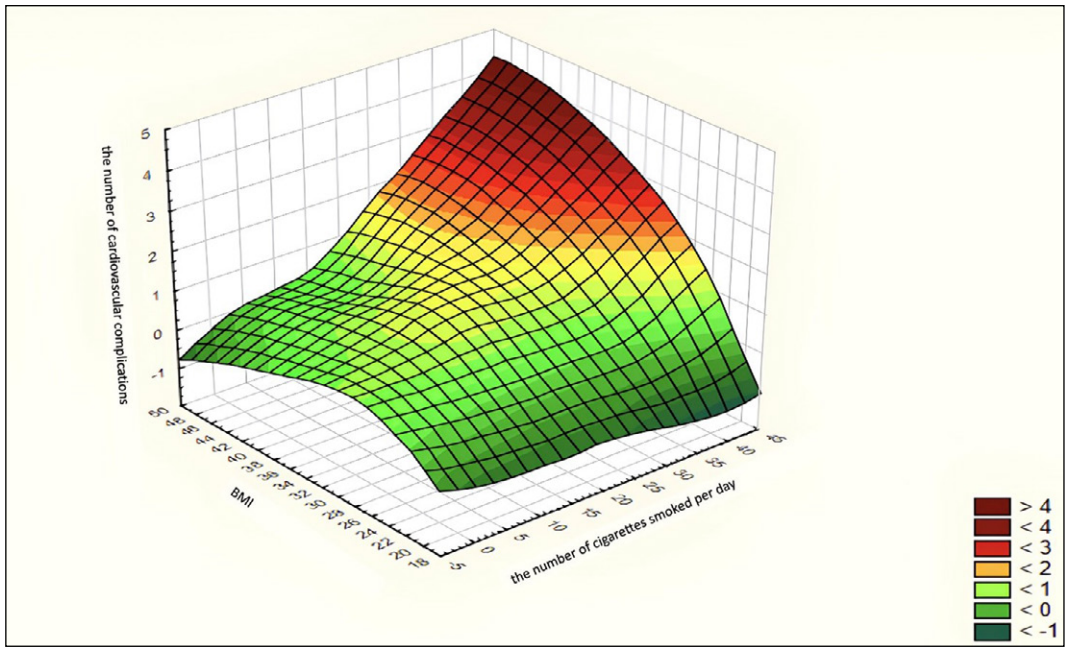

Fig. 3. Relationship between the number of cigarettes smoked per day, BMI and the number of cardiovascular complications in patients with STEMI
Picture taken by the authors

smokers compared to non-smokers (RR=2.38 [0.43; 13.22], p=0.018).

The risk of rhythm and conduction disturbances in smokers increases by one and a half times (RR=1.52 [0.69; 3.38], p=0.023), in the presence of DLP – by two times (RR=2.07, [0.57; 7.55], p=0.020), in the presence of more than five RFs – by 2.20 times (RR=2.20 [0.31; 15.38], p=0.039), with GFR <60 ml/min – by 2.36 times (RR=2.36 [0.90; 6.20], p=0.017). Therefore, the most significant RFs in Group II patients are smoking, T2DM and DLP.

In patients in Group III, the relative risk of major complications increases 1.45-fold in those aged over 60 years compared to younger individuals (RR=1.45 [0.77; 2.73], p=0.024) (Table 2). Additionally, the relative risk of all complications in the presence of DLP is 1.23 times higher (RR=1.23, [0.91; 1.65], p=0.017), and T2DM is one and a half times higher (RR=1.37 [0.83; 2.28], p=0.021). In obese patients with more than five RFs, the relative risk of complications increases by 39% (RR=1.39 [1.08; 1.80], p=0.021). With late hospitalization (i.e., more than 12

hours after AMI onset), the risk increases by 51% (RR=1.51 [0.97; 2.36], (p=0.024), with LDL-C level>1.4 mmol/l – by 43% (RR=1.43 [0.91; 2.26], p=0.012), with HDL-C level<1.0 mmol/l – by 54% (RR=1.54 [0.96; 2.49], p=0.012), and with GFR<60 ml/min – by 56% (RR=1.56 [0.84; 2.89], p=0.015). Special attention should be paid to the smoking factor, which increases the risk of major complications by as much as 8.37 times RR=8.37 [2.11; 33.16], p<0.001). Particularly, the relative risk of acute LV aneurysm in obese smokers increases by 6.56-fold (RR=6.56 [0.95; 45.44], p=0.011).

To better illustrate the combined effect of multiple factors on the occurrence of cardiovascular complications in patients with STEMI, we present 3D diagrams. Fig. 2 demonstrates a direct relationship between the number of complications, the number of cigarettes smoked per day, and the visceral adiposity index (VAI).

The increase in the number of cardiovascular complications in patients with STEMI, BMI level, and cigarettes smoked per day Fig. 3 demonstrates.

DISCUSSION

The results of our study confirm the fact that the presence of multiple RFs significantly determines the development of a complicated course of AMI, regardless of the patient's body weight. However, it is among individuals with OW and obesity (BMI >25 kg/m^2) that these factors have a more pronounced negative impact. The presence of ≥5 RF credibly increases the risk of major complications by one and a half times in patients with normal body weight. This is statistically proven (RR=1.58; p=0.016). According to the data of the large international INTERHEART study, more than 90% of the first myocardial infarction' risk in different populations is explained by nine factors that are potentially modifiable [16].

In the group of OW patients (group II), the presence of metabolic disorders plays an important role. The risk of acute LV aneurysm doubles in the presence of T2DM and DLP (RR=2.00; p=0.040 and p=0.011, respectively). Diabetes is equivalent to previous MI in predicting recurrent cardiovascular events. Similar results were demonstrated in the UKPDS study [17].

Low HDL-C (<1.0 mmol/L) is associated with a 2.5-fold increased risk of LV aneurysm (RR=2.53; p=0.022). This correlates with the findings of the Framingham Heart Study, where low HDL-C was identified as an independent predictor of CHD [18]. A negative impact of late hospitalization (>12 h after symptom onset) was also noted, increasing the risk of complications in both patients groups with OW (RR=1.61; p=0.046) and obesity (RR=1.51; p=0.024). This is confirmed by current recommendations of the European Society of Cardiology (ESC), which emphasize the crucial role of "time to reperfusion" in STEMI [19].

Smoking deserves special attention, as in obese patients it is associated with a sharp increase in the risk of major complications by 8.37 times (p<0.001), and the probability of developing LV aneurysm increases by 6.56 times (p=0.011). These data noticeably exceed those obtained in the large Global Burden of Disease analysis (GBD), which estimated smoking as a risk factor for cardiovascular death (RR ≈ 2.5) [20], and suggest the joint effect of smoking and obesity.

The risk of acute left ventricular failure (Killip III–IV) in OW individuals is increased in the presence of DLP (RR=2.64; p=0.010) and smoking (RR=2.38; p=0.018). The combined effect of several risk factors (≥5) leads to an increase in the possibility of rhythm and conduction disturbances by 2.2 times (p=0.039), and with a decrease in GFR <60 ml/min – by 2.36 times (p=0.017). This is coincides with the REACH study, which identified chronic kidney disease as an important predictor of poor prognosis in patients with atherothrombosis [21].

In the obese group (group III), individuals older than 60 years had a 1.45-fold higher risk of complications (p=0.024), and the presence of T2DM, DLP, high LDL-C, low HDL-C, and reduced GFR also significantly worsened the prognosis. These results are consistent with the IDF criteria for metabolic syndrome, which indicate a cardiometabolic "explosive" combination of RF [22].

The 3D diagrams we used also confirmed an evidence of a dose-dependent association between the number of cigarettes smoked, body mass index, and the number of complications, indicating a risk accumulation effect. This is consistent with the concept of "total risk burden" that underlies modern risk assessment scales, in particular SCORE2 [23].

Our results confirm that the presence of multiple risk factors significantly worsens the prognosis of STEMI, regardless of the patient's body weight. However, smoking, type 2 diabetes, DLP, reduced renal function, and late hospitalization in obese patients are particularly dangerous. A study of Chinese patients aged ≥60 years showed that smokers had higher levels of C-reactive protein and a higher incidence of acute MI (16.7% in smokers vs. 7.0% in nonsmokers; p=0.008) and worse 10-year survival [24]. Among persons younger than 60 years of age who had a STEMI, continued smoking at one year was associated with a 2.51-fold increased risk of MACE and a 2.52-fold increased risk of mortality compared with nonsmokers [25]. However, those who quit smoking had similar outcomes to nonsmokers. In a multinational cohort study, smokers had a higher risk of MACE and mortality over 5 years, as well as an increased risk of lung cancer.[26] A recent review (Global Heart, 2024–2025) confirms that smoking accelerates atherosclerosis, causes endothelial dysfunction, hypercoagulability, oxidative stress, and that quitting smoking even for a few months significantly reduces cardiovascular risk [27].

In our study, smoking increased the risk of complications

by 8.37 times (p<0.001), the risk of developing LV aneurysm by 6.56 times (p=0.011) in the obese group. This is strong evidence of the synergistic effect of smoking and obesity, consistent with current evidence of increased endothelial dysfunction and thrombosis with the simultaneous action of multiple RFs [27].

In the aforementioned study of young STEMI patients, smoking cessation within a year reduced the risk of MACE to that of nonsmokers [25]. This is supported by the results of the Global Heart Review, which shows that the benefits of smoking cessation begin to be apparent after 1-2 years [27].

Several large registries, including ISACS-STEMI (16,000 patients, COVID pandemic), show the "smoker's paradox" [28], i.e. reduced in-hospital and 30-day mortality in smokers after PCI. However, subsequent analyses suggest that age plays a role, as smokers are generally younger. Furthermore, the short-term benefits of rapid reperfusion outweigh the systemic long-term effects of smoking. It should be emphasized that this paradox does not imply a positive effect of smoking; it reminds us of the need to adjust for age and clinical factors in statistical analyses. Thus, smoking, type 2 diabetes, DLP, reduced GFR, and late hospital admission are the main predictors of a complicated AMI in OW and obese patients. This requires a more intensive multidisciplinary approach to the management of such patients, starting from the outpatient observation stage.

CONCLUSIONS

The total number of complications is observed three times more frequently in obese patients and approximately twice as frequently in overweight patients compared to those with normal body weight. Regardless of body mass index, significant predictors of complications include smoking, dyslipidemia, late hospitalization, and the simultaneous presence of five to six risk factors. At the same level of smoking intensity, the risk of complications in the early post-infarction period increases with a higher body mass index. Smoking increases the likelihood of complications by 1.5 times in patients with normal body weight and by eight times in obese patients.

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CONFLICT OF INTEREST

The Authors declare no conflict of interest

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