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Original Research Article

Gender-specific characteristics of acute myocardial infarction in the Grodno Region of the Republic of Belarus

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ABSTRACT

Background: Acute myocardial infarction (AMI) remains a leading cause of morbidity and mortality worldwide. Emerging evidence suggests significant gender-based differences in the pathophysiology, clinical presentation, and outcomes of MI. This study aimed to investigate gender-specific characteristics in clinical, laboratory, and angiographic parameters among patients with AMI in the Grodno Region of Belarus.
Methods: This prospective study included 100 patients (50 males, 50 females) admitted with a diagnosis of MI to the Grodno Regional Cardiological Center between January and December 2025. Clinical characteristics, laboratory parameters, and coronary angiography findings were analyzed. Statistical analysis was performed with STATISTICA 12.0.
Results: Female patients were significantly older than males at presentation ($p<0.001$). Inferior wall MI was more common in males ($p<0.001$), while females had a higher prevalence of diabetes mellitus ($p=0.02$) and anemia ($p=0.03$). Laboratory analysis revealed significantly higher creatinine, and estimated glomerular filtration rate in females, while males had higher glucose, and cardiac enzymes (AST, ALT, CPK-MB). Coronary angiography demonstrated a significantly higher rate of total coronary occlusion in males ($p=0.001$), despite similar distributions of affected vessels and revascularization strategies.
Conclusions: Significant gender-specific differences exist in the clinical presentation, laboratory profiles, and angiographic characteristics of patients with MI. Females present at an older age with a distinct comorbidity profile, while males exhibit a higher burden of total coronary occlusion. These findings underscore the need for gender-tailored approaches in the risk stratification and management of MI.

Keywords: Acute myocardial infarction, Gender differences, Coronary angiography, Percutaneous coronary intervention, Total occlusion

INTRODUCTION

Myocardial infarction (MI), commonly known as a heart attack, represents a critical event in cardiovascular medicine defined by the irreversible necrosis of heart muscle resulting from prolonged ischemia.[1] This condition, most frequently triggered by the rupture of an atherosclerotic plaque leading to coronary artery thrombosis, remains a leading cause of morbidity and mortality worldwide.[2] Understanding the nuances of MI is of paramount clinical importance, as it underpins strategies for risk stratification, acute management, and secondary prevention.

While traditionally viewed through a homogeneous lens, a growing body of evidence highlights that the pathophysiology, clinical presentation, and outcomes of MI are not uniform across populations. Specifically, significant biological and pathophysiological differences exist between men and women, influencing the pattern, extent, and severity of coronary artery involvement.[3-5]

Traditionally, it was believed that the leading cause of death in women was uterine, ovarian, and breast cancer, while men died primarily from cardiovascular diseases (CVD). However, in recent years, it has become clear that CVD, including MI, ranks first in the mortality structure for both men and women.[2] Therefore, the issue of gender-specific characteristics of the course and outcome of MI has become increasingly relevant.

This is due, firstly, to a trend toward a decrease in the incidence of MI in young men while it increases in older women, and, secondly, to a decrease in MI mortality in men, but not in women.[5] Therefore, a logical question arises: how justified is the treatment of men and women according to the same principles presented in international expert guidelines, which are based on data obtained in studies predominantly involving men.[6,7]

Recognizing these sex-based disparities is essential for moving beyond a one-size-fits-all approach, as they have profound implications for diagnostic accuracy, therapeutic efficacy, and ultimately, the improvement of cardiovascular outcomes for all patients. Our own research on this issue is of particular importance, as it allows us not only to confirm well-known gender differences in the occurrence and course of MI, but also to identify possible regional characteristics of the disease.

The aim of the study was to determine the gender-specific characteristics of MI among the population of Grodno Region of the Republic of Belarus by analyzing clinical, laboratory and angiographic characteristics.

METHODS

Study design and patient selection

The retrospective observational study included 100 patients with acute MI who were admitted to the Grodno Regional Clinical Cardiological Center (Republic of Belarus) for emergency treatment from January 2025 to December 2025. Group 1 included 50 male patients, while group 2 included 50 female patients.

We identified all cases with a main diagnosis of ST elevation myocardial infarction (STEMI) and non-ST elevation myocardial infarction (NSTEMI) between 01 January 2025 and 31 December 2025 (using an ICD code I21 or I22 within 28 days after onset of symptoms). Clinical and demographic data, the results of basic laboratory tests, medical history of comorbidities were collected for all patients from the hospital electronic database (4D client).

Exclusion criteria from the study were: acute myocarditis, pericarditis, or endocarditis, pulmonary embolism, severe valvular disease, major surgery within 30 days, and significant non-cardiac disease, such as advanced cancer (expected survival <1 year), severe liver or renal failure (dialysis).

Instrumental and laboratory assessment

Patients included in the study underwent instrumental and laboratory research methods. Patients underwent coronary angiography with possible percutaneous coronary intervention (PCI) at the same center according to the Judkins method (1967) in the X-ray operating room on the Philips Azurion 7 and GE Innova 3100 IQ angiographic units. The computer program of the GE Innova 3100 IQ unit was used for the quantitative assessment of stenoses.

Statistical methods

Statistical analysis was performed using the STATISTICA 12.0 computer software. Data distribution was assessed for normality via histogram analysis. Sets of quantitative indicators whose distribution deviated from normal were described using median (Me) values and lower and upper quartiles (Q1; Q3). Nominal data were described using absolute values and percentages. Given that most quantitative variables were not normally distributed, non-parametric methods were applied. Differences between two independent groups were evaluated by Mann-Whitney test, alongside a p value of less than 0.05 considered statistically significant.

Ethical statement

The study was performed in accordance with good clinical practice (GCP) standards and the principles of the Declaration of Helsinki.

RESULTS

Clinical characteristics of the patients are presented in Table 1.

There was a highly significant difference in age between the groups. Females were notably older than males at the time of presentation (median age 72.5 years versus 61.7 years; $p<0.001$). This aligns with the well-known phenomenon that women tend to present with MI later in life compared to men. The location of the infarct differed significantly between genders. Inferior MI was significantly more common in males (38%) compared to females (12%), with a p value of 0.001. Other locations (anterior, lateral, anterior-lateral, posterior-lateral) did not show statistically significant differences between the groups, although lateral MI was observed in 4% of females but 0% of males ($p=0.12$).

Both groups had similar median BMI values (approx. 28.5–28.8 kg/m²) and obesity rates ($p>0.05$). Hypertension was highly prevalent and equally distributed (94% in both sexes; $p > 0.05$). Atrial Fibrillation was present in 20% of both males and females ($p>0.05$). It is interesting that females had a significantly higher prevalence of diabetes mellitus compared to males (28% versus 8%; $p=0.02$) and also a significantly higher rate of anemia (18% versus 4%;

p=0.03). Laboratory parameters of patients are presented in Table 2.

The laboratory profile reveals distinct gender-related differences in hematological, renal, metabolic, and cardiac enzyme parameters, while markers of lipid profile and troponin levels were comparable between the groups.

Hematological parameters

Hemoglobin was significantly higher in males than in females (146 versus 133 g/l; p<0.001), which was in accordance with the previous results, confirming females having a higher prevalence of anemia. Red blood cell count (RBC) was also slightly but significantly higher in males (4.72 versus 4.56×10^{12}/l; p=0.01). Erythrocyte sedimentation rate (ESR) was lower in female patients (10 versus 15 mm/h; p=0.03). Platelet count showed a trend toward being higher in males but did not reach statistical significance (p=0.05). White blood cell count (WBC) was similar between sexes (p=0.08).

Renal function

Creatinine was higher in males (90.5 versus 79.0 µmol/l; p=0.009), while urea was higher in females (6.6 versus 5.8 mmol/l; p=0.04). Estimated glomerular filtration rate (eGFR) was significantly lower in females (59.8 versus 76.8 ml/min/1.73m²; p=0.005), indicating better renal function in females despite their higher urea levels.

Metabolic parameters

Glucose was significantly higher in females (7.8 versus 6.7 mmol/l; p=0.001), consistent with the higher prevalence of diabetes mellitus observed in females (28% versus 8% in Table 1). Sodium was slightly but significantly higher in males (138.9 versus 140.0 mEq/l; p=0.01). Potassium was borderline lower in females (4.05 versus 3.80 mEq/l; p=0.05). Lipid profile (total cholesterol, LDL, HDL, triglycerides) showed no significant differences between genders.

Table 1: Clinical characteristics of patients.

Parameters	Males (n=50)	Females (n=50)	P value
Age (years)	61.7 [52; 69.8]	72.5 [65; 81.8]	<0.001
Body mass index, kg/m²	28.5 [25.4; 30.3]	28.8 [25.2; 31.4]	>0.05
Obesity, N (%)	8 (16)	14 (28)	>0.05
Hypertension, N (%)	47 (94)	47 (94)	>0.05
Stage 1, N (%)	4 (8)	3 (6)	>0.05
Stage 2, N (%)	42 (84)	45 (90)	>0.05
Stage 3, N (%)	1 (2)	3 (6)	>0.05
Localization of MI	-	-	
Anterior, N (%)	22 (44)	26 (52)	>0.05
Inferior, N (%)	19 (38)	6 (12)	0.001
Lateral, N (%)	0 (0)	4 (4)	>0.05
Anterior-lateral, N (%)	2 (4)	2 (4)	>0.05
Posterior-lateral, N (%)	8 (16)	11 (22)	>0.05
Diabetes mellitus, N (%)	4 (8)	14 (28)	0.02
Atrial fibrillation, N (%)	10 (20)	10 (20)	>0.05
Anemia, N (%)	2 (4)	9 (18)	0.03

Cardiac enzymes and markers

Aspartate aminotransferase (AST) and alanine aminotransferase (ALT) were both significantly higher in males (AST: 38 versus 24 U/l, p=0.001; ALT: 34 versus 23 U/l, p=0.006). Lactate dehydrogenase (LDH) and creatine kinase-MB (CPK-MB) were also significantly elevated in males (LDH: 566 versus 490.5 IU/l, p = 0.05; CPK-MB: 38.1 versus 25.0 IU/l, p=0.04). Troponin levels, though numerically higher in males (4826.5 versus 1628 ng/l), did not reach statistical significance (p=0.16).

Coronary angiography parameters of the studied patients groups are given in Table 3.

There were no significant differences between groups in the involvement of the left main coronary artery, left anterior descending artery, left circumflex artery, or right coronary artery (p>0.05). Rates of stenting (66% versus 72%, p=0.66) and balloon dilation (58% versus 56%, p=1.00) were similar, as was the total number of stents placed (median 1 versus 1.5, p=0.21). A marked and statistically significant difference was observed in the prevalence of total coronary occlusion: 64% in group 1 compared to 30% in group 2 (p=0.001). The distribution of multivessel disease (stenosis >50%) was similar between groups for one-vessel disease (20% each, p>0.05) and for three or more affected vessels (38% versus 42%, p>0.05). However, two-vessel disease showed a borderline difference (30% in group 1 versus 18% in group 2, p=0.05). The coronary angiography data reveal that the

most prominent gender-related difference is the significantly higher rate of total occlusion in group 1 (presumably males) compared to group 2 (females). Despite similar distributions of individual vessel involvement and overall revascularization strategies, this disparity in total occlusion may reflect underlying differences in plaque morphology, thrombotic burden, or timing of presentation between sexes. The trend toward more two-vessel disease in group 1 further suggests potential variations in the extent of coronary atherosclerosis that warrant consideration in gender-tailored management strategies for acute MI.

Table 2: Laboratory parameters of patients.

Parameters	Males (n=50), Me [Q1; Q3]	Females (n=50), Me [Q1; Q3]	P value
RBC, 10^{12}/l	4.72 [4.42; 5.09]	4.56 [4.23; 4.73]	0.01
Hemoglobin, g/l	146 [140; 157]	133 [126; 142]	<0.001
WBC, 10^9/l	9.4 [7.6; 11.6]	8.7 [6.9; 10.3]	>0.05
ESR, mm/h	10 [6.75; 22]	15 [10; 14]	0.03
Platelets, 10^9/l	210 [154; 242]	213 [184; 262]	0.05
Urea, mmol/l	5.8 [5,1; 6,7]	6,6 [5,3; 8,8]	0.04
Creatinine, µmol/l	90.5 [80.9; 104.9]	79 [67.1; 107.8]	0.009
eGFR, ml/min/1.73m^2	76.8 [58.6; 90.75]	59.8 [47.8; 81.3]	0.005
Total cholesterol, mmol/l	5.47 [4.31; 6.29]	5.5 [4.4; 6.6]	>0.05
LDL, mmol/l	2.8 [2.4; 3.6]	2.66 [2.3; 3.72]	>0.05
HDL, mmol/l	1.15 [0.84; 1.4]	1.05 [0.82; 1.26]	>0.05
Triglycerides, g/l	1.67 [1.34; 2.38]	1,28 [1; 1.7]	>0.05
Glucose, mmol/l	6.7 [5.6; 7.4]	7.8 [6.4; 10.3]	0.001
Troponin, ng/l	4826.5 [531; 19575]	1628 [469; 14902]	>0.05
AST (IU/l)	38 [21; 76]	24 [17; 37]	0.001
ALT (IU/l)	34 [22; 65]	23 [16; 38]	0.006
LDH (IU/l)	566 [427; 783.5]	490.5 [387.4; 646]	0.05
CPK-MB (IU/l)	38.1 [21.1; 104.9]	25 [15.1; 64]	0.04
Sodium, mEq/l	140 [138; 142]	138.9 [136; 140]	0.01
Potassium (mEq/l)	4.05 [3.6; 4.5]	3.8 [3.6; 4]	0.05

Me – median value, Q1 – lower quartile, Q3 – upper quartile, RBC – red blood cells, WBC – white blood cells, ESR – erythrocyte sedimentation rate, eGFR – estimated glomerular filtration rate, LDL – low-density lipoproteins, HDL – high-density lipoproteins, AST - aspartate aminotransferase, ALT - alanine aminotransferase, LDH - lactate dehydrogenase, CPK-MB - creatine phosphokinase-MB

Table 3: Coronary angiography parameters.

Parameters	Males (n=50), Me [Q1; Q3]	Females (n=50), Me [Q1; Q3]	P value
Affected vessel	-	-	-
Left main coronary artery, n (%)	9 (18%)	3 (6%)	>0.05
Left anterior descending artery, n (%)	36 (72%)	36 (72%)	>0.05
Left circumflex artery, n (%)	28 (56%)	25 (50%)	>0.05
Right coronary artery, n (%)	31 (62%)	30 (60%)	>0.05
Stenting, n (%)	33 (66%)	36 (72%)	>0.05
Total number of stents	1 [1;2]	1,5 [1; 2,25]	>0.05
Balloon dilation, n (%)	29 (58%)	28 (56%)	>0.05
Total occlusion, n (%)	32 (64%)	15 (30%)	0.001
Number of vessel disease (stenosis >50%)	-	-	
1 affected vessel	10 (20%)	10 (20%)	>0.05
2 affected vessels	15 (30%)	9 (18%)	0.05
3 or more affected vessels	19 (38%)	21 (42%)	>0.05

Me – median value; Q1 – lower quartile; Q3 – upper quartile

DISCUSSION

The present study sought to delineate gender-specific characteristics of acute MI among patients in the Grodno Region of Belarus by systematically analyzing clinical, laboratory, and angiographic parameters. Our findings demonstrate significant disparities between male and female patients, reinforcing the growing recognition that sex is a critical determinant in the pathophysiology and

presentation of MI. One of the most prominent findings was the marked difference in age at presentation, with female patients being significantly older than their male counterparts (median 72.5 versus 61.7 years; p<0.001). This observation is consistent with existing literature, which attributes the later onset of MI in women to the cardioprotective effects of endogenous estrogen during the premenopausal period, with risk accelerating after menopause.[8] This age disparity has important clinical implications, as older age in women is often associated with greater comorbidity burden, atypical symptom presentation, and delays in seeking medical care, potentially contributing to worse outcomes.[9]

In terms of infarct localization, inferior wall MI was significantly more common in males (38% versus 12%; p<0.001). This finding aligns with previous studies suggesting that men more frequently present with inferior STEMI, which may be related to differences in coronary anatomy, plaque distribution, or thrombotic tendencies. The trend toward more lateral wall MI in females (4% versus 0%), though not statistically significant, warrants further investigation in larger cohorts.

Comorbidity analysis revealed a higher prevalence of diabetes mellitus (28% versus 8%; p=0.02) and anemia (18% versus 4%; p=0.03) among female patients. The association between diabetes and adverse cardiovascular outcomes in women is well documented, with diabetic women facing a disproportionately higher risk of heart failure and mortality following AMI compared to diabetic men.[10] These comorbidities likely contribute to the more advanced clinical presentation observed in women.

Laboratory findings further highlighted gender-specific differences. Renal function assessment revealed that females had significantly lower estimated glomerular filtration rate (eGFR) (59.8 versus 76.8 ml/min/1.73m^2; p=0.005), indicating worse renal function despite. This finding underscores the importance of using eGFR rather than creatinine alone when assessing renal function, particularly in older populations. Impaired renal function in males may contribute to higher rates of contrast-induced nephropathy following angiography and poorer long-term outcomes.[11]

Cardiac enzyme analysis showed significantly higher levels of AST, ALT, LDH, and CPK-MB in males, while troponin levels, though numerically higher, did not reach statistical significance (p=0.16). The discordance between traditional cardiac enzymes and troponin may reflect differences in non-cardiac enzyme release (e.g., from liver or skeletal muscle) or variations in infarct size and biomarker kinetics between sexes.[12] This observation warrants further investigation into whether sex-specific cutoffs for cardiac biomarkers are clinically relevant.

The most striking angiographic finding was the significantly higher rate of total coronary occlusion in males (64% versus 30%; p=0.001). This disparity was observed despite similar rates of stenting, balloon dilation, and involvement of individual coronary arteries. This finding suggests that males may present with a greater thrombotic burden or more aggressive plaque rupture phenotype, whereas females may more frequently experience non-occlusive MI or coronary microvascular dysfunction.[13] The borderline higher prevalence of two-vessel disease in males (30% versus 18%; p=0.05) further supports the notion of more extensive coronary atherosclerosis in men. These angiographic differences have important implications for revascularization strategies and secondary prevention.

Limitations

First, the sample size of 100 patients (50 per group) is relatively modest, which may limit the generalizability of findings and the ability to detect smaller but clinically significant differences. Second, the study was conducted at a single center in the Grodno Region of Belarus, and regional characteristics may limit extrapolation to other populations. Third, the absence of long-term follow-up data precludes assessment of gender-specific differences in outcomes such as major adverse cardiovascular events or mortality. Finally, while the exclusion criteria were appropriately applied to minimize confounding, this may also limit the applicability of findings to patients with complex comorbidities.

Despite these limitations, this study provides valuable insights into gender-specific characteristics of AMI in a Belarusian population and reinforces the need for sex-sensitive approaches in cardiovascular medicine. Future larger scale, multicenter studies with longitudinal follow-up is warranted to validate these findings and to determine whether gender-specific management protocols can improve outcomes in both men and women.

CONCLUSION

Female patients were notably older at presentation and exhibited a higher burden of diabetes mellitus and anemia, whereas male patients more frequently presented with inferior wall MI and demonstrated a substantially higher rate of total coronary occlusion on angiography. Laboratory analysis revealed distinct metabolic, renal, and cardiac enzyme patterns between sexes, with females showing higher glucose and urea levels and lower eGFR, while males exhibited higher hemoglobin, and cardiac enzyme levels.

The higher rate of total occlusion in males, despite similar revascularization approaches, suggests potential differences in plaque morphology or thrombotic response that merit further investigation. Additionally, the distinct comorbidity profiles and laboratory patterns underscore the need for clinicians to maintain a high index of suspicion for atypical presentations, particularly in older women.

These findings highlight that the traditional "one-size-fits-all" approach to MI management may be inadequate, and that gender-tailored strategies for risk stratification, diagnostic evaluation, and therapeutic intervention are warranted.

Future research should focus on elucidating the underlying mechanisms driving these gender-based disparities, including hormonal influences, differences in vascular biology, and genetic factors.

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