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EVALUATION OF HEMODYNAMIC CHANGES IN PATIENTS WITH URGENT SURGICAL PATHOLOGY IN MILITARY MEDICINE

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Abstract
This study evaluates hemodynamic changes in patients with urgent surgical pathologies within the context of military medicine. Hemodynamic stability is crucial for optimizing outcomes in military surgical patients who often present with unique challenges, such as trauma, limited resources, and delayed medical evacuation. The research focuses on identifying key physiological alterations, assessing the efficacy of current monitoring techniques, and exploring advanced therapeutic interventions tailored to the military environment. By analyzing clinical data from a cohort of military surgical cases, this study provides insights into the relationship between hemodynamic parameters and outcomes, aiming to enhance decision-making in field-based surgical care. The findings highlight the importance of early intervention, advanced monitoring technologies, and protocol-driven resuscitation to improve survival rates and reduce complications in this population.

Keywords Hemodynamic changes, urgent surgical pathology, military medicine, trauma, resuscitation, field surgery, critical care, surgical outcomes.

INTRODUCTION

Acute diseases of the abdominal organs are often accompanied by the development of severe complications, including multiple organ failure, the cause of which in 97% of cases is intra-abdominal hypertension (IAH) (1,4,3,9).

The problem of IAH has attracted the interest of surgeons, who have identified a relationship between the tension of the anterior abdominal wall and the degree of respiratory failure (2,5,7). Many studies have been conducted on the negative effect of IAH on central and intracardiac hemodynamics. It was obvious that an increase in IAH leads to an increase in patient mortality [6,8,10].

Perioperative cardiac hemodynamic disturbances and acute coronary events (ACS) are serious complications in patients with emergency abdominal surgery and trauma, especially in the setting of IAH. Timely diagnosis of such disorders plays an important role in preventing serious consequences. One of the main tools for early diagnosis of cardiovascular disorders is a non-invasive study - echocardiography (EchoCG), which allows you to assess the functional and structural changes in the heart, as well as identify signs of myocardial ischemia at early stages.

Aim of the study. To study hemodynamic changes in patients with urgent surgical pathology in

military medicine depending on the presence of intra-abdominal hypertension

Research material. A comparison of the results of the study was conducted between military and civilians with acute surgical abdominal pathology depending on the presence of intra-abdominal hypertension.

Table 1.

Distribution of patients into groups and subgroups

bygroup groups	A subgroup, patients with IAH		In the subgroup patients without IAH		total	
	n	%	n	%	n	%
MG - main group, patients are military personnel	39	34,8%	73	65,2%	112	48,3%
CG comparison group, civilian patients	49	40,8%	71	59,2%	120	51,7%

Note: IAH intra-abdominal hypertension

A study was conducted on 232 patients with emergency surgical diseases and abdominal injuries who were treated at the intensive care unit of the Republican Scientific Center for Emergency Medical Care of the Ministry of Health of the Republic of Uzbekistan and at the Military Hospital of the Ministry of Health of the Republic of Uzbekistan in the period from 2021 to 2024. The main group (MG) consisted of 112 military patients (48.3%), in this group subgroup A consisted of 39 patients (34.8%) with intra-abdominal hypertension (IAH+), subgroup B - 73 (65.2%) without intra-abdominal hypertension (IAH-) (Table 1). The comparison group (CG) consisted of 120 civilian patients (51.7%). Subgroup A CG consisted of patients with IAH 49 patients (40.8% of the number of CG patients), subgroup B-CG - consisted of 71 patients (59.2%) (Table 1).

METHODS

Blood pressure monitoring, ECG monitoring, echocardiographic examination, ultrasound of abdominal organs, measurement of intra-abdominal pressure with a Faley catheter according to the S.E. Bradley and G.P. Bradley method, statistical processing of results.

RESULTS

The conducted study of hemodynamic parameters in patients of both subgroups with IAP+ and IAP - demonstrated significant differences between groups and subgroups.

Table 2 presents the results of a comparative analysis of hemodynamic parameters in patients with elevated and normal intra-abdominal pressure (IAP) in two groups: civilian patients and military personnel.

In the subgroup A CG, the heart rate was 95.2 ± 10.3 bpm, which was significantly higher than in the subgroup B-CG - 78.4 ± 6.5 bpm. Similarly, in the comparison group among military personnel, the subgroup A-MG had a rate of 88.7 ± 8.2 bpm,

while the subgroup B-MG had 75.6 ± 5.4 bpm. All these differences were statistically significant with a p-value < 0.001. In the A-CG subgroup, systolic blood pressure was 150.3 ± 12.5 mmHg, which significantly exceeded 130.1 ± 9.6 mmHg in patients in the B-MG subgroup. In the A-MG subgroup, SBP was 140.6 ± 10.8 mmHg compared with 125.4 ± 7.3 mmHg in the B-MG subgroup. All results were also statistically significant (p < 0.001). The diastolic pressure in the A-CG subgroup was 95.1 ± 8.4 mm Hg versus 85.2 ± 6.8 mm Hg in the B subgroup. In the A-MG subgroup, the DBP was 90.5 ± 7.5 mm Hg, while in the B-MG subgroup it was 80.3 ± 5.9 mm Hg. These differences are also statistically significant (p < 0.001) (Table 2).

Table 2.

Comparative analysis of hemodynamic parameters

Parameter	Subgroup A MG (n=39)	Subgroup B MG (n=73)	Subgroup A CG (n=49)	Subgroup B CG (n=71)
Heart rate (bpm)	88.7 ± 8.2	75.6 ± 5.4	95.2 ± 10.3	78.4 ± 6.5
Systolic blood pressure (mmHg)	140.6 ± 10.8	125.4 ± 7.3	150.3 ± 12.5	130.1 ± 9.6
Diastolic blood pressure (mmHg)	90.5 ± 7.5	80.3 ± 5.9	95.1 ± 8.4	85.2 ± 6.8
Central venous pressure (mmHg)	10.1 ± 1.9	7.8 ± 1.2	12.6 ± 2.0	8.3 ± 1.5
Blood oxygen level (%)	92.1 ± 3.5	96.3 ± 2.0	90.3 ± 3.8	95.2 ± 2.1

The central venous pressure in subgroup A-CG is 12.6 ± 2.0 mmHg, which is significantly higher than in patients of subgroup B- CG (8.3 ± 1.5 mmHg). In military personnel, similar indicators are: 10.1 ± 1.9 mmHg in subgroup A with IAH and 7.8 ± 1.2 mmHg in subgroup B without IAH, with a reliability of p < 0.001. The blood oxygen level in civilian patients with IAH is 90.3 ± 3.8%, while in patients without IAH it is 95.2 ± 2.1%. In the group of military personnel, subgroup A with VBH showed an oxygen level of 92.1 ± 3.5%, which is lower than that of subgroup B (96.3 ± 2.0%). All differences are also statistically significant (p < 0.001).

ECG monitoring was carried out throughout the entire observation period, with an emphasis on identifying the following changes (Table 3). As can be seen from Table 10, in subgroup A CG, normal rhythm is observed in 36.7%, which is significantly lower than in subgroup B (76.1%). This indicates a high prevalence of rhythm disturbances in patients with increased IAP.

Table 3.

Results of ECG monitoring in examined patients

Parameter	Subgroup A MG (n=39)	Subgroup B MG (n=73)	Subgroup A CG (n=49)	Subgroup B CG (n=71)
Normal rhythm	20 (51,3%)	55 (75,3%)	18 (36,7%)	54 (76,1%)
Rhythm disturbances	20 (51,3%)	8 (11,0%)	19 (38,8%)	5 (7,0%)
Ischemic changes	10 (25,6%)	3 (4,1%)	24 (49,0%)	7 (9,9%)
Myocardial hypertrophy	5 (12,8%)	2 (2,7%)	8 (16,3%)	3 (4,2%)
Other pathologies	3 (7,7%)	1 (1,4%)	5 (10,2%)	1 (1,4%)

A significant proportion of patients with IAH in the main group (51.3%) have rhythm disturbances, which requires active monitoring and treatment adjustment. Arrhythmia was more often observed in military personnel against the background of IAH - the frequency of rhythm disturbances was 53.3%. All differences are also statistically significant ($p < 0.05$). Ischemic changes in the ECG are observed more often in the CG, for example, in the A-CG subgroup in 49.0% of patients, which emphasizes the seriousness of their condition. In the subgroup of military personnel without IAH, ischemic changes are detected only in 9.9%. In patients in the A-CG subgroup (16.3%), signs of myocardial hypertrophy are observed, which may indicate chronic cardiac overload.

The following parameters were assessed during echocardiography (Table 4). In the comparison group, the ejection fraction in patients with IAH (50.5 ± 5.2%) was significantly lower than in patients without IAH (60.1 ± 4.5%), indicating worsening of systolic cardiac function with increased IAP. The end-diastolic volume (EDV) in patients with IAH was higher (85.0 ± 10.0 ml) compared to patients without IAH (75.0 ± 9.0 ml).

Table 4.

Results of echocardiography parameters in the examined patients

Parameter	Subgroup A MG(n=39)	Subgroup B MG (n=73)	Subgroup A CG (n=49)	Subgroup B CG (n=71)
Ejection fraction (EF) (%)	55.8 ± 4.9	63.0 ± 5.1	50.5 ± 5.2	60.1 ± 4.5
End diastolic volume (EDV) (ml)	78.0 ± 8.5	70.0 ± 7.0	85.0 ± 10.0	75.0 ± 9.0

End systolic volume (ESV) (ml)	35.0 ± 6.5	25.0 ± 5.5	40.0 ± 8.0	30.0 ± 7.0
Left ventricular diastolic pressure (mmHg)	10.0 ± 2.5	6.0 ± 1.5	12.0 ± 3.0	8.0 ± 2.0
Maximum mitral flow velocity (m/s)	1.0 ± 0.2	0.7 ± 0.1	1.2 ± 0.2	0.8 ± 0.1

Similarly, the end-systolic volume (ESV) in patients with IAH is 40.0 ± 8.0 mL, which also indicates impaired normal cardiac function. In patients with IAH, the left ventricular diastolic pressure is higher (12.0 ± 3.0 mmHg) compared to patients without IAH (8.0 ± 2.0 mmHg), which may indicate increased cardiac preload. The peak mitral flow velocity in patients with IAH (1.2 ± 0.2 m/s) is also higher than in patients without IAH (0.8 ± 0.1 m/s), which may indicate impaired diastolic function.

The graph in Figure 1 shows the cardiac output (CO) values in patients from different groups. In patients with intra-abdominal hypertension (IAH+) in the CG, the CO was 5.5 l/min. In patients without IAH in the CG, this value increases to 6.7 l/min. In the MG, in servicemen with IAH, the CO is 5.9 l/min, and in patients without IAH, it is 7.2 l/min. Thus, patients with IAH have lower CO values compared to those with normal abdominal pressure.

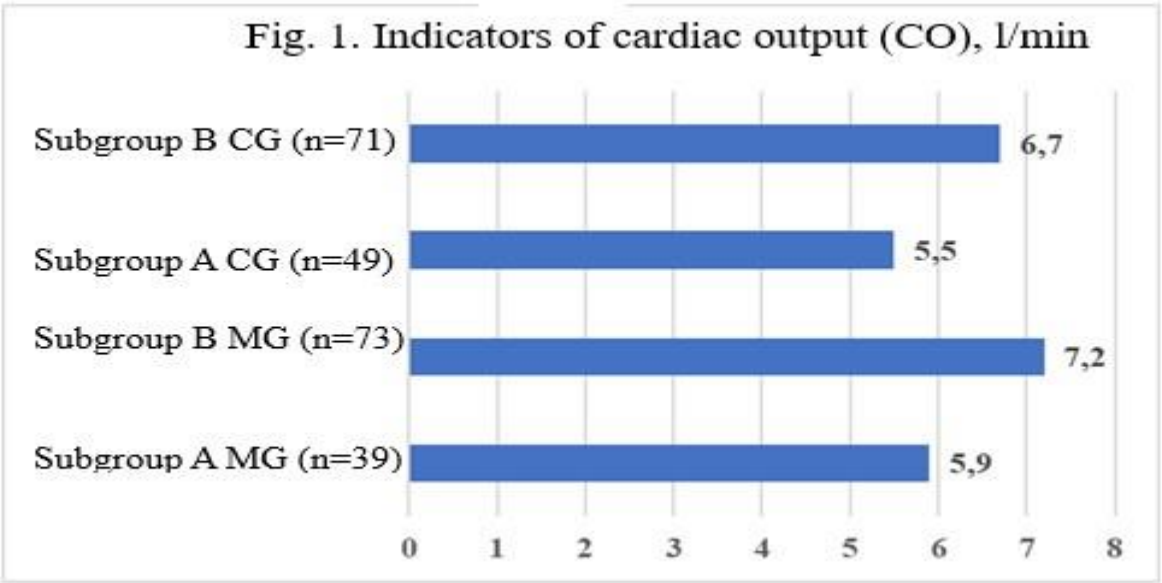
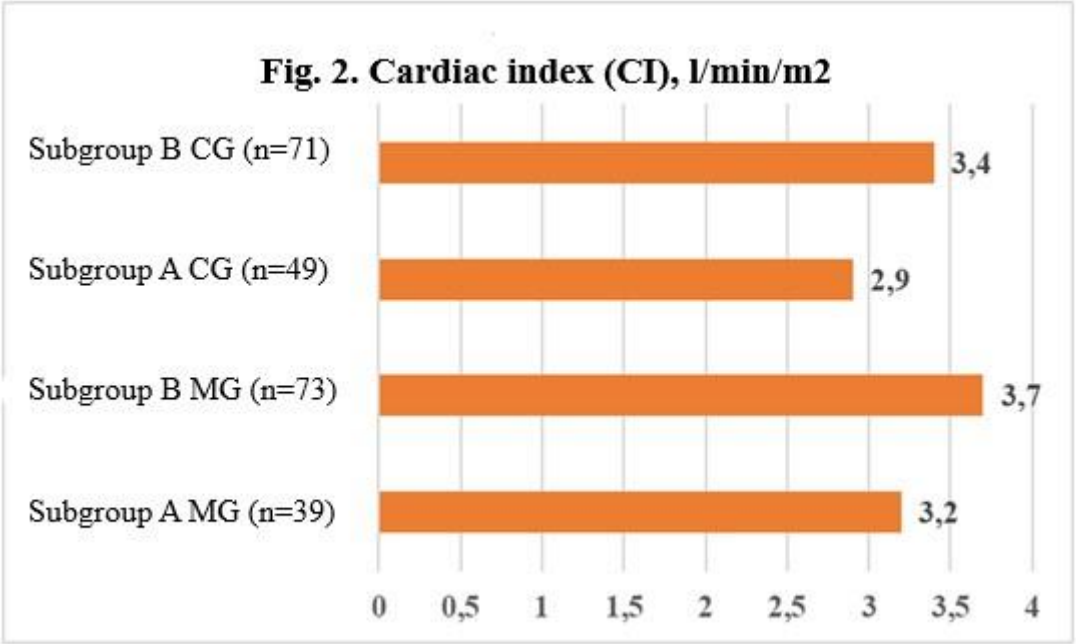
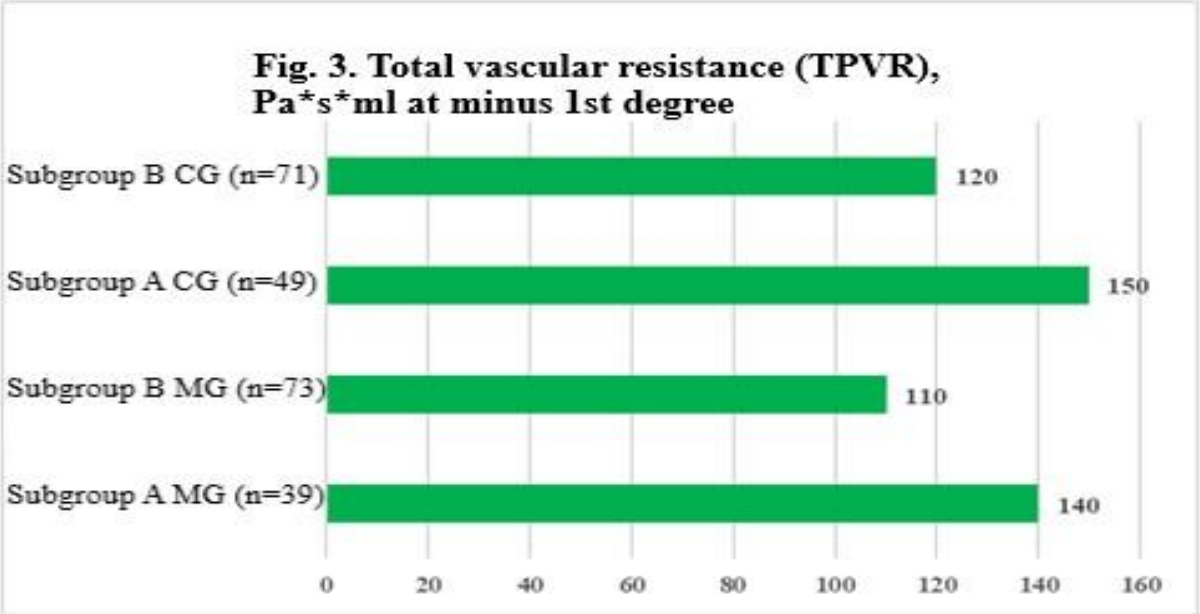


Figure 2 shows the cardiac index (CI) in the examined patients: In the SS with IAH, the CI was 2.9 L/min/m^2, indicating insufficient cardiac efficiency. In the CG without IAH, this indicator increased to 3.4 L/min/m^2. In the MG group with IAH, the CI is 3.2 L/min/m^2, while in patients without IAH, this indicator reaches 3.7 L/min/m^2. Patients with IAH demonstrate a lower cardiac index, indicating a decrease in the heart's ability to effectively pump blood.

Figure 3 shows the total vascular resistance (TPVR): In civilian patients with IAH, the TVR was 150 mmHg, indicating a high load on the cardiovascular system.



In civilian patients without IAH, this indicator decreased to 120 mm Hg. In the group of military personnel with IAH, the TPVR was 140 mm Hg, and without IAH - 110 mm Hg. High TPVR values in patients with IAH confirm increased resistance to blood flow, which can negatively affect cardiovascular function.



The diastolic function of the LV was assessed in groups depending on the presence of IAH (Table 5). In the MG with IAH, the value is 0.85 m/s, which is lower than in civilian patients without IAH (1.00 m/s). In the CG with IAH, this indicator is 0.80 m/s, and without IAH it reaches 1.10 m/s. These data indicate a deterioration in diastolic function in patients with IAH (Table 4.4). The value in the MG with IAH is 0.50 m/s, while in the MG without IAH it is 0.30 m/s. In the CG with IAH, the value is 0.60 m/s, and without IAH - 0.40 m/s. This also indicates a violation of the diastolic function.

In MG with IAH, the E/A ratio is 1.70, which is significantly lower than without IAH (3.33). CG with IAH has a ratio of 1.33, while in without IAH this figure is 2.75. A decreased E/A ratio indicates diastolic dysfunction. In MG with IAH, diastolic pressure is 10 mmHg, while in MG without IAH it is 8 mmHg. CG with IAH has a higher pressure of 12 mmHg compared to 9 mmHg in CG without IAH. This confirms the presence of left ventricular overload. Pulse pressure in MG with IAH is 50 mmHg, which is higher than in without IAH (40 mmHg).

Table 5.

Indicators of diastolic function of the left ventricle

Parameter	MG with IAH (n=39)	MG without IAH (n=73)	CG with IAH (n=49)	CG without IAH (n=71)
E (m/s)	0.85 ± 0.10	1.00 ± 0.12	0.80 ± 0.09	1.10 ± 0.14
A (m/s)	0.50 ± 0.08	0.30 ± 0.05	0.60 ± 0.07	0.40 ± 0.06
E/A	1.70 ± 0.15	3.33 ± 0.25	1.33 ± 0.12	2.75 ± 0.20
LV pressure (mmHg)	10 ± 2	8 ± 1	12 ± 3	9 ± 2

Pulse pressure (mmHg)	50 ± 5	40 ± 4	55 ± 6	35 ± 5

In CG with IAH, a pulse pressure of 55 mm Hg is demonstrated, while without IAH this indicator is 35 mm Hg (Table 4.4). Increased pulse pressure may be associated with an increase in total peripheral resistance.

The study showed that cardiac remodeling in IAP+ is characterized by both concentric hypertrophy and eccentric hypertrophy of the left ventricle. Concentric hypertrophy was detected in 52% of CG patients with IAP+, which is associated with an increase in afterload and myocardial adaptation to increased resistance. This type of remodeling leads to thickening of the left ventricular walls without a significant increase in its volume.

Eccentric hypertrophy was detected in 36% of CG patients with IAP+, which was characterized by an increase in the volume of the left ventricular cavity with a relatively normal thickness of its walls. This type of remodeling was more common in patients with chronically increased IAP and was associated with worsening diastolic function and a decrease in ejection fraction.

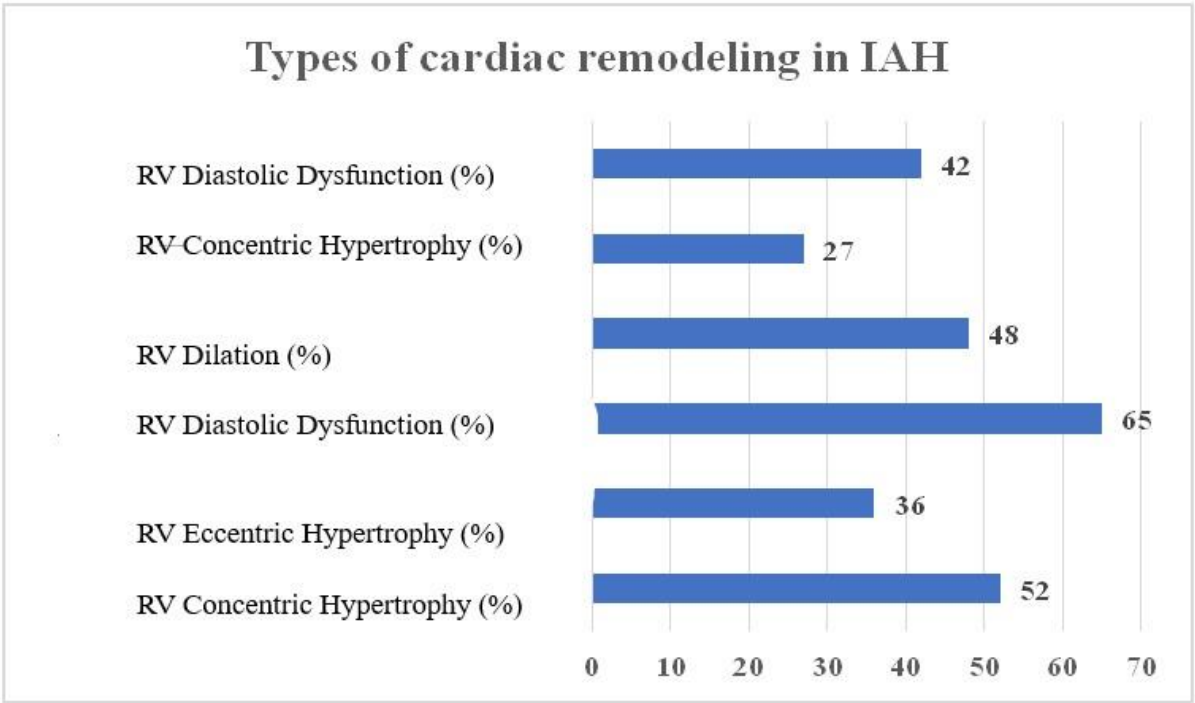


Figure 4. Types of remodeling of the right and left chambers of the heart in patients with intra-abdominal hypertension CG.

Diastolic dysfunction of the right and left ventricles is a common feature of cardiac remodeling in IAH+. Left ventricular diastolic dysfunction, expressed as an abnormal E/A ratio and decreased myocardial relaxation, is noted in 65% of MG patients with IABG+. The right ventricle also shows signs of

diastolic dysfunction in 42% of MG patients with elevated IAP.

Figure 4 shows the types of right and left heart remodeling in HS patients with intra-abdominal hypertension (IAH). It is evident that the most common changes are left ventricular diastolic dysfunction (65%) and left ventricular concentric hypertrophy (52%). Also, a significant number of patients demonstrate right ventricular dilation (48%) and left ventricular eccentric hypertrophy (36%). These data highlight how IAH affects cardiac structures, causing adaptive changes in the right and left heart.

Table6.

Troponin I, CPK-MB and LDH levels

Subgroup	Troponin I (M ± σ, ng/ml)	CPK-MB (M ± σ, U/L)	LDH (M ± σ, U/L)
A-MG	0.20 ± 0.10	190 ± 18	410 ± 45
B-MG	0.09 ± 0.04	140 ± 15	350 ± 40
A-CG	0.38 ± 0.12	250 ± 25	470 ± 50
B-CG	0.18 ± 0.09	180 ± 17	400 ± 42

The levels of cardiac-specific enzymes in CG patients with IAH+ (subgroup A CG) were significantly higher compared to patients from the comparison group, indicating a high risk of myocardial infarction (Table 6). Troponin I: In subgroup A CG — 0.38 ± 0.12 ng/ml. In subgroup A MG — 0.20 ± 0.10 ng/ml. In subgroup B CG — 0.18 ± 0.09 ng/ml. In subgroup B MG — 0.09 ± 0.04 ng/ml. CPK-MB: In subgroup A CG — 250 ± 25 U/l. In subgroup B MG — 190 ± 18 U/l. In subgroup B CG - 180 ± 17 U/L. In subgroup B MG - 140 ± 15 U/L. LDH: In subgroup A CG - 470 ± 50 U/L. In subgroup A MG - 410 ± 45 U/L. In subgroup B CG - 400 ± 42 U/L. In subgroup B MG - 350 ± 40 U/L. Among patients with elevated troponin I (> 0.2 ng/ml) and CPK-MB (> 200 U/L) levels, there was an increased incidence of myocardial infarction.

Increased levels of cardiac-specific enzymes significantly correlate with the development of myocardial infarction in patients with acute abdominal pathology, especially in the presence of intra-abdominal hypertension and concomitant cardiovascular pathology.

The results of the study also showed that an acute increase in IAP causes more pronounced changes in central and intracardiac hemodynamics compared to a chronic increase in IAP, which was diagnosed only in the CG. In acute IAP, the decrease in cardiac output was 20%, while in chronic increase, this figure was about 10%. This is due to the fact that an acute increase in IAP leads to a sharp disruption of venous return and an increase

in afterload, which causes a significant decrease in cardiac output and an increase in central venous pressure.

The ejection fraction in patients with acute IAP decreased to 42%, indicating a significant impairment of cardiac contractility. In chronic IAP, this figure remained at 48%, indicating smaller changes caused by cardiac adaptation to increased load. However, even in chronic IAP, signs of diastolic dysfunction were noted, observed in 58% of patients. Patients with chronic increase in IAP show a smaller decrease in cardiac output compared to patients with acute IAP, which is associated with partial development of adaptive mechanisms. Blood pressure in patients with acute increase in IAP is often reduced due to a sharp deterioration in systemic circulation, while patients with chronic IAP have more stable indicators. CVP increases with both acute and chronic increases in IAP, but with an acute increase, a more significant increase in CVP is observed. The levels of cardiac-specific enzymes (troponin I, CPK-MB) are increased in both conditions, but with an acute increase in IAP, more pronounced myocardial damage is observed (Table 7). These data indicate greater myocardial damage with an acute increase in IAP.

Table7.

Central and intracardiac hemodynamic parameters in acute and chronic increase in IAP in CG

Indicator	Acute increase in IAP (M ± σ)	Chronic increase in IAP (M ± σ)
Cardiac output (L/min)	3,2 ± 0,6	4,0 ± 0,7
Blood pressure (mmHg)	93,5 ± 12,1	112,9 ± 10,7
CVP (mmHg)	16,7 ± 3,5	12,8 ± 2,4

Intra-abdominal hypertension has a negative impact on the cardiovascular status of both military personnel and civilians, but the degree of this impact varies. Civilians with IAH+ have a higher incidence of cardiovascular complications (61.2%) than military personnel with IAH+ (51.3%). Military personnel with IAH+ have a higher cardiac output (3.8±0.5 l/min) compared to civilians (3.2±0.4 l/min), which may indicate more effective compensatory mechanisms. Differences in the mechanisms of complications may be associated with age, physical fitness, and the presence of concomitant pathology.

CONCLUSION

The study found that the main predictors of cardiovascular complications in military personnel with intra-abdominal hypertension include: intra-

abdominal hypertension, which increases the risk of cardiovascular complications by 2.5 times compared to patients without intra-abdominal hypertension. Elevated troponin I levels (>0.05 ng/ml), which is associated with a 35.0% increase in the risk of complications, the presence of arterial hypertension, which increases the risk of complications by 25.0%. High BMI (≥28 kg/m^2), which is associated with a 20.0% increase in risk. Decreased cardiac output (<4.0 l/min), which increases the risk of complications by 18.0%.

Thus, acute increase in IAP is associated with a sharp decrease in cardiac output, arterial hypotension, and a more pronounced increase in CVP. Elevated levels of cardiac-specific enzymes indicate greater myocardial damage with acute increase in IAP. Chronic increase in IAP is accompanied by less pronounced hemodynamic disturbances. Patients with chronic increase in IAP have more stable blood pressure readings, a smaller increase in CVP, and lower levels of cardiac-specific enzymes, indicating partial adaptation of the heart to increased IAP.

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