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Impaired esophagogastric motor function as a predictor for development of hiatal hernia in military personnel

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Abstract. ***Background.*** *Disorders of esophagogastric motility, often associated with the development of hiatal hernia (HH), represent a common pathological condition. The characteristics of these functional changes may vary depending on lifestyle factors, levels of physical activity, and adaptive mechanisms, which differ between military personnel and civilians. Evaluation of such differences is essential for the development of individualized approaches to the diagnosis and treatment of HH. The purpose was to identify esophagogastric motility disorders as predictors of hiatal hernia development in military personnel by analyzing parameters obtained through digital pneumoballoon manometry.* ***Materials and methods.*** *Digital pneumoballoon manometry of the esophagus and stomach was performed in 66 patients with hiatal hernia (30 military personnel and 36 civilians, serving as the comparison group). The analysis included assessment of the amplitude and duration of peristaltic waves, rhythmic fluctuations of the esophageal wall, and pressure in the areas of the lower esophageal sphincter and pyloroduodenal sphincter.* ***Results.*** *The amplitude of the peristaltic wave in military personnel was 1.9 times higher than in civilians, whereas the wave duration in civilians was 40.5 % longer ($p < 0.05$). Rhythmic oscillations of the esophageal wall were less pronounced in civilians, suggesting more significant motility disorders. Pressure in the lower esophageal sphincter region was reduced by 50.7 % in military personnel ($p < 0.05$) and by 53.7 % in civilians ($p < 0.01$) compared to control values, contributing to the development of gastroesophageal reflux. Pressure in the pyloroduodenal sphincter region increased 2.2-fold in military personnel and 2.8-fold in civilians ($p < 0.05$).* ***Conclusions.*** *Assessment of esophagogastric motility using digital pneumoballoon manometry enables the identification of predictors of HH development in military personnel. The results underscore the need for a personalized approach to the treatment of hiatal hernia.*

Keywords: *hiatal hernia predictors; esophagogastric motility; lower esophageal sphincter pressure; pyloroduodenal sphincter pressure; functional diagnosis*

Introduction

Disorders of esophagogastric motility are commonly associated with the development of gastroesophageal reflux disease and hiatal hernia (HH) [1, 2]. These conditions significantly influence the quality of life of patients by causing dyspeptic symptoms, reflux esophagitis, and complications affecting the upper gastrointestinal tract [3].

One of the key factors that impact the severity of esophagogastric motility dysfunction in patients with HH is lifestyle, including the level of physical activity. Military personnel, due to the demands of service, are subjected to considerable physical and psychological stress, which may contribute to the onset or progression of these disorders [4]. In civilian patients, risk factors may include a sedentary lifestyle, excess body weight, and associated metabolic disturbances. The role of esophagogastric motility disorders in the development of HH remains a subject of active scientific investigation. It has been established that dysfunction of the lower esophageal sphincter (LES), alterations in esophageal peristalsis, and increased pressure in the pyloroduodenal sphincter region may play a significant role in the pathogenesis of this condition [5]. However, the early predictors of these changes in patients with varying levels of physical activity and adaptive capacity, particularly among military personnel, remain not fully understood.

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In modern gastroenterology, manometry using multichannel catheters is recognized as the "gold standard" for detecting early esophageal motility disorders [6]. Nevertheless, high-resolution manometry remains largely inaccessible in some countries. For example, researchers have highlighted the need to improve access to this technique in Japan [7, 8], where barium esophagography — with a reported sensitivity of 94 % — serves as an alternative diagnostic approach [9]. Additionally, the Chicago Classification v3.0 offers a structured framework for distinguishing between "major" and "minor" esophageal motility disorders [10, 11].

The pneumoballoon manometry method shows promise for long-term monitoring of motor activity in the esophagus, stomach, and duodenum. It enables the assessment of frequency, amplitude, and nature of smooth muscle contractions in the walls of the esophagus, stomach, and duodenum, which are responsible for peristalsis and food transit. In this context, the use of functional provocation tests such as peristalsis stimulation through fractional water swallowing is considered a promising diagnostic approach [5, 12]. Modern combined techniques, such as manometry integrated with pH-metry and impedance measurement, significantly enhance diagnostic capabilities, particularly in evaluating both acid and non-acid reflux.

Gastrointestinal motor function is essential for normal digestion, facilitating the mixing of food with digestive enzymes and its propulsion through the gastrointestinal tract. Disruptions in esophagogastric motility may lead to the development of erosive or non-erosive reflux esophagitis, peptic ulcer disease, and other pathologies. In cases of esophagogastric disorders, manometry provides valuable data on peristaltic activity, LES function, and pyloroduodenal sphincter performance [13–15].

The relevance of this study lies in the need to identify early predictors of esophagogastric motility disorders in military personnel and civilians with hiatal hernia. Digital pneumoballoon manometry offers objective data on the predictors of motility dysfunction and supports a personalized approach to managing this condition.

The purpose was to identify esophagogastric motility disorders as predictors of hiatal hernia development in military personnel by analyzing parameters obtained through digital pneumoballoon manometry.

Materials and methods

To assess esophagogastric motility, intraluminal pressure was recorded using a pneumatic balloon affixed to the tip of a probe. A Microtech Stone Extraction Balloon SRB-T-9/12/15-20 endoscopic probe was utilized, connected to a pressure sensor and an insufflation syringe. Following system calibration within the range of 0–500 mmHg, the pneumatic balloon was introduced endoscopically and advanced through the esophagus; peak pressure values were recorded at each anatomical segment. Data were digitally recorded, and pressure values were calculated as the difference between peak pressure within the region of interest and baseline pressure in adjacent segments. Data visualization and processing were performed using MS Excel, including the calculation of pressure in the pyloroduodenal region, LES, as well as the period and amplitude of pressure fluctuations in the balloon when positioned in the esophagus.

The study was conducted in the Department of Digestive Surgery at the State Institution "Institute of Gastroenterology of the National Academy of Medical Sciences of Ukraine" in 2023–2024. It involved 9 healthy volunteers without esophagogastroduodenal pathology (control group) and 66 patients with hiatal hernia (ICD-10 code K44.9), who were divided into two groups: group I (n = 30) — military personnel, further divided by two types of HH: type I (axial, n = 11) and type II (paraesophageal, n = 19); group II (n = 36) — civilians (comparison group), also categorized into type I (axial, n = 22) and type II (paraesophageal, n = 14).

The cohort included 49 men (74.2 %) and 17 women (25.8 %). The age of the patients ranged from 31 to 63 years. The mean age was (47.13 ± 2.81) years overall, with military personnel averaging (41.57 ± 3.84) years and civilians (58.73 ± 2.68) years ($p > 0.05$).

Statistical analysis included descriptive statistics and parametric methods (Student's t-test) for normally distributed variables, as confirmed by the Shapiro-Wilk test. Differences were considered statistically significant at $p < 0.05$. Data are presented as mean ± standard error (M ± m), with minimum and maximum values indicated.

Results

Analysis of digital pneumoballoon manometry in patients with hiatal hernia revealed significant alterations in esophagogastric motility.

Among military personnel with type I HH, the mean pressure in the pyloroduodenal sphincter region was (39.94 ± 14.03) mmHg, which was significantly higher than in the control group ((17.15 ± 6.60) mmHg). In patients with type II HH, the pressure was comparable ((39.77 ± 8.07) mmHg, $p < 0.05$). The frequency of pyloroduodenal sphincter hypertonicity in military personnel was 50.0 % in type I HH and 75.0 % in type II HH.

The LES pressure was significantly decreased in military personnel with both types of HH. In type I HH, it averaged (9.18 ± 4.59) mmHg, while in type II HH, it was (5.67 ± 1.75) mmHg representing a 59 % reduction compared to the control group ($p < 0.01$).

Esophageal peristaltic activity varied significantly between the two HH types. In military personnel with type I HH, the amplitude of the peristaltic wave was 5.5 times higher than in the control group ((83.09 ± 4.15) mmHg, $p < 0.001$), while in those with type II HH, it was 2.9 times higher ((43.84 ± 9.31) mmHg, $p < 0.05$). Additionally, the amplitude of the peristaltic wave in type I HH was 90 % higher compared to type II HH ($p < 0.05$).

Analysis of rhythmic esophageal wall oscillations showed variability in amplitude depending on HH type: (5.51 ± 2.82) mmHg in type I HH and (13.17 ± 4.78) mmHg in type II HH. The periodicity of these oscillations also varied significantly, reaching (4.62 ± 0.92) seconds in type II HH, which exceeded the normal values observed in the control group ((2.99 ± 0.13) seconds) (Table 1).

Among civilians with type I HH, the mean pressure in the pyloroduodenal sphincter region was (45.47 ± 8.14) mmHg, which was 2.6 times higher than the control value ((17.15 ± 6.60) mmHg, $p < 0.05$). In civilians with type II HH, this parameter reached (53.47 ± 11.84) mmHg, excee-

Table 1 — Characteristics of digital pneumoballoon manometry in assessing esophagogastric motility in military personnel with hiatal hernia, M ± m (min; max)

Parameter		Control (n = 9)	Military personnel with HH	
			Type I (n = 11)	Type II (n = 19)
Pyloroduodenal sphincter pressure, mmHg		17.15 ± 6.60 (0.75; 49.14)	39.94 ± 14.03 (1.17; 95.50)	39.77 ± 8.07 (3.88; 131.71)*
Lower esophageal sphincter pressure, mmHg		13.70 ± 0.48 (13.36; 14.04)	9.18 ± 4.59 (0.01; 36.13)	5.67 ± 1.75 (0.18; 26.06)**
Esophageal peristaltic wave	Amplitude, mmHg	15.21 ± 10.26 (3.63; 41.33)	83.09 ± 4.15 (83.09; 83.09)***	43.84 ± 9.31 (31.04; 75.57)*#
	Duration, s	12.67 ± 1.51 (7.50; 15.00)	11.00 ± 0.55 (11.00; 11.00)	11.40 ± 1.25 (5.67; 15.67)
Rhythmic esophageal wall oscillations	Amplitude, mmHg	9.67 ± 4.12 (4.81; 16.13)	5.51 ± 2.82 (1.62; 15.26)	13.17 ± 4.78 (1.41; 45.83)
	Periodicity, s	2.99 ± 0.13 (2.80; 3.17)	2.77 ± 0.49 (1.09; 3.67)	4.62 ± 0.92 (2.00; 10.33)

Notes: * — p < 0.05, statistically significant difference between military personnel and the control group; ** — p < 0.01, statistically significant difference between military personnel and the control group; *** — p < 0.001, statistically significant difference between military personnel and the control group; # — statistically significant compared to the values in type I hiatal hernia, at a significance level of p < 0.05.

ding the control value by 3.1 times ($p < 0.05$). The frequency of pyloroduodenal sphincter hypertonicity among civilians was 68.4 % in type I HH and 83.3 % in type II HH.

The LES pressure was significantly reduced in civilians. In type I HH, it was (6.37 ± 1.53) mmHg, which is 53.5 % lower than in the control group ($p < 0.01$), and in type II HH, it was (6.28 ± 2.24) mmHg, a 54.1 % reduction compared to the controls ($p < 0.05$).

Esophageal peristaltic activity in civilians with compromised functional competence of the gastroesophageal junction (GEJ) also showed alterations. The amplitude of the peristaltic wave in type I HH was (21.44 ± 5.32) mmHg, while in type II HH, it was (27.23 ± 5.69) mmHg, indicating lower values compared to military personnel.

The peristaltic wave duration in civilians with type I HH was significantly prolonged ((22.48 ± 4.51) seconds, $p < 0.05$), whereas in type II HH, it was (15.53 ± 2.20) seconds ($p > 0.05$), indicating a reduction in peristaltic efficiency.

Analysis of rhythmic oscillations of the esophageal wall did not reveal significant differences between HH types. The amplitude of oscillations in type I HH was (7.68 ± 1.81) mmHg, while in type II HH, it was (9.14 ± 6.09) mmHg ($p < 0.05$). The periodicity of oscillations was higher in civilians with type I HH ((4.31 ± 0.68) seconds) compared to those with type II HH ((3.70 ± 0.52) seconds) (Table 2).

Discussion

The obtained results indicate significant alterations in esophagogastric motility in patients with HH.

The observed increase in pyloroduodenal sphincter pressure in military personnel with HH, regardless of its type, suggests the development of sphincter hypertonicity, which may contribute to delayed gastric emptying [8].

The reduction in the LES pressure in military personnel with type I and II HH by 33.0 and 58.6 %, respectively ($p < 0.01$), confirms functional insufficiency of the LES, which serves as a pathogenic factor in the development of

Table 2 — Characteristics of digital pneumoballoon manometry in assessing esophagogastric motility in civilians with hiatal hernia, M ± m (min; max)

Parameter		Control (n = 9)	Civilians with HH and GEJ dysfunction	
			Type I (n = 22)	Type I (n = 14)
Pyloroduodenal sphincter pressure, mmHg		17.15 ± 6.60 (0.75; 49.14)	45.47 ± 8.14 (0.62; 140.67)*	53.47 ± 11.84 (0.99; 144.22)*
Lower esophageal sphincter pressure, mmHg		13.70 ± 0.48 (13.36; 14.04)	6.37 ± 1.53 (0.36; 21.48)**	6.28 ± 2.24 (0.23; 21.68)*
Esophageal peristaltic wave	Amplitude, mmHg	15.21 ± 10.26 (3.63; 41.33)	21.44 ± 5.32 (5.50; 53.96)	27.23 ± 5.69 (2.92; 35.46)
	Periodicity, s	12.67 ± 1.51 (7.50; 15.00)	22.48 ± 4.51 (13.50; 50.17)*	15.53 ± 2.20 (12.50; 23.00)
Rhythmic esophageal wall oscillations	Amplitude, mmHg	9.67 ± 4.12 (4.81; 16.13)	7.68 ± 1.81 (2.89; 25.13)	9.14 ± 6.09 (2.78; 24.83)
	Periodicity, s	2.99 ± 0.13 (2.80; 3.17)	4.31 ± 0.68 (2.50; 9.33)	3.70 ± 0.52 (3.00; 5.00)

Notes: * — p < 0.05, statistically significant difference between civilians and the control group; ** — p < 0.01, statistically significant difference between civilians and the control group.

gastroesophageal reflux. This reduction was particularly pronounced in military personnel with type II HH, indicating more severe sphincter dysfunction.

When analyzing peristaltic parameters, it is noteworthy that military personnel with type I HH exhibited esophageal motor hyperactivity, as evidenced by a significant increase in the amplitude of the peristaltic wave. In contrast, military personnel with type II HH demonstrated a lower amplitude, which may indicate compensatory exhaustion of the esophageal muscular layer or impaired neural regulation.

The observed differences in rhythmic oscillation parameters of the esophageal wall between military and civilian groups can be attributed to varying degrees of compensatory response. Higher amplitude and periodicity values observed in type II HH may reflect compensatory hyperactivity of the smooth muscle elements in response to reflux exposure.

Thus, the study results demonstrate significant alterations in esophagogastric motility among patients with HH, highlighting the necessity for a differentiated therapeutic approach based on hernia type. Further research should focus on evaluating the effectiveness of therapeutic strategies aimed at correcting the identified motility disorders.

The findings also indicate that civilians with hiatal hernia exhibited pronounced esophagogastric motility disturbances. Pyloroduodenal sphincter hypertonicity was diagnosed more frequently in the civilian group (61.2 %) compared to military personnel (53.8 %), suggesting more pronounced impairment of motor regulation in civilians.

Both civilians (53.7 %, $p < 0.01$) and military personnel (50.7 %, $p < 0.05$) demonstrated a significant decrease in the LES pressure compared to the control group, confirming sphincter insufficiency and a predisposition to gastroesophageal reflux in both type I and II hiatal hernia.

Esophageal peristaltic activity in civilians was found to be less pronounced than in military personnel. Specifically, the amplitude of the peristaltic wave in civilians was 49.6 % lower compared to military subjects ($p < 0.05$). At the same time, the duration of the peristaltic wave in civilians with HH was significantly prolonged, by 50.5 % compared to the control group ($p < 0.05$), indicating reduced effectiveness of peristaltic contractions. Rhythmic oscillations of the esophageal wall in civilians showed a tendency toward increased periodicity in type I HH, possibly reflecting compensatory mechanisms of motor function in response to the LES insufficiency.

Thus, the obtained results indicate more pronounced esophagogastric motility dysfunction in civilians with hiatal hernia compared to military personnel. These differences may be attributed both to the underlying pathophysiological mechanisms of the disease and to variations in adaptive responses to pathological changes.

Conclusions

1. In military personnel with type I and II HH, the mean pressure in the pyloroduodenal sphincter region was increased by 2.3 times ($p < 0.05$) in both types compared to the control group, indicating the development of sphincter hypertonicity. The LES pressure decreased by 50.7 % ($p < 0.05$) in military personnel and by 53.7 % ($p < 0.01$) in civilians, confirming the LES insufficiency and an increased risk of gastroesophageal reflux. The amplitude of the esophageal peristaltic wave in military personnel with type I HH was 5.5 times higher than in the control group. In civilians, the peristaltic wave amplitude was 49.6 % lower compared to military personnel ($p < 0.05$), which may indicate the presence of compensatory mechanisms in the military group.

2. The duration of the peristaltic wave in civilian patients with HH was 67.9 % longer than in military personnel ($p < 0.05$), indicating delayed bolus transit. Rhythmic oscillations of the esophageal wall in military personnel were characterized by lower amplitude, but higher periodicity compared to civilians, which may reflect an adaptive response to pathological changes.

3. Esophagogastric motility disorders were more pronounced in civilian patients compared to military personnel, which may be attributed to differences in lifestyle, adaptive mechanisms, and levels of physical activity.

The obtained data may serve as potential predictors for the early diagnosis of hiatal hernia in military personnel.

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Порушення стравохідно-шлункової моторної функції як предиктор розвитку грижі стравохідного отвору діафрагми у військовослужбовців

Резюме. ***Актуальність.*** Порушення стравохідно-шлункової моторної функції, яка супроводжується розвитком грижі стравохідного отвору діафрагми (ГСОД), є поширеною патологією. Ці зміни можуть залежати від способу життя, рівня фізичного навантаження й адаптаційних механізмів, що відрізняються у військовослужбовців і цивільних. Оцінка таких відмінностей є важливою для розробки індивідуалізованих підходів до діагностики та лікування ГСОД. ***Мета:*** визначити порушення стравохідно-шлункової моторної функції як предиктора розвитку ГСОД у військовослужбовців шляхом аналізу показників цифрової пневмобалонної манометрії. ***Матеріали та методи.*** Проведено цифрову пневмобалонну манометрію стравоходу і шлунка в 66 пацієнтів із ГСОД (30 військовослужбовців і 36 цивільних (група порівняння)). Проаналізовано амплітуди й період перистальтичної хвилі, ритмічні коливання стінки стравоходу, тиск у зоні нижнього стравохідного сфінктера та пілородуоденального сфінктера. ***Результати.*** Амплітуда перистальтичної хвилі у військовослужбовців була в 1,9 раза вищою, ніж у цивільних, але період хвилі в цивільних був на 40,5 % довшим ($p < 0,05$). Ритмічні коливання стінки стравоходу в цивільних були менш вираженими, що може свідчити про більш значні порушення моторики. Тиск у зоні нижнього стравохідного сфінктера був знижений на 50,7 % у військових ($p < 0,05$) та на 53,7 % у цивільних ($p < 0,01$) порівняно з контролем, що призводило до розвитку гастроезофагеального рефлюксу. Тиск у зоні пілородуоденального сфінктера був підвищений відповідно у 2,2 і 2,8 раза у військовослужбовців та цивільних ($p < 0,05$). ***Висновки.*** Оцінка стравохідно-шлункової моторної функції за допомогою цифрової пневмобалонної манометрії дозволяє встановити предиктори розвитку ГСОД у військовослужбовців. Отримані результати вказують на необхідність персоналізованого підходу до лікування ГСОД.

Ключові слова: предиктори грижі стравохідного отвору діафрагми; стравохідно-шлункова моторна функція; тиск у зоні нижнього стравохідного сфінктера; тиск у зоні пілородуоденального сфінктера; функціональні дослідження