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ORIGINAL PAPER

Assessment of erectile dysfunction in 965 Azerbaijani men: Associations with BMI, testosterone, and vitamin D levels

Rashad Sholan [1, 2], Rufat Aliyev [1], Seymur Karimov [3], Rahman Ismayilov [3], Elvin Bayramov [4]

[1] Scientific Research Center, State Security Service Military Hospital, Baku, Azerbaijan;
[2] Scientific Research Center, Azerbaijan Medical University, Baku, Azerbaijan;
[3] Department of Kidney Diseases and Organ Transplantation, State Security Service Military Hospital, Baku, Azerbaijan;
[4] Department of Laboratory, State Security Service Military Hospital, Baku, Azerbaijan.

Summary

Background: *Erectile dysfunction (ED) is a common male sexual disorder with significant psychosocial and physiological impacts. While modifiable risk factors such as body mass index (BMI), serum testosterone, and vitamin D levels have been linked to ED, regional data from the Caucasus, including Azerbaijan, are limited.*

Methods: *This retrospective cohort study included 965 Azerbaijani men aged 35-75 years who presented with symptoms suggestive of ED between 2019 and 2024. Erectile function was assessed using the International Index of Erectile Function-5 (IIEF-5). An IIEF-5 score of ≤ 21 was considered as ED. Serum total testosterone, 25-hydroxyvitamin D [25(OH)D] levels, and BMI were evaluated. Correlations and multivariate logistic regression analyses were conducted to identify independent factors associated with IIEF-5-defined ED in symptomatic men.*

Results: *Among men presenting with ED-related symptoms, 54.4% met the IIEF-5 criteria for ED. Obesity (BMI ≥ 30 kg/m²) was present in 46.1% of participants and significantly more common in men with ED (58.3% vs. 31.6%, p < 0.001). Total testosterone levels <10 nmol/L were observed in 54.7% of men with ED versus 46.1% without (p = 0.008). Spearman analysis showed inverse correlations between IIEF-5 scores and BMI (r = -0.316, p < 0.001), and a positive correlation with testosterone (r = 0.108, p < 0.001). No associations were found between 25(OH)D levels and ED. In multivariate analysis, obesity remained an independent factors associated with IIEF-5-defined ED (OR: 2.969, 95% CI: 2.27-3.88, p < 0.001).*

Conclusions: *Obesity and low testosterone levels are significantly associated with ED in Azerbaijani men presenting with ED-related symptoms. In contrast, vitamin D status was not an independent predictor. These findings underscore the importance of addressing weight and hormonal health in ED management strategies.*

KEY WORDS: Erectile dysfunction; Body mass index; Testosterone; Vitamin D; Men's health.

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INTRODUCTION

Erectile dysfunction (ED), defined as the persistent inability to attain or maintain an erection sufficient for satisfactory sexual performance, is a common form of male sexual dysfunction that significantly affects quality of life and interpersonal relationships. Its prevalence increases with age and is strongly associated with chronic health conditions such as diabetes mellitus, cardiovascular disease, and hypogonadism (1, 2). While the vascular and neuroendocrine mechanisms underpinning erectile physiology are well described, emerging evidence highlights the influence of modifiable factors, including *body mass index* (BMI), serum testosterone, and vitamin D levels, on erectile function (3-5).

Obesity, particularly central adiposity, has been recognized as a major independent risk factor for ED, due in part to its effects on endothelial dysfunction, hormonal imbalances, and increased cardiovascular risk (6, 7). Low serum testosterone levels are frequently observed in obese individuals and are linked to reduced libido and impaired erectile function, especially in the context of metabolic syndrome or type 2 diabetes mellitus (4, 8). Additionally, vitamin D deficiency has been implicated in endothelial dysfunction and reduced nitric oxide availability, both of which are critical to normal penile hemodynamics, though its direct impact on ED remains inconclusive (9, 10).

Despite a growing body of literature exploring these associations, data from the Caucasus region, including Azerbaijan, remain scarce. To address this gap, the present study aimed to evaluate the ED rate in a large cohort of Azerbaijani men with symptoms suggestive of ED and investigate its associations with BMI, serum total testosterone, and vitamin D levels. Understanding these relationships in a regional context may inform future preventive strategies and personalized interventions for men at risk of ED.

MATERIALS AND METHODS

This retrospective cohort study included male patients aged 35 to 75 years who presented to the urology outpatient clinic of our center with complaints suggestive of ED (e.g., decreased frequency of erections, difficulty in achieving or maintaining an erection) between January 2019 and December 2024. Ethical approval for the study was obtained from the *Institutional Ethics Committee of the Scientific Research Center*. Demographic and clinical data, including age, BMI, *serum 25-hydroxyvitamin D* [25(OH)D]

levels, total testosterone levels, and International Index of Erectile Function-5 (IIEF-5) scores, were retrieved from the hospital's electronic medical records and outpatient clinical notes. Patients with incomplete data or those who had not completed the IIEF-5 questionnaire were excluded from the analysis. In accordance with established scoring guidelines (11), IIEF-5 scores were categorized as follows: 22-25 indicating normal erectile function, 17-21 mild ED, 12-16 mild-to-moderate ED, and 8-11 moderate ED. No patients in this cohort fell within the severe ED category (score ≤ 7). For the purpose of this study, ED was defined as an IIEF-5 score of ≤ 21. The primary objectives of the study were to characterize the clinical and biochemical features of Azerbaijani men presenting with erectile dysfunction and to explore potential associations between erectile dysfunction and serum total testosterone and 25(OH)D levels.

Statistical analysis

All statistical analyses were performed using Python version 3.1. Descriptive statistics were expressed as frequencies (percentages) for categorical variables, and as mean ± standard deviation or median (range: minimum-maximum) for continuous variables, depending on data distribution. Group comparisons for categorical variables were performed using the chi-square test implemented via the scipy.stats.chi2_contingency function.For continuous variables across IIEF-5 severity categories, one-way ANOVA was applied for normally distributed data andthe Kruskal-Wallis test for non-normally distributed data. Spearman's rank correlation coefficients and their statistical significance were computed using scipy.stats.spearmanr. A correlation heatmap was generated using seaborn.heatmap to visualize the relationships among continuous variables. Multivariate logistic regression was performed via statsmodels.api.logit to identify independent factors associated with IIEF-5-defined ED, with results reported as *odds ratios* (ORs) and 95% *confidence intervals* (CIs). A p-value < 0.05 was considered statistically significant.

Table 1.
Patient characteristics.

Characteristics	Total 965 patients
Age, mean ± SD, years	48.4 ± 11.0
Age categories, n (%)	
35-65 years	855 (88.6)
≥ 65 years	110 (11.4)
BMI, mean ± SD, kg/m²	29.2 ± 5.7
BMI categories, n (%)	
Underweight (< 18.5 kg/m²)	8 (0.8)
Normal weight (18.5-24.9 kg/m²)	228 (23.6)
Overweight (25-29.9 kg/m²)	284 (29.4)
Moderate obesity (30-34.9 kg/m²)	251 (26.0)
Severe obesity (35-39.9 kg/m²)	161 (16.7)
Morbid obesity (≥ 40 kg/m²)	33 (3.4)
25(OH)D level, median (range), ng/mL	28.6 (4.7-117.7)
25(OH)D categories, n (%)	
Severe deficiency (< 12 ng/mL)	28 (2.9)
Deficiency (12–20 ng/mL)	167 (17.3)
Insufficiency (21–29 ng/mL)	343 (35.5)
Sufficiency (Optimal) (30-49 ng/mL)	332 (34.4)
Possible excess (50-99 ng/mL)	91 (9.4)
Toxicity risk (≥ 100 ng/mL)	4 (0.4)
Total testosterone level, median (range), nmol/L	9.8 (0.025-52)
IIEF-5 score, median (range)	20 (8-30)
IIEF-5 categories, n (%)	
Normal erectile function	440 (45.6)
Mild ED	285 (29.5)
Mild to Moderate ED	199 (20.6)
Moderate ED	41 (4.2)

25(OH)D: 25-hydroxyvitamin D; BMI: Body mass index; ED: Erectile dysfunction; IIEF: International Index of Erectile Function; SD: Standard deviation.

Results

A total of 965 male patients were included in the study, with a mean age of 48.4 ± 11 years; 11.4% were aged 65 years or older. The mean BMI was 29.2 ± 5.7 kg/m², and 46.1% of the participants were classified as obese (BMI ≥ 30 kg/m²). The median 25(OH)D level was 28.6 ng/mL (range: 4.7-117.7), and deficiency was observed in 20.2% of patients. The median total testosterone level was 9.8 nmol/L (range: 0.025-52). Based on IIEF-5 score categories, ED was diagnosed in 525 patients (54.4%). Detailed patient characteristics are presented in Table 1.

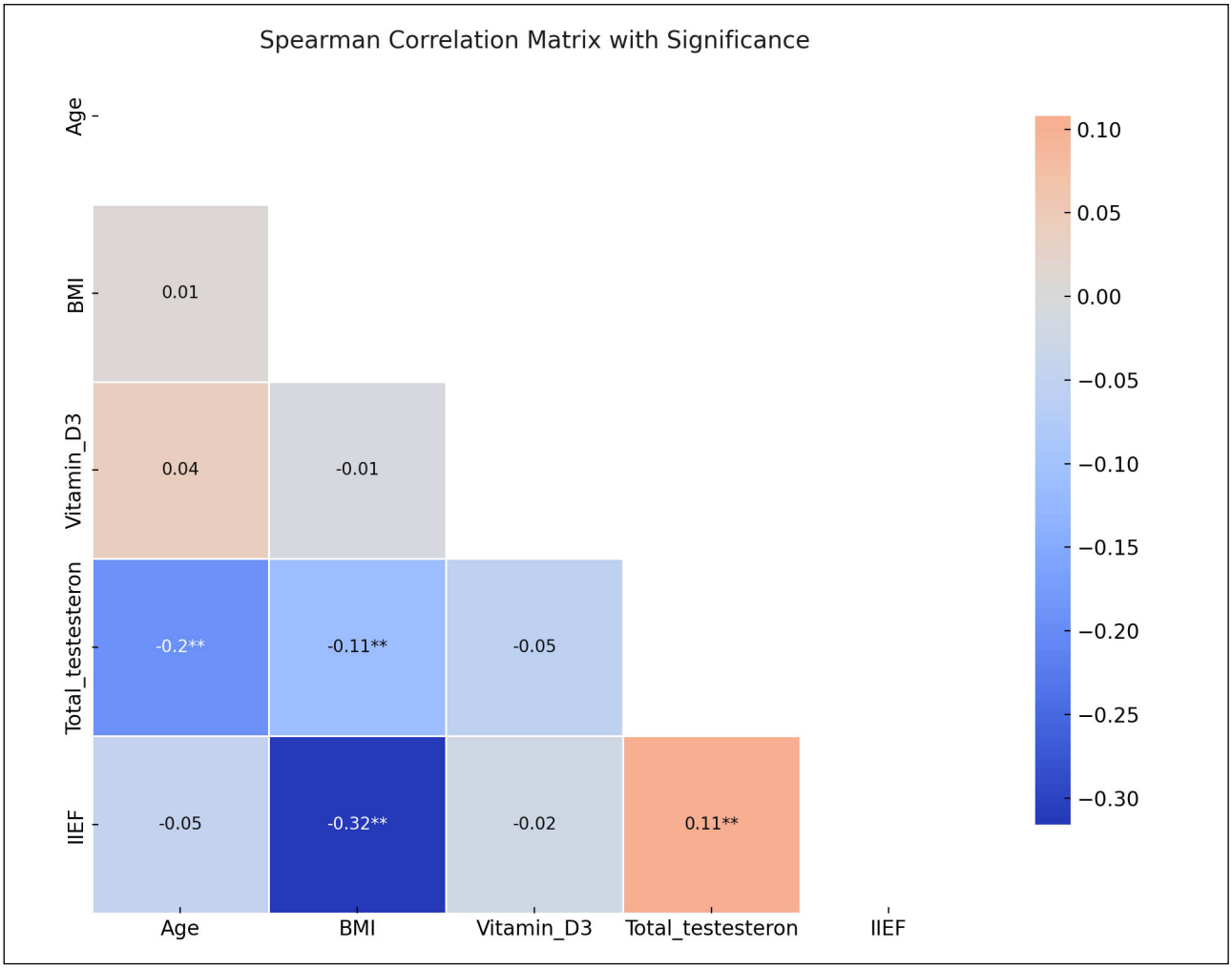
Correlation analysis revealed a significant inverse relationship between total testosterone levels and both age (r = -0.195, p < 0.001) and BMI (r = -0.110, p < 0.001). No significant associations were found between 25(OH)D levels and any of the assessed parameters. However, IIEF-5 scores were negatively correlated with BMI (r = -0.316, p < 0.001) and positively correlated with total testosterone levels (r = 0.108, p < 0.001) (Figure 1).

Comparative analysis between patients who did or did not meet the IIEF-5 criteria for ED showed no significant difference in age distribution (< 65 *vs.* ≥ 65 years, p = 0.146) or prevalence of 25(OH)D deficiency (p = 0.327). Obesity was significantly more common among those with ED (58.3%) compared to those without (31.6%) (p < 0.001) (Figure 2). Additionally, total testosterone levels < 10 nmol/L were observed in 54.7% of patients with ED *versus* 46.1% of those without (p = 0.008) (Table 2).

Further subgroup analysis based on IIEF-5 severity categories (normal erectile function, mild ED, mild-to-moderate ED, moderate ED) demonstrated a statistically significant difference of BMI in patients with different ED severity (p < 0.001). Median total testosterone levels were also significantly different in patients with different ED severity (p = 0.042), while 25(OH)D levels did not significantly differ across the groups (p = 0.627) (Table 3).

The independent impact of study parameters on ED was assessed using a multivariate logistic regression model including age ≥ 65 years, obesity, 25(OH)D deficiency, and total testosterone <10 nmol/L. In this model, obesity emerged as an independent risk factor for ED (OR: 2.969, 95% CI: 2.274-3.877, p < 0.001) (Table 4).

Figure 1.
Spearman correlation matrix of age, BMI, vitamin D3, total testosterone, and IIEF-5 score. The heatmap shows correlation coefficients between variables, with color intensity indicating the strength and direction of correlation. Significant correlations are marked with two asterisks. The upper triangle is masked for clarity.



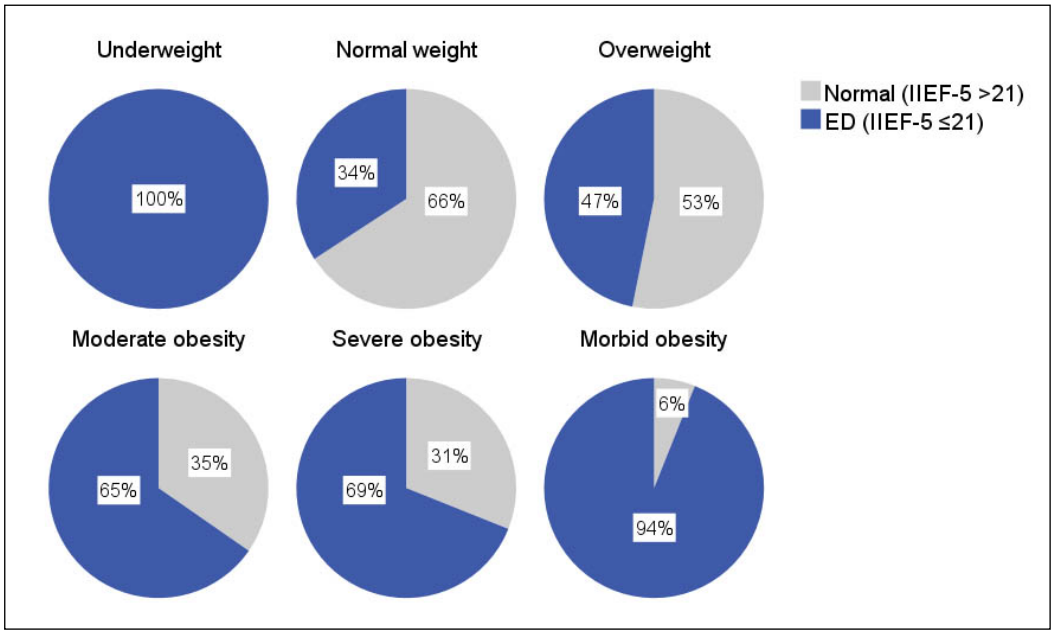


Figure 2.
Distribution of erectile dysfunction based on IIEF-5 scores according to BMI categories.

Table 2.
Comparison of patients with and without erectile dysfunction according to IIEF-5 score.

Parameters, n (%)	Erectile dysfunction		P value
	Absent (IIEF-5 > 21), n = 440	Present (IIEF-5 ≤ 21), n = 525	
Age, mean ± SD, years	48.4 ± 11.0		
Age ≥ 65 years	43 (9.8)	67 (12.8)	0.146
Obesity (BMI ≥ 30 kg/m²)	139 (31.6)	306 (58.3)	**< 0.001**
25(OH)D deficiency (< 20 ng/mL)	95 (21.6)	100 (19.0)	0.327
Total testosterone < 10 nmol/L	203 (46.1)	287 (54.7)	**0.008**

** Bold text indicates statistical significance at p < 0.05 level.*
25(OH)D: 25-hydroxyvitamin D; BMI: Body mass index; IIEF: International Index of Erectile Function.

Table 3.
Comparison of BMI, vitamin D, and testosterone levels according to IIEF-5 erectile dysfunction categories.

Parameters	IIEF-5 score categories				P value
	> 21	17-21	12-16	8-11	
BMI*, kg/m²	27.4 ± 5.2	30.1 ± 4.6	31.7 ± 6.8	29.1 ± 57	**< 0.001**
25(OH)D&, ng/mL	28 (4.7-118)	29 (6.8-104)	29 (9-98)	30 (10.2-93)	0.627
Total testosterone&, nmol/L	11 (0.03-52)	8.3 (0.03-52)	8.8 (0.03-40)	9.3 (0.2-28)	**0.042**

*Data presented with *mean ± SD or &median (range). Bold text indicates statistical significance at p < 0.05 level.*
25(OH)D: 25-hydroxyvitamin D; BMI: Body mass index; IIEF: International Index of Erectile Function; SD: Standard deviation.

Table 4.
Multivariate logistic regression analysis of risk factors for erectile dysfunction based on IIEF-5 scores.

Risk factors	OR	95% CI	P value
Age ≥ 65 years	1.304	0.853-1.992	0.220
Obesity (BMI ≥ 30 kg/m²)	2.969	2.274-3.877	**< 0.001**
25(OH)D deficiency (< 20 ng/mL)	0.889	0.640-1.235	0.483
Total testosterone < 10 nmol/L	1.270	0,973-1.657	0.079

** Bold text indicates statistical significance at p < 0.05 level.*
A25(OH)D: 25-hydroxyvitamin D, BMI: Body mass index, CI: Confidence interval, OR: Odds ratio.

Discussion

This study represents the first large-scale investigation of ED and its clinical associations in an Azerbaijani male population who presented with symptoms suggestive of ED. Among the 965 men included, 54.4% met the IIEF-5 criteria for ED, aligning with global data indicating a substantial burden of ED among middle-aged and older men (1, 2). Interestingly, 45.6% of patients presenting with ED-related complaints scored above the diagnostic threshold for ED on the IIEF-5. This discrepancy may reflect transient erectile difficulties, performance anxiety, or a mismatch between perceived and clinically defined dysfunction. Similar findings have been reported in previous studies, where subjective complaints did not always align with standardized diagnostic tools (12). Our analysis focused on three modifiable clinical parameters-BMI, serum total testosterone, and 25(OH)D. Among these, obesity emerged as the most significant independent predictor of IIEF-5-defined ED, followed by a modest but statistically meaningful association with total testosterone. No significant association was found between 25(OH)D levels and ED.

Obesity showed a strong inverse correlation with IIEF-5 scores (r = -0.316, p < 0.001) and remained independently associated with ED in multivariate analysis (OR: 2.969, 95% CI: 2.27-3.88, p < 0.001). These results are consistent with prior evidence highlighting the role of excess adiposity in erectile dysfunction. Interventional studies have demonstrated that weight reduction through dietary interventions, physical activity, or bariatric surgery leads to improvements in erectile function and hormonal balance (13, 14). The underlying mechanisms may include improvements in endothelial function, reduction of systemic inflammation, and enhanced nitric oxide bioavailability.

Total testosterone was also associated with ED. Men with ED had a higher prevalence of testosterone levels below 10 nmol/L, and testosterone positively correlated with IIEF-5 scores (r = 0.108, p < 0.001). These findings are in line with major trials such as the Testosterone Trials and TRAVERSE, which showed that *testosterone replacement therapy* (TRT) improves sexual desire and activity, though its effect on erectile function is variable and often modest (15-17). The limited impact of TRT on erectile rigidity may be explained by the complex interplay of hormonal, neurovascular, and psychological components in ED. Indeed, evidence suggests that testosterone may act synergistically with PDE5i rather than as a stand-alone therapy (18).

In contrast, no association was identified between 25(OH)D levels and ED. Neither the prevalence of deficiency nor serum concentrations differed between men who did or did not meet the IIEF-5 criteria for ED, and 25(OH)D was not correlated with IIEF-5 scores. These findings are consistent with recent randomized trials, including the D-Health Trial, which reported no improvement in erectile function after long-term vitamin D supplementation (5). While experimental and observational

studies have proposed mechanisms linking vitamin D to endothelial and erectile function (10, 19), clinical evidence remains inconsistent. Some meta-analyses have reported a weak association between low 25(OH)D levels and reduced IIEF scores (9, 20), particularly in men with arteriogenic ED (21). However, these associations often disappear in subgroup or adjusted analyses, suggesting that vitamin D may not be a primary determinant of ED in the general population. Mechanistic studies have identified increased oxidative stress and downregulation of secretory leukocyte protease inhibitor as potential contributors to ED in vitamin D-deficient states (22), yet these findings require validation in clinical cohorts. Moreover, genetic studies have failed to show associations between common vitamin D receptor polymorphisms and ED risk (23), further weakening the argument for a causal role. Based on current evidence, routine screening or supplementation of vitamin D solely for ED management cannot be recommended, except in men with concurrent deficiency or relevant vascular comorbidities.

This study has several limitations. First, its retrospective, single-center design may limit generalizability and preclude causal inference. Second, important ED-related risk factors such as comorbidities, smoking status, or psychosocial parameters were not included due to incomplete or inconsistent documentation in our institutional database. To avoid introducing bias, we focused exclusively on parameters with high data integrity and reliability. Despite these limitations, the study has notable strengths. It is the first of its kind from Azerbaijan and provides valuable epidemiologic and clinical insights from a previously unrepresented population. The inclusion of a large, well-characterized cohort enhances the robustness of our findings. By offering region-specific data on ED and its correlates, this study provides a solid foundation for future research in the Caucasus region and supports the development of culturally and clinically tailored preventive strategies.

Conclusions

In conclusion, this study demonstrates that obesity and low testosterone levels are significantly associated with ED in Azerbaijani men, while no such relationship was observed for vitamin D status. These findings support the prioritization of weight management and endocrine evaluation in the clinical approach to ED. Although vitamin D may influence erectile physiology through vascular and hormonal pathways, its relevance as an independent predictor of ED remains unsubstantiated in this cohort. Further prospective studies are warranted to clarify its role in specific ED subtypes and patient populations.

Declarations

Ethical approval and consent for participate: *All procedures performed in the study involving human participants were in accordance with the 1964 Helsinki declaration and its later amendments. Written informed consent was obtained from all patients for participation in the study. The study was approved by State Security Service Scientific Research Center Ethics Board (Decision no: ETEK: 25/05).*

Availability of data and material: *All data that support the findings of this study are available within the article and from the corresponding author.*

Competing interests: *The authors declare that they have no conflict of interest.*

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Correspondence

Rashad Sholan, MD, PhD, Dsci (Corresponding Author)
sholanrashad@gmail.com

Rufat Aliyev MD, PhD, Assoc. Prof.
mqos@yandex.com

Scientific Research Center, State Security Service Military Hospital and Azerbaijan Medical University, Baku, Azerbaijan. AZ1000, Baku City, Badamdar, Mektebli street

Seymur Karimov, MD
dr.seymurkarimov@gmail.com

Rahman Ismayilov, MD, PhD
rehman-ismayilov88@mail.ru

Department of Kidney Diseases and Organ Transplantation, State Security Service Military Hospital, Baku, Azerbaijan.

Elvin Bayramov MD
elvin.bayramli30@gmail.com

Department of Laboratory, State Security Service Military Hospital, Baku, Azerbaijan