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Impact of Chronic Kidney Disease and Renal Replacement Therapy on Reproductive Health and Life Quality

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Abstract **The aim of the study** was to evaluate the dynamics of erectile function in patients with chronic kidney disease over a long period of time - from the initial treatment to 12 months after hemodialysis, to analyze the impact of chronic kidney disease and hemodialysis on erectile function, as well as to identify the key pathogenetic mechanisms underlying this process. **Background.** Chronic kidney disease is a serious medical and social problem affecting various aspects of a patient's health, including his cardiovascular system, metabolic processes and quality of life. One of the significant but often underestimated complications of chronic kidney disease is erectile dysfunction, which has a significant impact on the psycho-emotional state and general well-being of patients. **Material and methods.** The study included 201 patients with chronic kidney disease who went to the Republican Specialized Scientific and Practical Medical Center of Urology with complaints of erectile dysfunction from 2022 to 2025. **Results.** The mean age of patients was 35,3±2,1 years. The majority of patients belonged to the young age category (18-44 years), which confirms the prevalence of CKD among the able-bodied population - 162 (80.6%). Middle age (45-59 years) was registered in 38 (18,9%) cases. **Discussion.** It was revealed that the severity of reproductive disorders depended not only on the stage of CKD and duration of replacement therapy, but also on individual factors such as age, presence of concomitant endocrine and cardiovascular diseases, etc. **Conclusion.** Reproductive disorders in patients with CKD are a common and significant problem affecting not only the quality of life but also the long-term outcome of the disease. Patients with CKD undergoing hemodialysis have been found to have significant endocrine and vascular disorders leading to reproductive disorders, including hypogonadism and erectile dysfunction.

Keywords Chronic kidney disease, Reproductive disorders, Sexual dysfunction, Infertility, Hypogonadism, Hormonal disorders, Hemodialysis, Fertility

1. Introduction

Chronic kidney disease (CKD) is a serious medical and social problem affecting various aspects of a patient's health, including his cardiovascular system, metabolic processes and quality of life. One of the significant but often underestimated complications of CKD is erectile dysfunction (ED), which has a significant impact on the psycho-emotional state and general well-being of patients. Erectile dysfunction in patients with CKD is associated with a number of pathogenetic factors, including endothelial dysfunction, hormonal changes, uremic intoxication, and vascular dysfunction. Chronic kidney disease is a multifactorial progressive disease accompanied by systemic disorders of metabolism, endocrine and immune regulation. Reproductive disorders are a common complication of CKD. In the late stages of the disease, the secretion of sex hormones, spermatogenesis cycle is disturbed, which leads to erectile dysfunction, infertility and decreased libido.

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Despite the success of renal replacement therapy, only some patients achieve full recovery of reproductive function. The article presents current ideas about the pathogenesis, clinical manifestations and approaches to the treatment of reproductive disorders in patients with CKD. The need for a multidisciplinary approach, including nephrologist, endocrinologist and andrologist, in the management of such patients is emphasized.

One of the often underestimated but clinically significant problems is reproductive dysfunction in patients. According to various authors, up to 90% of men with end-stage CKD experience some forms of reproductive disorders [1,2].

Pathogenesis of reproductive disorders in CKD. Urogenital disorders are caused by a combination of the following factors:

- hyperprolactinemia;
- resistance to gonadotropins;
- impaired gonadoliberin secretion;
- decreased levels of testosterone, estradiol and progesterone;
- intoxication with uremic metabolites.

Hypogonadism, decreased libido, erectile dysfunction and oligozoospermia are developed in such type of patients [3].

Effect of hemodialysis and peritoneal dialysis. Regular dialysis improves the general condition, but only partially restores the hormonal background. Some studies have reported a moderate increase in testosterone levels and a decrease in prolactin after conversion from peritoneal dialysis to hemodialysis [4]. However, fertility remains low.

Reproductive function after kidney transplantation. Successful kidney transplantation contributes to partial or complete restoration of endocrine function of the hypothalamic -pituitary-gonadal system. Patients have improved libido and spermatogenesis [5].

However, a number of factors limit the restoration of fertility:

- the use of glucocorticoids and calcineurin inhibitors (cyclosporine, tacrolimus);
- hypertension and hyperlipidemia;
- residual uremic intoxication;
- injury of pituitary gland and gonads due to prolonged CKD.

Our findings may contribute to the development of more efficient management of patients with CKD, aimed at improving their reproductive health and overall quality of life.

2. Material and Methods

In this study, we investigated 201 patients with CKD who visited to Republican Specialized Scientific and Practical Medical Center of Urology with complaints of ED from 2022 to 2025. The inclusion criteria were as follows:

- Age over 18 years.
- Confirmed diagnosis of CKD (stages 2-5).
- Patients receiving renal replacement therapy (hemodialysis).
- Presence of data on laboratory and clinical parameters in dynamics.

Exclusion criteria consisted of the following factors:

- Decompensated comorbidities preventing participation in the study.
- Inadequate clinical and laboratory data.
- Patients with terminal oncologic diseases.
- Female patients.

Examination of patients included:

- anamnesis collection (reproductive function, libido, fertility, sexual activity);
- physical examination;
- laboratory tests: testosterone level, LH, FSH;
- ultrasound Doppler ultrasonography of the cavernous and dorsal arteries of the penis and scrotal organs.

Statistical analysis was performed using Statistica 12.0 software, using Student's t-test, χ^2 and correlation analysis ($p < 0.05$ was considered statistically significant).

3. Results

The mean age of patients was 35,3±2,1 years. The majority of patients belonged to the young age category (18-44 years), which confirms the prevalence of CKD among the able-bodied population - 162 (80.6%). Middle age (45-59 years) was recorded in 38 (18.9%) cases. Older patients (60-74 years) accounted for the smallest proportion - only 1 (0.5%) patient (Table 1).

Table 1. Distribution of patients by age

Parameters	n=201	
	n	%
Mean age (M±m, years)	35.3±2.1	
Young age (18-44 years)	162	80.6%
Middle age (45-59 years)	38	18.9%
Older age (60-74 years)	1	0.5%
Total	**201**	**100%**

The main cause of CKD development among the patients included in the study was chronic glomerulonephritis, which was diagnosed in 176 (87.6%) patients. The second most frequent cause was polycystic kidney disease, detected in 6 (3.0%) cases. Chronic kidney disease of unclear etiology was also recorded in 6 (3.0%) cases. Type II diabetes mellitus and various developmental abnormalities of the urinary system were the least common causes of CKD, accounting for 1.0% of cases (Table 2).

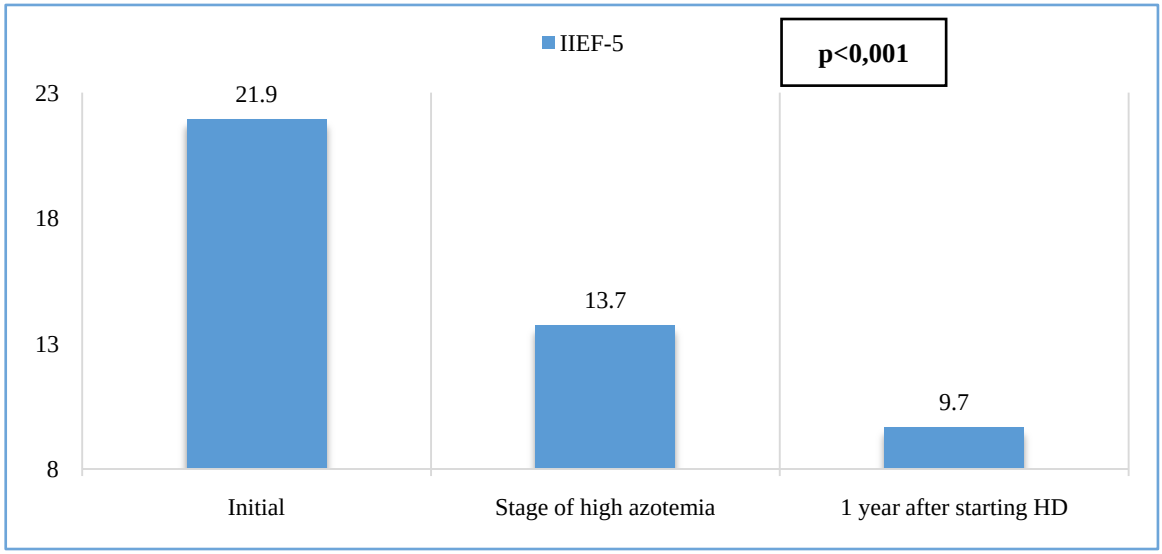
Table 2. Distribution of patients by cause of CKD development

Pathology	n=201	
	n	%
Chronic glomerulonephritis	176	87.6%
Polycystic kidney disease	6	3.0%
Chronic kidney disease of unclear etiology	6	3.0%
Urolithiasis	5	2.5%
Chronic pyelonephritis	4	2.0%
Type II diabetes mellitus	2	1.0%
Abnormalities of the urinary system	2	1.0%
Total	**201**	**100%**

At the initial stage of the study, 75 (37.3%) patients had mild erectile dysfunction, 126 (62.7%) patients had no erectile dysfunction. However, as CKD progressed, at the terminal stage (stage 5 CKD) and in conditions of high azotemia, erectile dysfunction of varying severity, from mild to moderate (according to IIEF-5), was developed in almost all patients. No improvement in erectile function was observed 12 months after initiation of hemodialysis. In contrast, a significant proportion of patients had worsened dysfunction, and 13.9% of patients experienced severe ED. These data underline the importance of finding efficient strategies to correct and prevent sexual dysfunction in CKD patients on hemodialysis (Table 3).

Table 3. Distribution of patients with CKD on hemodialysis according to IIEF-5 data at the stages of the study

	Degree of ED		Initial	Stage of high azotemia	12 months after the start of hemodialysis
IIEF-5	Severe	n	0	0	28
		%	0.0%	0.0%	13.9%
	Moderate	n	0	8	132
		%	0.0%	4.0%	65.7%
	Moderately light	n	0	186	41
		%	0.0%	92.50%	20.4%
	Light	n	75	7	0
		%	37.3%	3.50%	0.0%
	No ED	n	126	0	0
		%	62.7%	0.00%	0.0%
	Total	**n**	**201**	**201**	**201**
		%	**100%**	**100%**	**100%**



Stage	**IIEF=201)**
	M±m
Initial	21.9±0.1
Stage of high azotemia	13.7±0.1
1 year after starting HD	9.7±0.1
F(2.600)=2418.29; p<0.001	

Figure 1. Dynamics of average values of the International Index of Erectile Function (IIEF-5)

The presented diagram (Fig. 1) reflects the dynamics of the average indicators of the international index of erectile function (IIEF-5). At the initial stage (before the progression of azotemia), the average IIEF-5 index was 21.9±0.1, which indicates a marked decrease in erectile function, but still a preserved level of sexual activity.

In the high azotemia stage, further deterioration was observed - the MIEF-5 index decreased to 13.7±0.1, indicating a significant deterioration of erectile function. One year after the start of hemodialysis, an even more pronounced decrease to 9.7±0.1 was observed, indicating a critical deterioration of erectile function despite renal replacement therapy. The conducted one-way analysis of variance (ANOVA) showed a high degree of significance of differences between the stages of observation ($F(2,600)=2418.29$; $p<0.001$), which indicated a significant decrease in erectile function indicators with the progression of CKD and the duration of hemodialysis (HD).

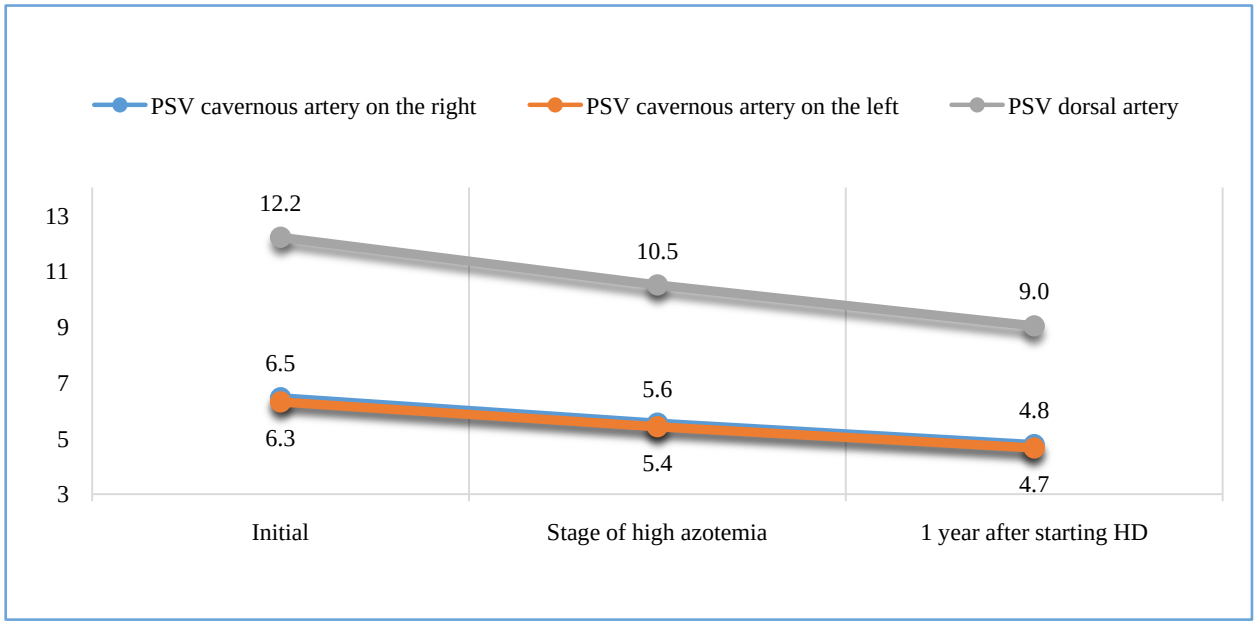
Measurement of peak systolic velocity (PSV) in the cavernous arteries (right and left) and dorsal artery is an important method for diagnosing vascular disorders of the penis that underlie erectile dysfunction. The dynamics at the stages of observation of patients with CKD on HD showed that there was a significant decrease in PSV in the cavernous and dorsal arteries with the progression of CKD and the continuation of HD. This indicates progressive vascular disorders that may play a leading role in the development of ED in patients with end-stage renal failure. Dynamic analysis of changes shows that in the cavernous artery on the

right, the initial PSV value was 6.5±0.1 cm/s, at the stage of high azotemia it decreased to 5.6±0.1 cm/s (a decrease of 13.8%), and after 1 year on hemodialysis it reached 4.8±0.1 cm/s (an additional decrease of 14.3%). The overall reduction was 26.2% (p<0.001). Similar changes were also found in the cavernous artery on the left: the initial value was 6.3±0.1 cm/s, at the stage of high azotemia 5.4±0.1 cm/s (a decrease of 14.3%), and after a year on hemodialysis 4.7±0.1 cm/s (an additional decrease of 13.0%), which in total led to a decrease of 25.4% (p<0.001). The dorsal artery initially had higher values (12.2±0.2 cm/s), but it also demonstrated a progressive decrease: 10.5±0.2 cm/s at the stage of high azotemia (–13.9%) and 9.0±0.2 cm/s after one year on HD (–14.3%), which in total amounted to 26.2% (p<0.001) (Fig. 2).

PSV dynamics during the follow-up phases of CKD patients on HD showed that there was a significant decrease in PSV in the cavernous and dorsal arteries with progression of CKD and continuation of HD. It demonstrated progressive vascular abnormalities that may play a leading role in the development of ED in patients with end-stage renal failure.

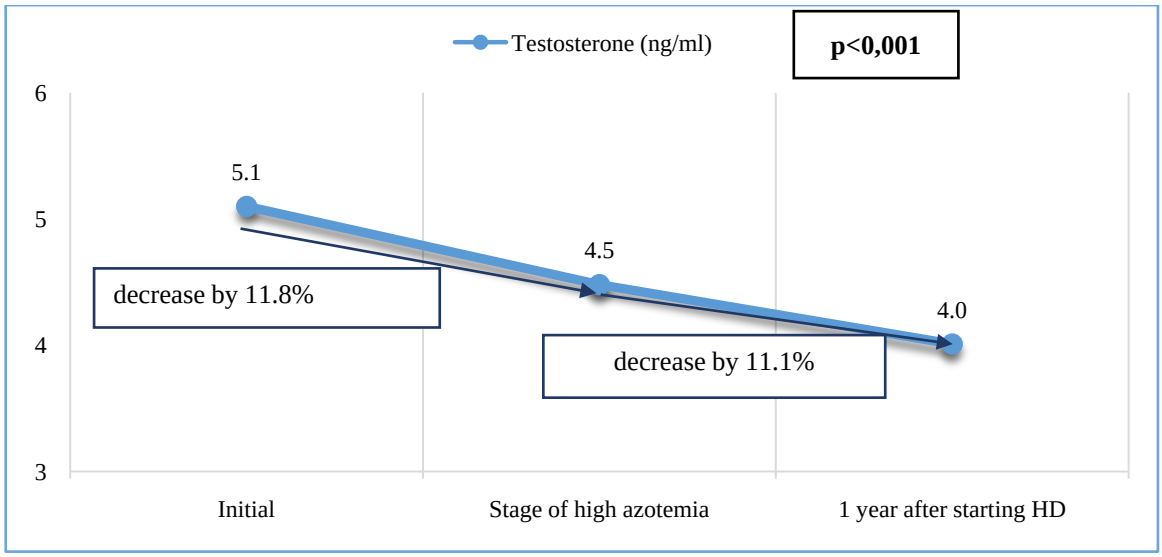
Dynamic analysis of changes showed that in the cavernous artery on the right, the initial PSV value was 6.5±0.1 cm/s, at the stage of high azotemia it decreased to 5.6±0.1 cm/s (a decrease of 13.8%), and after 1 year on hemodialysis it reached 4.8±0.1 cm/s (an additional decrease of 14.3%). As a result, the overall reduction was 26.2% (p<0.001). Similar changes were also found in the cavernous artery on the left: the initial value was 6.3±0.1 cm/s, at the stage of high azotemia it amounted to 5.4±0.1 cm/s (a decrease of 14.3%), and after a year on hemodialysis it reached 4.7±0.1 cm/s (an additional decrease of 13.0%), which in total led to a decrease of 25.4% (p<0.001). The dorsal artery initially had higher values (12.2±0.2 cm/s), but also demonstrated a progressive decrease: 10.5±0.2 cm/s at the stage of high azotemia (–13.9%) and 9.0±0.2 cm/s after one year on HD (–14.3%), which in total amounted to 26.2% (p<0.001).

Laboratory analysis showed a progressive decrease in testosterone levels as the condition worsened and HD progressed. Thus, at the initial stage, the testosterone level was 5.1±0.2 ng/ml, at the stage of high azotemia it decreased to 4.5±0.2 ng/ml (a decrease of 11.8%), and after 1 year on HD it reached 4.0±0.1 ng/ml (an additional decrease of 11.1%). On the whole, the decrease for the whole period amounted to 21,6% (p<0,001). Analysis of variance (ANOVA) revealed significant differences between the observation stages (F(2,600) =23.49; p<0.001), which confirms the presence of hypogonadism in patients with CKD, which may be one of the factors of ED. The most pronounced decrease in testosterone occured during the first year of HD, which required regular monitoring of the endocrine profile of patients (Fig. 3).



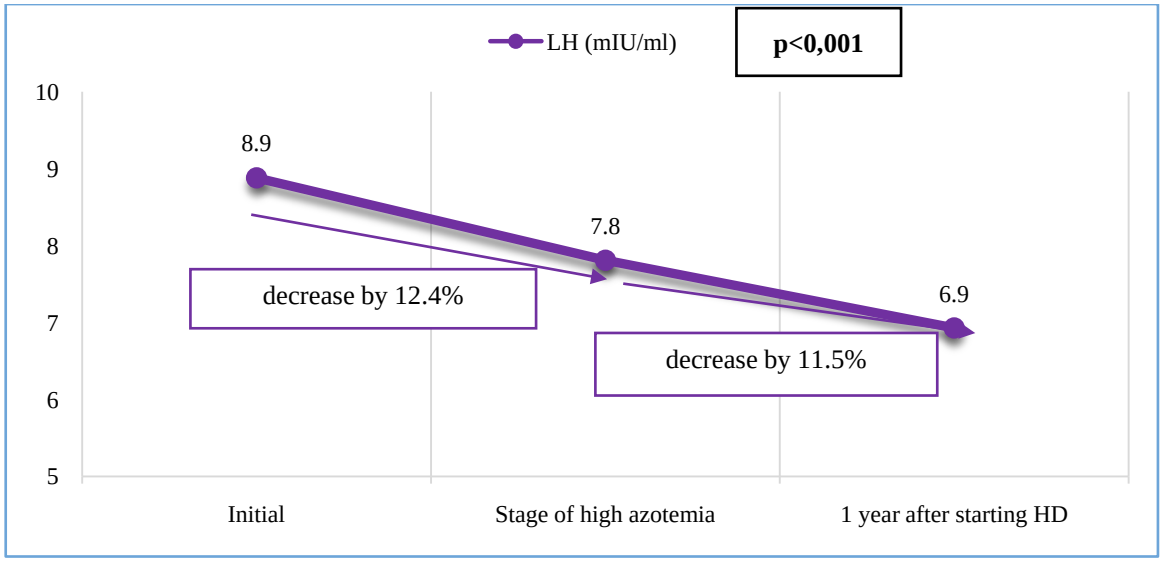
Stage	PSV cavernous artery on the right (n=201)	PSV cavernous artery on the left (n=201)	PSV dorsal artery (n=201)
	M±m	M±m	M±m
Initial	6.5±0.1	6.3±0.1	12.2±0.2
Stage of high azotemia	5.6±0.1	5.4±0.1	10.5±0.2
1 year after starting HD	4.8±0.1	4.7±0.1	9±0.2
ANOVA	F(2.600)=287.65; p<0.001	F(2.600)=77.81; p<0.001	F(2.600)=81.40; p<0.001

Figure 2. Dynamics of peak systolic velocity in the cavernous arteries (right and left) and the dorsal artery of the penis



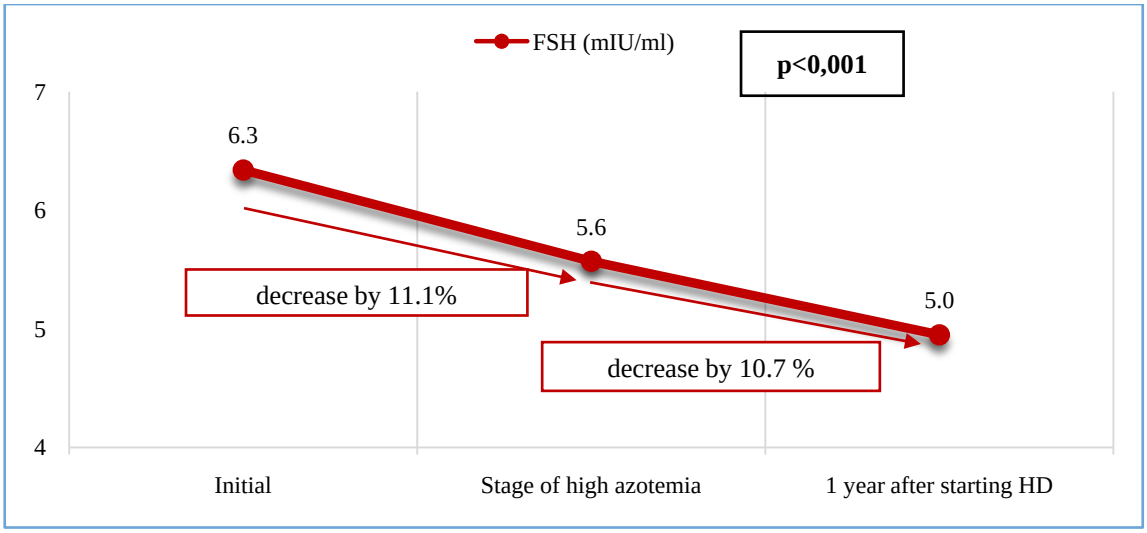
Stage	Testosterone (ng/ml) (n=201)
	M±m
Initial	5,1±0,2
Stage of high azotemia	4,5±0,2
1 year after starting HD	4±0,1
ANOVA – F(2,600)=23,49; p<0,001	

Figure 3. Dynamics of average testosterone levels at stages of management of patients with CKD and ED



Stage	LH (mIU/ml) (n=201)
	M±m
Initial	8.9±0.1
Stage of high azotemia	7.8±0.1
1 year after starting HD	6.9±0.1
ANOVA – F(2,600)=127,81; p<0,001	

Figure 4. Dynamics of average LH levels at stages of management of patients with CKD and ED



Stage	FSH (mIU/ml) (n=201)
	M±m
Initial	6.3±0.1
Stage of high azotemia	5.6±0.1
1 year after starting HD	5±0.1
ANOVA – F(2,600)=47,88; p<0,001	

Figure 5. Dynamics of average FSH levels at stages of management of patients with CKD and ED

The next laboratory indicator for diagnosing pathologies of the reproductive system and causes of ED is the determination of the level of luteinizing hormone (LH). According to the obtained results, a progressive decrease in LH levels was observed against the background of deterioration of renal function and continuation of HD. It may be associated with suppression of the hypothalamic-pituitary-gonadal axis, metabolic disorders, and possible dysregulation of gonadotropin secretion, which leads to the development of hypogonadotropic hypogonadism. At the initial stage, the LH level was 8.9±0.1 mIU/ml, at the stage of high azotemia it decreased to 7.8±0.1 mIU/ml (a decrease of 12.4%), and after 1 year on HD it reached 6.9±0.1 mIU/ml (an additional decrease of 11.5%). Overall, the decrease over the entire period was 22.5% ($p<0.001$). Analysis of variance (ANOVA) revealed significant differences between the groups ($F(2,600) =127.81$; $p<0.001$), which confirms a significant decrease in LH levels with the progression of renal failure and the HD passage (Fig. 4).

Also, our data showed that there was a progressive decrease in follicle-stimulating hormone (FSH) levels with worsening renal function and continued HD. Thus, at the initial stage, the FSH level was 6.3±0.1 mIU/ml, at the stage of high azotemia it decreased to 5.6±0.1 mIU/ml (a decrease of 11.1%), and after 1 year on HD it reached 5.0±0.1 mIU/ml (an additional decrease of 10.7%). Overall, the decrease over the entire period was 20.6% ($p<0.001$). Analysis of variance (ANOVA) revealed significant differences between the observation stages ($F(2,600)=47.88$; $p<0.001$), which confirmed the presence of endocrine disorders in patients with CKD, which might be associated with hypogonadotropic hypogonadism (Fig. 5).

4. Discussion

Reproductive disorders in patients with chronic kidney disease represent one of the most complex and understudied areas of nephrology and transplantology. Current research indicates a high prevalence of sexual dysfunction, hypogonadism, infertility and decreased libido in patients suffering from terminal CKD.

The main pathogenetic mechanisms of sexual dysfunction at CKD are chronic intoxication with uremic toxins, anemia, hyperprolactinemia, electrolyte disorders, as well as secondary hyperparathyroidism and disorders of hypothalamic-pituitary-gonadal axis function. Impaired metabolism of sex hormones, decreased testosterone in men and estrogens in women are closely related to the level of glomerular filtration and become especially pronounced with the transition to programmed hemodialysis.

Most frequently it associated with the use of glucocorticosteroids, calcineurin inhibitors, and antimetabolites, which can adversely affect spermatogenesis, libido and erectile function.

In our presented study it was revealed that the severity of reproductive disorders depends not only on the stage of CKD and duration of replacement therapy, but also on individual factors such as age, presence of concomitant endocrine and cardiovascular diseases, etc. Thus, erectile dysfunction (IIEF-5) is closely associated with impaired blood flow in the cavernous arteries (PSV) and decreased testosterone. Hypogonadism (low levels of testosterone, LH, FSH) leads

to deterioration of spermogram parameters, vascular disorders (decreased PSV) worsen erectile function.

Based on the conducted correlation analysis, multivariate analysis (linear regression) and statistical processing of data, it can be concluded that ED in CKD has a mixed genesis, including vascular (arteriogenic or impaired veno-occlusive mechanism), hormonal (endocrine) and mixed components.

Particular attention should be paid to the need for a multidisciplinary approach in the evaluation and correction of reproductive disorders in this type of patients. Comprehensive evaluation of the hormonal profile, ultrasound and laboratory examination, as well as timely consultation with a urologist -andrologist and endocrinologist can increase the chances of restoring reproductive function and improving the life quality of patients.

5. Conclusions

Reproductive disorders in patients with CKD are a common and significant problem affecting not only the quality of life but also the long-term outcome of the disease.

Patients with CKD undergoing hemodialysis have been found to have significant endocrine and vascular disorders leading to reproductive disorders, including hypogonadism and ED.

Analysis of erectile function in patients with CKD and dialysis therapy showed a progressive deterioration of sexual function with increasing azotemia and duration of HD.

Conflict of Interests' Statement

The authors declare no conflict of interest.

This study does not include the involvement of any budgetary, grant or other funds.

The article is published for the first time and is part of a scientific work.

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Ethical Approval and Consent to Participate

The Research Ethics Board of our institution does not require review or approval of case reports. Our research was carried out in accordance with the World Medical Association Code of Ethics (Declaration of Helsinki).

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