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DISRUPTIONS OF SPERMATOGENIC FUNCTION AFTER TESTICLE TORSION IN CHILDHOOD AND ADOLESCENCE

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Aim of research. To assess the state of spermatogenesis in men after an experience of testicle torsion in childhood and adolescence. **Materials and methods.** A semen analysis was performed involving 76 men, ages 18 to 29 years, who had testicle torsion in childhood and adolescence. Inclusion criteria in this study were an age of 18 years and an active sexual life. Analysis of the ejaculate was performed in accordance with the World Health Organization Guidelines for the study of human ejaculate. Macroscopic and microscopic evaluation of ejaculate, as well as assessment of motility, viability, number, and morphology of sperm was performed. The control group included 49 men who lacked potential risk factors for male infertility. **Results and discussion.** Changes in the ejaculate depended on the patient's age, as well as the duration and degree of testicular ischemia. When the gonad was preserved after critical ischemia occurred, the spermogram indices were significantly worse than when performing primary orchiectomy, which indicates functional failure of the gonad following its atrophy and suggests that it is inadvisable to maintain the gonad with the expectation of improved long-term results. **Conclusions:** 1. Changes in the spermogram after ischemia were observed in terms of sperm morphology and mobility. 2. The most pronounced changes in the spermogram were noted in patients who had experienced third-degree inversion of the testicle with preservation of gonads; the least pronounced changes were noted in patients who had experience inversion with spontaneous generation and incomplete inversion, which involved minimal ischemic damage. 3. The worst ischemia in puberty occurred in the context of mature sex glands. 4. There was a direct dependence of spermogram changes on the duration of acute ischemia. 5. The most unfavorable combination occurred in puberty, with disease lasting for more than 1 day, comprising complete inversion with "critical" ischemia. 6. After critical ischemia with preservation of the gonad, the semen is less favorable than after completion of orchiectomy, due to the failure of atrophied gonads; this finding casts doubt on the practice of gonad preservation.

Keywords: testicle torsion; spermatogenesis; testicular ischemia.

НАРУШЕНИЯ СПЕРМАТОГЕННОЙ ФУНКЦИИ ПОСЛЕ ПЕРЕНЕСЕННОГО ЗАВОРОТА ЯИЧКА В ДЕТСКОМ И ПОДРОСТКОВОМ ВОЗРАСТЕ

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Цель исследования — оценить состояние сперматогенеза у мужчин после перенесенного заворота яичка в детском и подростковом возрасте. **Материалы и методы.** Проведен анализ эякулята 76 мужчин в возрасте от 18 до 29 лет, перенесших заворот яичка в детском и подростковом возрасте. Критериями включения в исследование считали возраст 18 лет и наличие половой жизни. Анализ эякулята проводили в соответствии с рекомендациями Руководства ВОЗ по исследованию эякулята человека. Выполняли макроскопическую и микроскопическую оценку эякулята, оценку подвижности, жизнеспособности, количества, морфологии сперматозоидов. Группой контроля являлись 49 пациентов, у которых отсутствовали потенциальные факторы мужского бесплодия. **Результаты и обсуждение.** Изменения эякулята зависели от возраста пациента, длительности и степени ишемии яичка. При сохраненной гонаде после перенесенной критической ишемии показатели спермограммы были достоверно хуже, чем при выполнении первичной орхэктомии, что свидетельствует о функциональной несостоятельности гонады на фоне ее атрофии и позволяет считать нецелесообразным ее сохранение с точки зрения отдаленных результатов. **Выводы.** 1. Изменения в спермограмме после перенесенной ишемии наблюдаются в части морфологии сперматозоидов и их подвижности. 2. Наиболее выраженные изменения спермограммы отмечаются при завороте яичка III степени с сохранением гонады, наименьшие — при завороте со спонтанной деторсией и неполном завороте, что соответствует минимальному ишемическому повреждению. 3. Наихудшие показатели зарегистрированы при перенесенной ишемии в пубертатном возрасте на фоне зрелых половых желез. 4. Изменения спермограммы зависят от продолжительности острой ишемии. 5. Наиболее неблагоприятное сочетание — пубертатный возраст, срок заболевания более суток, полный заворот с критической ишемией. 6. Показатели спермограммы при критической ишемии гонады с сохранением яичка являются наименее благоприятными по сравнению с показателями после орхэктомии, что говорит о функциональной недостаточности атрофированной гонады и ставит под сомнение вопрос ее сохранения.

Ключевые слова: заворот яичка; сперматогенез; ишемия яичка.

INTRODUCTION

Impaired spermatogenesis in men after andrologic pathology in childhood is the most difficult and at the same time the most important aspect of assessing disease outcome [1]. This is exactly true for acute testicular ischemia. Semen analysis in adults is advisable. However, usually, there is a long interval between the history of acute ischemia and assessment of consequences; in some cases, the interval can reach ≥15 years [2, 3]. Investigation early after an acute episode before adulthood is not entirely accurate, since spermatogenesis is not yet completely established in all cases. According to some researchers, semen analysis at age 16–17 years, and in some cases even earlier, is quite possible in terms of the functional maturity of the gonads, but collection of material for research is complex and ambiguous from a legal and social viewpoint [4]. Despite the absence of legislative regulatory acts, there is an unstated agreement among the professional community in Russia and abroad, according to which semen analysis is not performed in patients younger than 18 years. Even in the 1980s, a more loyal period with respect to medical law, semen analysis was performed only after reaching stated maturity [5].

Testicular torsion is a common uroandrologic disorder requiring immediate intervention [6]. Relatively few studies exist of the functional viability of the gonads after testicular torsion in childhood and adolescence. Bychkov et al. [1] reported a decrease in sperm motility on semen analysis in 12 men above 18 years old with a history of testicular torsion. Voronyuk et al. [7] analyzed seminograms in 12 patients with a history of torsion at the age of 18–25 years and found a decreased sperm count and decreased number of morphologically normal sperm. However, this and other studies were conducted on small groups and did not consider the features of disorders depending on the duration of ischemia, form of torsion, and other factors. The decreased number and motility of sperm cells is possibly due to oxidative stress in testicular tissue [8]. Hadziselimovic et al. [9] found gross changes in the sperm structure and a decreased sperm count on testicular biopsies.

When the gonad was preserved after testicular torsion and orchiectomy, the semen analysis parameters decreased almost equally, which indicated a gross spermatogenesis failure after ischemia with morphologically moderate atrophy [10].

Bychkova et al. [1] demonstrated a decreased sperm count to ≤20 million/mL, ≤50% sperm with normal morphology mainly for ischemia >48 h, and a significantly decreased number of motile spermatozoa of ≤50%. Terms of ischemia for the development of these changes were not specified, and changes in the ejaculate for the removal of one testicle were not studied. Snodgrass [11] showed similar data on the changes in semen, but did not provide a correlation between changes in the semen and the clinical situation during the acute episode.

In total, the literature data on the subject are limited by few studies with small samples and do not expose all issues, leaving our research objectives to be topical.

MATERIAL AND METHODS

We observed 298 patients with different types of testicular torsion who underwent surgical treatment at Yaroslavl Regional Children's Clinical Hospital (medical director, M.V. Pisareva). Semen analysis was performed in 76 patients who were 18–29 years old at 1.5–15 years after testicular torsion. Criteria for performing semen analysis were the attainment of age 18 years and sexual life before investigation.

Semen samples were obtained via masturbation in the laboratory in a sterile glass container nontoxic for spermatozoa, after not less than 3 days of sexual abstinence. Sperm were prepared via a simple washing method. Biggers–Whitten–Whittingham's (BWW), Earle's, and Ham's F-10 solutions, supplemented preferably with human serum albumin (HSA) or serum, were used. HSA supplementation was performed in the following manner: 300 mg HSA, 1.5 mg sodium pyruvate, 0.18 mL sodium lactate (60% v/v syrup), and 100 mg sodium bicarbonate were added to 50 mL medium. The quality of semen analysis was assured by adherence to the World Health Organization (WHO) 2012 Laboratory Manual for the examination and processing of human semen. Macroscopic and microscopic examinations of ejaculate with the assessment of sperm motility, vitality, and count were performed. Sperm morphology was evaluated using Shorr stain. White blood cell level and immature germ cell count and antibodies on spermatozoa cells were determined.

The control group included 49 patients who underwent examination for marital infertility with excluded male infertility factors in the Reproductology Department of Yaroslavl Regional Prenatal Centre (medical director, D.L. Gur'ev, PhD). Semen collection was the same for both groups.

Statistical data were analyzed by XL Statistics 4. The Mann–Whitney *U* test was used to evaluate quantitative value differences between the two groups. The level of significance was defined as $p < 0.05$.

RESULTS AND DISCUSSION

Parameter values in patients with a history of testicular torsion in the study and healthy control groups were compared with WHO 2010 reference levels (Table 1). No semen indicators were found

Table 1

Indices of the spermogram in the study and control groups

Таблица 1

Показатели спермограммы в основной и контрольной группах

WHO criteria 2010	Study group (n = 76)	Control group (n = 49)	WHO reference value 2010
Sperm volume, mL	3.7 ± 0.4	4.1 ± 0.6	≥ 1.5
Sperm concentration, M/mL	21.3 ± 3.5	24.5 ± 0.5	≥ 15
Kinesiogram 1. Progressive motility (PR) a) fast linear movement, % b) slow linear movement, % 2. Nonlinear motility (NP) c) swimming in circle and/or twitching, % 3. Immotile sperms (d), %	 5 31 22 42	 6 45 17 32	 a) ≥ 20% a + b) ≥ 32% c) < 20% d) < 40%
Sperm vitality, %	60	67	≥ 58
Normal forms, %	3	4	≥ 4
Abnormal heads, %	95	94	
Abnormal midpieces, %	22	18	
Abnormal principal pieces, %	24	20	
Sperm cells with cytoplasmic vacuole, %	1.1	1.1	

Note. For values of ejaculate volume and amount of spermatozoa, $p < 0.05$.
Примечание. Для значений объема эякулята, количества сперматозоидов $p < 0{,}05$.

characterizing the inflammatory process in the urogenital tract in all cases. Changes in semen analysis were detected mainly in terms of sperm morphology and kinesiograms. In the semen analyses, no parameters typical for inflammation in the urogenital tract were found. Changes in semen analysis were mainly observed in sperm morphology and kinesiograms.

Sperm motility was significantly lower in patients with a history of testicular torsion than in healthy controls (Table 1). There was also a significant difference in terms of sperm morphology.

Changes in semen were compared between patients with different types of testicular torsion and the control group (Table 2). There was no correlation between semen volume and concentration of spermatozoa with the type of torsion, whereas morphology and motility had certain features. The greatest number of morphologic defects and lowest sperm motility were identified for testicular torsion with severe grades II–III ischemia, whereas minimal ischemia (torsion with spontaneous detorsion or intermittent testicular torsion) showed the most optimal values on semen analysis.

Changes in semen depending on the duration of ischemia in the acute period were compared (Table 3). There were increased changes in sperm motility and morphology depending on the duration of ischemia. There was a progressive decrease in the number of live sperm. Regarding sperm morphology, the most pronounced changes were in the sperm head. There

Table 2

Changes in the spermogram due to various forms of torsion

Таблица 2

Изменения спермограммы при различных формах заворота

WHO criteria 2010	Type of torsion							
	Incomplete (n = 10)	Grade I (n = 11)	Grade II (n = 11)	Grade III (n = 13)	SD (n = 10)	RT (n = 7)	IT (n = 13)	Control group (n = 49)
Sperm volume, mL	3.5 ± 0.6	3.9 ± 0.5	3.6 ± 0.8	3.7 ± 0.7	3.9 ± 0.8	3.4 ± 0.6	3.5 ± 0.6	3.7 ± 0.4
Sperm concentration, M/mL	23.1 ±1.6	22.2 ± 1.7	19.7 ± 2.1	14.7 ± 1.9	24.1 ± 1.5	23.7 ± 1.7	23.6 ± 1.8	24.5 ± 1.4
a) fast linear movement, %	6	6	5	4	6	5	6	6
b) slow linear movement, %	44	41	35	29	42	38	43	45
c) swimming in circle and/or twitching, %	17	19	23	25	18	19	18	17
d) immotile sperms, %	33	32	37	42	34	38	33	32
Sperm vitality, %	66	59	59	57	66	62	64	67
Normal forms, %	4	4	4	3	4	4	4	4
Abnormal heads, %	90	93	95	98	92	94	91	94
Abnormal midpieces, %	17	18	17	18	17	18	18	18
Abnormal principal pieces, %	18	19	21	24	19	19	19	20

Note. For values of ejaculate volume and amount of spermatozoa, $p < 0.05$. IT – incomplete torsion, SD – torsion with spontaneous detorsion, RT – recurrent torsion, IM – intermittent torsion, OE – orchiectomy, CG – control group.

Примечание. Для значений объема эякулята, количества сперматозоидов $p < 0,05$. НП — неполный заворот, СД — заворот со спонтанной деторсией, РЦД — рецидивирующий заворот, ИМ — интермиттирующий заворот, ОЭ — орхэктомия, ГК — группа контроля.

Table 3

Changes in the spermogram depending on the duration of ischemia in the acute period

Таблица 3

Изменения спермограммы в зависимости от длительности перенесенной ишемии в остром периоде

WHO criteria 2010	Duration of acute ischemia, hours					
	< 6 (*n* = 17)	6–12 (*n* = 28)	12–24 (*n* = 14)	24–48 (*n* = 11)	Over 48 (*n* = 7)	Control group (*n* = 49)
Sperm volume, mL	3.4 ± 0.3	3.4 ± 0.2	3.7 ± 0.3	3.7 ± 0.2	3.7 ± 0.4	3.7 ± 0.4
Sperm concentration, M/mL	22.3 ± 1.1	22.1 ± 1.4	19.7 ± 1.7	19.1 ± 1.6	19.2 ± 1.8	24.5 ± 1.4
Kinesiogram						
1. Progressive motility (PR)						
a) fast linear movement, %	9	7	5	4	3	6
b) slow linear movement, %	44	43	36	30	23	45
2. Nonlinear motility (NP)	16	19	22	22	26	17
c) swimming in circle and/or twitching, %						
3. Immotile sperms (d), %	31	33	37	44	48	32
Sperm vitality, %	63	63	60	56	54	67
Normal forms, %	4	4	3	3	2	4
Abnormal heads, %	94	95	95	99	99	94
Abnormal midpieces, %	18	18	18	19	19	18
Abnormal principal pieces, %	20	20	21	21	21	20

Note. For values of ejaculate volume and amount of spermatozoa, $p < 0.05$.
Примечание. Для значений объема эякулята, количества сперматозоидов $p < 0,05$.

was no significant correlation between semen volume and duration of ischemia. The same was noted for decreased sperm count.

Changes in semen analysis and patient age at acute testicular ischemia were correlated (Table 4). There was an inverse dependence: the greater the patient's age at ischemia, the worse the semen values. The lowest semen values were documented in patients with a history of testicular ischemia at age >14 years on the background of almost established reproductive function. Values of semen volume were consistent for ischemia at any age. Decreased sperm number of 1 mL was observed only for ischemia at older ages with lower correlation than that for motility and morphology.

Semen values and severity of ischemia were correlated. Patients were divided into three groups: gonad viability is beyond doubt, critical gonad ischemia, and orchiectomy was performed (Table 5). Semen analysis showed that the worst semen values were noted for critical gonad ischemia with its preservation, which was equivalent to severe atrophy (>50% of the volume). Semen analysis values after orchiectomy corresponded to those for torsion with preservation of viable gonad, indicating a high compensatory ability of the reproductive system.

Table 4

Changes in the spermogram depending on the age of patients during the period of acute testicular ischemia

Таблица 4

Изменения спермограммы в зависимости от возраста пациентов на период острой тестикулярной ишемии

WHO criteria 2010	Age at the time of acute testicular ischemia, years						
	< 1 (n = 3)	1–3 (n = 4)	3–7 (n = 13)	7–10 (n = 16)	10–14 (n = 22)	15–18 (n = 18)	Control group (n = 49)
Sperm volume, mL	3.4 ± 0.6	3.4 ± 0.4	3.7 ± 0.4	3.3 ± 0.6	3.7 ± 0.5	3.3 ± 0.5	3.7 ± 0.4
Sperm concentration, M/mL	23.2 ± 1.1	22.2 ± 1.4	24.1 ± 1.6	23.4 ± 1.5	21.5 ± 1.5	20.3 ± 1.5	24.5 ± 0.5
Kinesiogram							
1. Progressive motility (PR)							
a) fast linear movement, %	13	15	14	7	6	5	6
b) slow linear movement, %	39	36	37	28	25	22	45
2. Nonlinear motility (NP)							
c) swimming in circle and/or twitching, %	16	19	20	24	29	29	17
3. Immotile sperms (d), %	33	30	29	41	40	44	32
Sperm vitality, %	72	73	70	66	59	57	67
Normal forms, %	4	4	4	3	3	3	4
Abnormal heads, %	94	94	94	95	94	98	94
Abnormal midpieces, %	15	15	18	17	18	19	18
Abnormal principal pieces, %	20	18	18	19	19	21	20

Note. For values of ejaculate volume and amount of spermatozoa, $p < 0.05$; CG – control group.
Примечание. Для значений объема эякулята, количества сперматозоидов $p < 0,05$. ГК — группа контроля.

CONCLUSION

Summarizing the analysis of semen changes when the testicle is inverted, we formulated the following points:

- Changes in semen after ischemia are observed in sperm morphology and motility.
- The most evident changes in semen occur for grade III testicular torsion with gonad preservation and the least ones for torsion with spontaneous detorsion and for incomplete torsion that corresponds to minimal ischemia and minimal duration of ischemia.
- The greater the patient's age at ischemia, the worse the semen values. The worst values were documented in patients with a history of ischemia at puberty against the background of anatomically and functionally formed gonads.
- Changes in semen are directly dependent on the duration of the acute ischemic period.
- The combination of puberty, disease duration >24 h, and complete torsion with critical ischemia with controversial viability, noted during the initial intraoperative assessment, is the most unfavorable for semen quality.
- Semen values in cases of critical ischemia of the gonad with testicular preservation are the least favorable compared with those after orchiectomy, which indicates functional failure of the atrophied preserved gonad and discredits the appropriateness of its preservation in critical ischemia.

Table 5

Changes in the spermogram depending on ischemic severity

Таблица 5

Изменения спермограммы в зависимости от выраженности ишемии

WHO criteria 2010	Group of patients (*n* = 76)			
	Viable gonad (*n* = 36)	Critical gonadal ischemia (*n* = 9)	OE due to necrosis of gonad (*n* = 31)	Control group (*n* = 49)
Sperm volume, mL	3.3 ± 0.7	3.0 ± 0.9	3.1 ± 0.8	3.7 ± 0.4
Sperm concentration, M/mL	20.1 ± 1.6	14.8 ± 1.5	15.7 ± 1.7	24.5 ± 0.5
Kinesiogram 1. Progressive motility (PR) a) fast linear movement, % b) slow linear movement, % 2. Nonlinear motility (NP) c) swimming in circle and/or twitching, % 3. Immotile sperms (d), %	 14 22 21 43	 3 21 24 52	 14 21 20 45	 6 45 17 32
Sperm vitality, %	71	56	70	67
Normal forms, %	4	2	4	4
Abnormal heads, %	93	98	93	94
Abnormal midpieces, %	17	24	18	18
Abnormal principal pieces, %	20	26	23	20

Note. For values of ejaculate volume and amount of spermatozoa, $p < 0.05$; OE – orchiectomy, CG – control group.
Примечание. Для значений объема эякулята, количества сперматозоидов $p < 0,05$. ОЭ — орхэктомия, ГК — группа контроля.

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