

ELECTRICAL MYOSTIMULATION EFFECTS ON NEUROMUSCULAR CONDUCTION AND FUNCTIONAL STATE OF MUSCLES AFTER COMPONENT SEPARATION

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Muscular dysfunction of the anterior abdominal wall persists in many patients post component separation due to postoperative ventral hernia. Electrical myostimulation can contribute to better recovery, but its efficacy after such surgical procedures is poorly understood. The study aimed to assess the effect of the postoperative electrical myostimulation on the neuromuscular conduction and functional activity of the rectus abdominis muscles. A total of 128 patients (average age 47.9 ± 8.6 years) post component separation were included in a prospective controlled non-randomized study. The index group ($n = 64$) received electrical myostimulation starting from day 10 (12 sessions, 5–10 min each, 3 times a week, COMPEX SP-2.0® muscle stimulator, Switzerland), and the control one ($n = 64$) received no electrical myostimulation. Electroneuromyography of the rectus abdominis muscles was performed before and after the course using the Synapsis system (Neurotech, Russia). In the index group, the latency period reduced from 10.1 to 7.9 ms (by 21.8%; $p < 0.001$), and in the control group it reduced from 9.7 to 9.2 ms (by 5.2%; $p < 0.001$); the intergroup difference $p = 0.002$. The M-response amplitude improved in both groups (index group: from 8.4 to 8.9 mV, +5.6%, $p < 0.001$; control group: from 8.2 to 8.8 mV, +6.8%, $p < 0.001$), without any intergroup differences ($p = 0.295$). The induced muscle contraction velocity changed minimally in the index group (from 45.0 to 45.4 m/s, $p = 0.049$) and did not change in the control group ($p = 0.316$); in 89.1% of patients, the values were still below normal. Conclusions: postoperative electrical myostimulation significantly accelerates the neuromuscular conduction restoration, but does not affect the muscular response amplitude. It is reasonable to include electrical myostimulation in rehabilitation programmes.

Keywords: electrical myostimulation, postoperative rehabilitation, ventral hernia, hernioplasty, neuromuscular conduction, electroneuromyography

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ВЛИЯНИЕ ЭЛЕКТРОМИОСТИМУЛЯЦИИ НА НЕРВНО-МЫШЕЧНУЮ ПРОВОДИМОСТЬ И ФУНКЦИОНАЛЬНОЕ СОСТОЯНИЕ МЫШЦ ПОСЛЕ СЕПАРАЦИОННОЙ ГЕРНИОПЛАСТИКИ

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После сепарационной герниопластики по поводу послеоперационных вентральных грыж у многих пациентов сохраняется мышечная дисфункция передней брюшной стенки. Электромиостимуляция может улучшить восстановление, но ее эффективность после таких операций изучена недостаточно. Целью исследования было оценить влияние послеоперационной электромиостимуляции на нервно-мышечную проводимость и функциональную активность прямых мышц живота. В проспективное контролируемое нерандомизированное исследование включили 128 пациентов (средний возраст $47,9 \pm 8,6$ лет), перенесших сепарационную герниопластику. Основная группа ($n = 64$) получала электромиостимуляцию с 10-х суток (12 сеансов по 5–10 мин, 3 раза в неделю, аппарат COMPEX SP-2.0®, Швейцария), контрольная ($n = 64$) — нет. Электронейромиографию прямых мышц живота проводили до и после курса на аппарате «Супарсис» (ООО НМФ «Нейротех», Россия). В основной группе латентный период сократился с 10,1 до 7,9 мс (на 21,8%; $p < 0,001$), в контрольной — с 9,7 до 9,2 мс (на 5,2%; $p < 0,001$); межгрупповое различие $p = 0,002$. Амплитуда М-ответа улучшилась в обеих группах (основная: с 8,4 до 8,9 мВ, +5,6%, $p < 0,001$; контрольная: с 8,2 до 8,8 мВ, +6,8%, $p < 0,001$) без различий между группами ($p = 0,295$). Скорость индуцированного мышечного сокращения в основной группе изменилась минимально (с 45,0 до 45,4 м/с, $p = 0,049$), в контрольной — нет ($p = 0,316$); у 89,1% пациентов показатель оставался ниже нормы. Выводы: послеоперационная электромиостимуляция достоверно ускоряет восстановление нервно-мышечной проводимости, но не влияет на амплитуду мышечного ответа. Включение электромиостимуляции в реабилитационные программы целесообразно.

Ключевые слова: электромиостимуляция, послеоперационная реабилитация, вентральные грыжи, герниопластика, нервно-мышечная проводимость, электронейромиография

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In recent decades, surgery for postoperative ventral hernias (PHR) has fundamentally changed. Widespread introduction into world's clinical practice of separation hernioplasty techniques, such as the anterior component separation according to Ramirez, posterior component separation with the transversus abdominis release (TAR), and their combination, has made it possible to radically reduce the incidence of recurrence and severe postoperative complications even in patients with giant and repeatedly recurring hernias [1, 2]. The possibility of adequate anterior abdominal wall defect closure with restoration of the anterior abdominal wall structural integrity and functional framework has transformed the formerly palliative interventions into full-fledged reconstructive surgical procedures. However, despite the obvious progress in surgical techniques, the problem of full functional rehabilitation of patients post component separation has not been finally resolved.

Extensive mobilization of the muscular-aponeurotic layers, which is inevitable with separation techniques, is associated with the severe surgical soft tissue injury, intersection of intermuscular neurovascular bundles, and creation of extensive wound surfaces. This results in a complex of pathophysiological alterations in the anterior abdominal wall muscles, primarily in the rectus abdominis muscles. Intraoperative damage to the terminal branches of the intercostal nerves innervating the rectus abdominis muscles, as well as the development of local inflammatory edema and ischemia in the operated site underlie the neuromuscular conduction impairment [3]. The above factors cause temporary denervation of muscle fibers, the clinical manifestations of which are the nerve conduction slowdown and muscle contractility reduction. A significant proportion of patients show signs of muscle dysfunction in the postoperative period, even with the technically flawless surgery: structural atrophy of muscle fibers, decreased muscle fiber contractility, nerve conduction slowdown in motor fibers [4]. Clinical manifestations of such impairment include persistent abdominal weakness, persistent pain, limitation of daily physical activity, and, as a result, significant deterioration of the patients' quality of life for weeks or even months after hospital discharge [5]. Thus, there is an objective need to develop effective and pathogenetically substantiated postoperative rehabilitation methods aimed at accelerating the abdominal wall muscle functional state restoration.

Today, various approaches to rehabilitation of patients post hernioplasty are used, including therapeutic exercises, breathing exercises, manual therapy, kinesiotaping, and physiotherapy treatments. However, the effectiveness of many of these methods in terms of restoring neuromuscular conduction remains insufficiently proven, and the terms of prescription and optimal exposure parameters are not standardized [6]. In particular, active physical exercise in the early postoperative period is often limited due to pain and the risk of suture failure, which dictates the need to search for alternative, passive methods of muscle activity stimulation.

Instrumental electrical myostimulation (EMS) represents one of the most promising and physiological methods of impact onto the neuromuscular system in the context of forced hypokinesia. The EMS therapeutic effect is based on artificial generation of electrical impulses, which reach motor neuron terminals and muscle fibers, causing depolarization and subsequent contraction of the latter. This enables simulation of the physiological voluntary muscle contraction process, maintains tissue trophism, and prevents the development of neurogenic atrophy during periods, when active movement is limited due to pain or the risk of suture failure [7]. Experimental

studies involving the use of hernioplasty models have clearly demonstrated that the use of EMS of the anterior abdominal wall muscles contributes to the significant decrease in the postoperative muscle fiber atrophy severity, microcirculation improvement in the operated area, and faster return of muscle activity functional parameters back to normal [8].

Despite the compelling theoretical and experimental basis, the clinical use of EMS in rehabilitation programmes after hernioplasty due to PVH is still poorly understood. The clinical data available in the literature are fragmentary, often contradictory and do not allow for the development of unambiguous guidelines for practical healthcare [9]. In particular, questions remain about optimal time intervals for the beginning of stimulation in the early postoperative period, most effective electric current parameters (frequency, pulse duration, intensity), as well as differentiated EMS effects on the outcomes of various types of reconstructive interventions on the anterior abdominal wall, depending on the traumatic nature of the procedure [10, 11]. The lack of standardized protocols and evidence base hinders the widespread implementation of this method into routine clinical practice of abdominal surgeons and medical rehabilitation specialists.

The study aimed to assess the effect of postoperative EMS on the restoration of neuromuscular conduction and functional activity of the rectus abdominis muscles in patients post component separation due to ventral hernia.

METHODS

A prospective controlled non-randomized study was conducted at the Department of Surgery of the Vorokhobov City Clinical Hospital, Moscow, between September 2019 and March 2022. The study design was compliant with the CONSORT guidelines for non-randomized interventional studies [12].

Selection of patients

Of 207 patients post elective open component separation due to postoperative ventral hernias (PVH), 128 individuals (71 females, 57 males) age 28–83 years (average age 47.9 ± 8.6 years) were included in the study after applying the selection criteria. The follow-up period was 6–10 months (median follow-up period 8 months).

Inclusion criteria: age over 18 years; elective open component separation with the retromuscular polypropylene implant installation; submitted informed consent to take part in the study; remote communication capability for protocol execution monitoring; body mass index (BMI) ≤ 39.9 kg/m².

Non-inclusion criteria (assessed before patient enrollment): refusal of submitting the informed consent; history of recurrent PVH; pacemaker installed; decompensated somatic disorder (decompensated diabetes mellitus, NYHA functional class III–IV chronic heart failure, grade II–III chronic respiratory failure); active cancer or cancer treatment finished less than 6 months before; clinically significant musculoskeletal disorder limiting the performance of test exercises; mental disorder impeding the protocol execution; personal circumstances making participation impossible.

Exclusion criteria (applied after patient enrollment): postoperative complications requiring the rehabilitation tactics modification (wound infection, hematoma requiring drainage, thromboembolic complications, pneumonia, recurrent hernia during follow-up); informed consent revocation by the patient; identification of a previously undiagnosed condition meeting the non-inclusion criteria during follow-up.

Characteristics of hernias

The following parameters were analyzed to assess comparability of the groups based on the hernial defect baseline characteristics: hernia orifice size (cm), localization according to the European Hernia Society (EHS) guidelines, presence of the loss of domain (determined based on the computed tomography (CT) data as a ratio of hernia sac volume to abdominal cavity volume > 20%). The above characteristics are provided in Table 1. No significant intergroup differences in these parameters were revealed ($p > 0.05$).

Surgical technique

All the patients underwent open posterior component separation with the transversus abdominis release (TAR) in combination with the retromuscular polypropylene implant placement. The term “combination” reflects the combination of a separation component (mobilization of the muscular aponeurotic layers) with the prosthetic reconstruction. All interventions were performed by the same surgical team in accordance with the standardized protocol. The average hernial defect area calculated based on CT data was $150.4 \pm 38.1 \text{ cm}^2$ (range 103.0–351.3 cm^2). The implant size was selected individually in order to ensure complete defect closure capturing at least 5 cm of healthy tissue in each direction.

Group formation

The patients were divided into two groups, 64 individuals per group, depending on the postoperative rehabilitation protocol. The index group was through the course of electrical myostimulation (EMS) starting from day 10 after surgery; the control group was through standard rehabilitation without EMS.

Justification for the timing of the electrical myostimulation start and duration

The EMS course was started on day 10 after surgery due to the fact that the acute phase of postoperative inflammation was over by this time, severe pain was relieved, and no surgical wound dehiscence was observed, which enabled safe electrode placement on the rectus abdominis muscles without any risk of tissue infection or damage. The course duration of 12 sessions (4 weeks) was selected based on the earlier published experimental data, according to which the minimal time necessary for the clinically significant changes in neuromuscular conduction under exposure to EMS was at least 10–12 sessions [6]. The frequency of procedures (3 sessions per week with an interval of at least 48 h) ensured the optimal balance of the stimulating effect and the time necessary for restoration of muscle fibers after applying electrical load.

Electrical myostimulation protocol

The COMPEX SP-2.0® 6-channel muscle stimulator (Compex Medical SA, Switzerland) was used for EMS. Stimulation was conducted with the pulse current frequency of 5.0–30.0 Hz and pulse duration of 50.0–100.0 μs . The course consisted of 12 sessions (3 sessions per week with an interval of at least 48 h), 5–10 min each. The procedure was conducted in a supine position; in a number of cases, the patient was asked to perform slight flexion of the neck and bring the chin to the chest for additional tension in the rectus abdominis muscles to enhance the effect (Fig.).

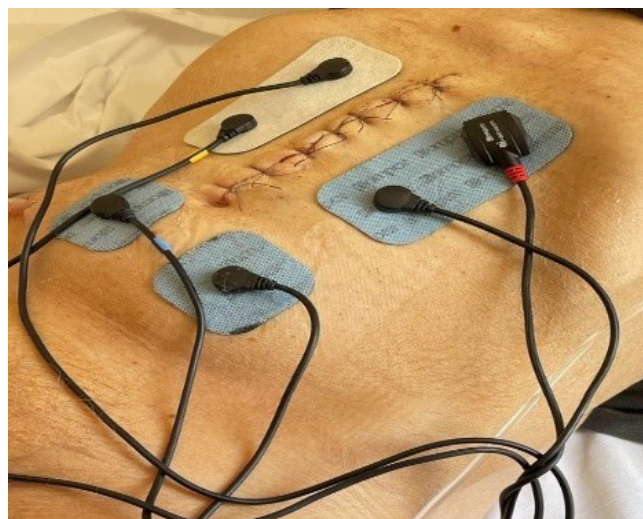


Fig. Electrical muscles myostimulation of the anterior abdominal wall (10th day after hernioplasty)

Assessment methods

The main instrumental method for assessing the neuromuscular system functional state was electroneuromyography (ENMG) of the rectus abdominis muscles performed with the 4-channel Synapsis system (Neurotech, Russia) using the following settings: operating sampling frequency — 40.0 kHz, stimulation amplitude — 0–100.0 mA, signal measurement range — 0.1–200.0 mV. The following parameters were analyzed: latency period (LP, normal range 5.0–7.0 ms) reflecting the nerve conduction time; M-response amplitude (normal range 5.0–10.0 mV) characterizing the total muscle fiber activity; induced muscle contraction measure (IMR, normal range 50.0–75.0 m/s) estimating the rate of muscle fiber contraction in response to the electrical stimulus. Parameters were recorded twice: at the baseline (before the EMS course in the index group and in comparable terms in the control group) and after the end of the 4-week rehabilitation course.

Statistical data processing was performed using the StatTech v.4.8.0 software package (StatTech, Russia). The quantitative data distribution was tested for normality using the Shapiro–Wilk data. The normally distributed data were presented as the mean (M) \pm standard deviation (SD); Student's t -test was used to compare such data in two groups, and the paired t -test was used to compare the data obtained before and after the intervention. The non-normally distributed data were described using the median (Me) and interquartile range (Q_1 – Q_3); the Mann–Whitney U -test (for unrelated samples) and Wilcoxon test (for related samples) were used for comparison. Categorical data were presented as absolute values (n) and percentage (%). The differences were considered significant at $p < 0.05$.

RESULTS

When conducting electroneuromyography before the beginning of the electrical myostimulation course, there were no significant differences in latency period values between the index and control groups ($p = 0.639$). The intergroup differences became significant after the end of the electrical myostimulation course ($p = 0.002$) (Table 1).

The best latency period values were recorded in the group of patients, who received postoperative EMS: the median latency period reduced from 10.1 ms to 7.9 ms, i.e. by 21.8%

Table 1. Dynamic changes in neuromyography latency period values (ms)

Group	Follow-up stages				p
	LP before		LP after		
	Me	Q ₁ –Q ₃	Me	Q ₁ –Q ₃	
No EMS	9.7	8.3–12.0	9.2	8.0–11.3	< 0.001*
EMS	10.1	8.2–11.9	7.9	7.0–9.9	< 0.001*
p	0.639		0.002*		–

Note: * — significant differences ($p < 0.05$), the following methods were used: Mann–Whitney U -test, Wilcoxon test.

Table 2. Dynamic changes in neurographic muscle motor response amplitude values (mV)

Group	Follow-up stages				p
	M-response before		M-response after		
	Me	Q ₁ –Q ₃	Me	Q ₁ –Q ₃	
No EMS	8.2	7.5–9.1	8.8	8.0–9.3	< 0.001*
EMS	8.4	7.8–9.3	8.9	8.1–9.8	< 0.001*
p	0.139		0.295		–

Note: * — significant differences ($p < 0.05$), the following methods were used: Mann–Whitney U -test, Wilcoxon test.

($p < 0.001$). In the control group, the median latency period reduced from 9.7 ms to 9.2 ms, which corresponded to reduction by 5.2% ($p < 0.001$).

The analysis of the M-response amplitude revealed no significant differences between groups both before the beginning ($p = 0.139$) and after the end ($p = 0.295$) of the EMS course. At the same time, the parameter improvement relative to baseline was reported in both groups. In the control group, the mean M-response amplitude four weeks after surgery was 8.8 mV, which was 6.8% higher compared to the baseline value of 8.2 mV ($p < 0.001$). In the index group, the amplitude increased from 8.4 mV to 8.9 mV, i.e. by 5.6% ($p < 0.001$) (Table 2).

There were no significant intergroup differences in the induced muscle contraction rate, neither before, nor after the rehabilitation course. In 89.1% of subjects, the values of this parameter remained below the reference value of 50.0 m/s throughout the follow-up period. In the index group, the minimal, but significant increase in the induced muscle contraction rate was reported: the median increased from 45.0 m/s to 45.4 m/s ($p = 0.049$). There were no dynamic changes in this parameter in the control group ($p = 0.316$) (Table 3).

DISCUSSION

The study conducted has shown that postoperative EMS of the anterior abdominal wall muscles in patients post component separation significantly improves neuromuscular conduction, which is most clearly manifested by the latency period reduction. In the index group, the latency period reduced by 21.8%, while in the control group it reduced by 5.2% only ($p = 0.002$). These data suggest that EMS accelerates the

physiological neuromuscular function restoration in the early postoperative period.

Such a pronounced latency period reduction under the exposure to EMS can be explained by several mechanisms. First, rhythmic electrical stimulation contributes to microcirculation improvement in the operated area, thereby accelerating the postoperative edema resorption and reducing the nerve fiber compression. Second, passive muscle fiber contraction under the exposure to electrical impulses maintains activity of the sodium-potassium pumps in the sarcolemma and prevents the development of denervation hypersensitivity. Third, regular stimulation of motor units prevents atrophy of the fast (type II) muscle fibers most vulnerable in the context of postoperative immobilization.

The M-response amplitude improved to approximately equal extent in both groups (by 5.6% in the index group and 6.8% in the control group), which suggests natural processes of the muscle tissue postoperative regeneration that do not depend on the use of EMS. The findings are consistent with the fact that EMS primarily affects neurogenic mechanisms underlying the muscle activity regulation, rather than the actual contractile properties of muscle fibers [13]. Similar conclusions were drawn by other authors, who showed that the neuromuscular conduction values improved faster, than the muscle strength and volume increased after the EMS course [14].

The induced muscle contraction rate remained low in the vast majority of patients (89.1%), although in the index group the minimal, but significant increase in this value (from 45.0 to 45.4 m/s, $p = 0.049$) was reported. The fact, that in most patients the induced muscle contraction rate did not reach normal values even after the rehabilitation course completion, suggests the postoperative muscle dysfunction severity and

Table 3. Dynamic changes in neurographic induced muscle contraction values (m/s)

Group	Follow-up stages				p
	IMR before		IMR after		
	M \pm SD	95% CI	M \pm SD	95% CI	
No EMS	45.6 \pm 1.9	45.1–46.2	45.8 \pm 2.2	45.1–46.4	0.316
EMS	45.0 \pm 2.0	44.6–45.8	45.4 \pm 2.0	44.8–46.0	0.049*
p	0.293		0.436		–

Note: * — significant differences ($p < 0.05$), the following method was used: Student's t -test.

the need for longer recovery period. It is likely that the longer rehabilitation course or combining EMS with other physical therapy methods, such as therapeutic and breathing exercises is needed to bring this parameter back to normal. Our findings are consistent with the data showing that the use of EMS after extensive abdominal surgery made it possible to reduce the muscle mass loss by 20–25%, but did not ensure complete restoration of functional parameters during the 4-week follow-up period [15]. Furthermore, our data are correlated to the experimental results obtained using the hernioplasty model that has shown that EMS accelerates restoration of the muscle bioelectrical activity, but longer time is required to achieve full functional recovery [6].

Clinical significance of the findings lies in the fact that even a relatively short EMS course can considerably accelerate the neuromuscular conduction restoration, which can contribute to earlier activation of patients, decreased risk of developing abnormal motor stereotypes, and, finally, to improved quality of life in the postoperative period. It is important to note that the EMS procedure was well tolerated by patients; it caused no complications and did not require the patients' active involvement, which made it especially valuable in the early postoperative period, when the opportunities for active physical activity were limited.

Limitations of this study include the lack of blinding design, the relatively short follow-up period (four weeks of intervention), and the lack of assessment of long-term outcomes. Furthermore, clinical outcomes, such as quality of life and pain severity, were not assessed. These may become the subject of further research. Assessment of the impact of various EMS parameters (frequency, pulse duration, intensity) on the muscle function recovery rate and development of

personalized rehabilitation protocols depending on the surgery extent and baseline characteristics of the patient also seem to be a promising area.

CONCLUSIONS

The study conducted has demonstrated a significant positive effect of postoperative EMS on the functional recovery of the anterior abdominal wall muscles in patients post open component separation due to PVH. The ENMG analysis revealed a significant improvement of the neuromuscular conduction parameters in the group that received EMS, with the significant LP reduction by 21.8% relative to baseline (from 10.1 to 7.9 ms; $p < 0.001$). In the control group that did not receive EMS, the dynamics of LP restoration was 5.2%. However, the M-response amplitude changes in both groups were comparable, which suggests natural processes of postoperative muscle function restoration that do not depend on the use of EMS. Of special interest is the identified trend towards IMR improvement in the EMS group, despite the fact that absolute values of this parameters remained below normal. The findings confirm the feasibility of including EMS in postoperative rehabilitation programmes, which could potentially contribute to the more rapid neuromuscular conduction restoration and serve as a preventative measure for prolonged muscle atony among patients post hernioplasty for PVH. Thus, EMS is a promising postoperative rehabilitation instrument. However, further studies with the longer follow-up period and assessment of the long-term outcomes depending on the hernioplasty type and other parameters of the patient are required for optimization of protocols.

References

- Pochhammer J, Ibaldo C, Weller MP, et al. Retromuscular, periprosthetic drainage after hernioplasty with sublay mesh reinforcement in ventral hernias results in less retromuscular fluid collections but longer hospital stay and analgetic use with unclear effect on clinical outcome — a randomized controlled trial. *Langenbecks Arch Surg.* 2024; 409 (1): 334. DOI: 10.1007/s00423-024-03522-6.
- Serafio-Gómez JL, Aragón-Quintana C, Bustillos-Ponce M, et al. Effective Management of Giant Ventral Hernias: A Comprehensive Approach Combining Preoperative Botulinum Toxin Application, Modified Ramirez's Component Separation, and Rives-Stoppa Hernioplasty. *Cureus.* 2023; 15 (11): e48967. DOI: 10.7759/cureus.48967.
- Zabolotskikh IB, Lebedinskiy KM, Belkin AA, Butrov AV, Kondratev AN, Lubnin AY, et al. Perioperatsionnoe vedenie patsientov s nervno-myshechnymi zabolevaniyami (proekt klinicheskikh rekomendatsiy FAR Rossii). *Regionnaya anesteziya i lechenie ostroy boli.* 2014; (2): 56-75. DOI: 10.17816/RAOL43254. Russian.
- Daes J, Oma E, Jorgensen LN. Changes in the abdominal wall after anterior, posterior, and combined component separation. *Hernia.* 2022; 26 (1): 17–27. DOI: 10.1007/s10029-021-02535-0.
- Ciomperlik H, Dhanani NH, Cassata N, et al. Patient quality of life before and after ventral hernia repair. *Surgery.* 2021; 169 (5): 1158–63. DOI: 10.1016/j.surg.2020.11.003.
- Petrushko SI, Portnyagin EV, Michurov EI, Repina EV, Sagynaliev AS, Rozhina AV. Reabilitatsiya bol'nykh posle gernioplastiki v rannem posleoperatsionnom periode. *Trudnyi patsient.* 2020; 18 (3): 46–48. DOI: 10.24411/2074-1995-2020-10020.
- Da Mota Moreira I, Krause A, Memmert D. Effects of electromyostimulation on physiological determinants of endurance-performance in healthy subjects: a systematic review. *J Sports Med Phys Fitness.* 2022; 62 (12): 1654–61. DOI: 10.23736/S0022-4707.22.13428-6.
- Demin NA, Achkasov EE, Karkischenko VN, et al. Possibilities of physical rehabilitation using myostimulation after ventral hernia repair retro-rectus. *Clinical and Experimental Surgery. Petrovsky Journal.* 2022; 10 (3): 114–24. DOI: 10.33029/2308-1198-2022-10-3-114-124.
- Ricci PA, Di Thommazo-Luporini L, Santos-de-Araújo AD, et al. Combining Whole-Body Electromyostimulation and Dynamic Exercise After Bariatric Surgery: A Randomized, Double-Blind, and Sham-Controlled Trial. *Obes Surg.* 2025. DOI: 10.1007/s11695-025-08107-w.
- Christopher AN, Fowler C, Patel V, et al. Bilateral transversus abdominis release: Complex hernia repair without sacrificing quality of life. *Am J Surg.* 2022; 223 (2): 250–6. DOI: 10.1016/j.amjsurg.2021.03.020.
- Cai X, Wang F, Zhu Y, et al. Application of bridging mesh repair in giant ventral incisional hernia. *Updates Surg.* 2024; 76 (6): 2411–20. DOI: 10.1007/s13304-024-01825-3.
- Thabane L, Hopewell S, Lancaster GA, et al. Methods and processes for development of a CONSORT extension for reporting pilot randomized controlled trials. *Pilot Feasibility Stud.* 2016; 2: 25. DOI: 10.1186/s40814-016-0065-z.
- Adams V. Electromyostimulation to fight atrophy and to build muscle: facts and numbers. *J Cachexia Sarcopenia Muscle.* 2018; 9 (4): 631–4. DOI: 10.1002/jcsm.12332.
- Moreau D, Dubots P, Boggio V, et al. Effects of electromyostimulation and strength training on muscle soreness, muscle damage and sympathetic activation. *J Sports Sci.* 1995; 13 (2): 95–100. DOI: 10.1080/02640419508732216.
- Hardy EJ, Hatt J, Doleman B, et al. Post-operative electrical muscle stimulation attenuates loss of muscle mass and function following major abdominal surgery in older adults: a split body randomised control trial. *Age Ageing.* 2022; 51 (10): afac234. DOI: 10.1093/ageing/afac234.

Литература

- Pochhammer J, Ibaldo C, Weller MP, et al. Retromuscular, periprosthetic drainage after hernioplasty with sublay mesh reinforcement in ventral hernias results in less retromuscular fluid collections but longer hospital stay and analgetic use with unclear effect on clinical outcome — a randomized controlled trial. *Langenbecks Arch Surg.* 2024; 409 (1): 334. DOI: 10.1007/s00423-024-03522-6.
- Serafio-Gómez JL, Aragón-Quintana C, Bustillos-Ponce M, et al. Effective Management of Giant Ventral Hernias: A Comprehensive Approach Combining Preoperative Botulinum Toxin Application, Modified Ramírez's Component Separation, and Rives-Stoppa Hernioplasty. *Cureus.* 2023; 15 (11): e48967. DOI: 10.7759/cureus.48967.
- Заболотских И. Б., Лебединский К. М., Белкин А. А., Бутров А. В., Кондратьев А. Н., Лубнин А. Ю., и др. Периоперационное ведение пациентов с нервно-мышечными заболеваниями (проект клинических рекомендаций ФАР России). *Региональная анестезия и лечение острой боли.* 2014; 8 (2): 58–75.
- Daes J, Oma E, Jorgensen LN. Changes in the abdominal wall after anterior, posterior, and combined component separation. *Hernia.* 2022; 26 (1): 17–27. DOI: 10.1007/s10029-021-02535-0.
- Ciomperlik H, Dhanani NH, Cassata N, et al. Patient quality of life before and after ventral hernia repair. *Surgery.* 2021; 169 (5): 1158–63. DOI: 10.1016/j.surg.2020.11.003.
- Petrushko SI, Portnyagin EV, Michurov EI, Repina EV, Sagynaliev AS, Rozhina AV. Reabilitatsiya bol'nykh posle gernioplastiki v rannem posleoperatsionnom periode. *Trudnyi patsient.* 2020; 18 (3): 46–48. DOI: 10.24411/2074-1995-2020-10020.
- Da Mota Moreira I, Krause A, Memmert D. Effects of electromyostimulation on physiological determinants of endurance-performance in healthy subjects: a systematic review. *J Sports Med Phys Fitness.* 2022; 62 (12): 1654–61. DOI: 10.23736/S0022-4707.22.13428-6.
- Demin NA, Achkasov EE, Karkischenko VN, et al. Possibilities of physical rehabilitation using myostimulation after ventral hernia repair retro-rectus. *Clinical and Experimental Surgery. Petrovsky Journal.* 2022; 10 (3): 114–24. DOI: 10.33029/2308-1198-2022-10-3-114-124.
- Ricci PA, Di Thommazo-Luporini L, Santos-de-Araújo AD, et al. Combining Whole-Body Electromyostimulation and Dynamic Exercise After Bariatric Surgery: A Randomized, Double-Blind, and Sham-Controlled Trial. *Obes Surg.* 2025. DOI: 10.1007/s11695-025-08107-w.
- Christopher AN, Fowler C, Patel V, et al. Bilateral transversus abdominis release: Complex hernia repair without sacrificing quality of life. *Am J Surg.* 2022; 223 (2): 250–6. DOI: 10.1016/j.amjsurg.2021.03.020.
- Cai X, Wang F, Zhu Y, et al. Application of bridging mesh repair in giant ventral incisional hernia. *Updates Surg.* 2024; 76 (6): 2411–20. DOI: 10.1007/s13304-024-01825-3.
- Thabane L, Hopewell S, Lancaster GA, et al. Methods and processes for development of a CONSORT extension for reporting pilot randomized controlled trials. *Pilot Feasibility Stud.* 2016; 2: 25. DOI: 10.1186/s40814-016-0065-z.
- Adams V. Electromyostimulation to fight atrophy and to build muscle: facts and numbers. *J Cachexia Sarcopenia Muscle.* 2018; 9 (4): 631–4. DOI: 10.1002/jcsm.12332.
- Moreau D, Dubots P, Boggio V, et al. Effects of electromyostimulation and strength training on muscle soreness, muscle damage and sympathetic activation. *J Sports Sci.* 1995; 13 (2): 95–100. DOI: 10.1080/02640419508732216.
- Hardy EJ, Hatt J, Doleman B, et al. Post-operative electrical muscle stimulation attenuates loss of muscle mass and function following major abdominal surgery in older adults: a split body randomised control trial. *Age Ageing.* 2022; 51 (10): afac234. DOI: 10.1093/ageing/afac234.