



Original study article | Оригинальное исследование
DOI: <https://doi.org/10.35693/SIM699336>

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Use of botulinum toxin type A in the preoperative preparation of patients with ventral hernias: effect on the postoperative period

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Abstract

Aim: to evaluate the effect of preoperative botulinum toxin type A (BoNT-A) administration on the early postoperative period in patients with large incisional ventral hernias (IVH) compared with a control group.

Material and methods. A retrospective analysis of 19 patients with IVH class W3 (EHS classification) was performed. The main group (n=9) included patients who received preoperative BoNT-A injections (Dysport 900-1000 U or Xeomin 200 U) into the lateral abdominal muscles under US guidance followed by TAR repair. The control group (n=10) included patients operated without BoNT-A preparation (methods: TAR, Rives-Stoppa, TAR+bridge). The operative time, intensity of pain syndrome according to VAS on days 1, 3 and 5, the duration of opioid analgesic use, the frequency and structure of complications, and the length of hospital stay were evaluated.

Results. In the BoNT-A group, pain intensity was significantly lower on day 1 (VAS median 18.0 [11.5; 26.0] mm vs. 43.5 [40.0; 52.8] mm in

control, $p < 0.001$), day 3 (11.0 [8.5; 13.0] mm vs. 41.5 [38.0; 42.8] mm, $p < 0.001$) and day 5 (2.0 [1.0; 3.5] mm vs. 31.5 [29.0; 33.0] mm, $p < 0.001$). The overall complication rate in the BoNT-A group was 11.1% (surgical site hematoma in 1 patient) vs. 70.0% in the control group ($p = 0.027$), with no infectious complications recorded in the BoNT-A group (0% vs. 40.0% in control, $p = 0.087$). The median length of hospital stay in the BoNT-A group was 8.0 [7.0; 8.0] days vs. 9.0 [8.0; 15.8] days in the control group ($p = 0.095$).

Conclusion. Preoperative botulinum therapy is a safe and effective method that significantly reduces the intensity of postoperative pain and the frequency of complications in patients with large ventral hernias.

Keywords: botulinum toxin type A, ventral hernia, preoperative preparation, postoperative period, chemical component separation, pain.

Conflict of interest: nothing to disclose.

Citation

Akhmadeeva LR, Galimov OV, Gizatullin RR, Allayarov ND, Bakeev MR, Valitova EV. Use of botulinum toxin type A in the preoperative preparation of patients with ventral hernias: effect on the postoperative period. *Science and Innovations in Medicine*. 2026;11(1):63-68. DOI: <https://doi.org/10.35693/SIM699336>

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Received: 26.12.2025

Accepted: 22.01.2025

Published: 26.01.2026

Применение ботулинического токсина типа А в предоперационной подготовке пациентов с вентральными грыжами: влияние на течение послеоперационного периода

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Аннотация

Цель: оценить влияние предоперационного введения ботулинического токсина типа А (БТА) на течение раннего послеоперационного периода у пациентов с большими послеоперационными вентральными грыжами (ПОВГ) в сравнении с контрольной группой.

Материал и методы. Проведен ретроспективный анализ 19 пациентов с ПОВГ класса W3 по классификации EHS. Основную группу (n=9) составили пациенты, получившие предоперационные инъекции БТА (Диспорт 900-1000 ЕД или Ксеомин 200 ЕД) в боковые мышцы живота под УЗ-контролем с последующей герниопластикой TAR. Контрольную группу (n=10) составили пациенты, оперированные без подготовки БТА (методы:

TAR, Rives – Stoppa, TAR+bridge). Оценивались время операции, интенсивность болевого синдрома по ВАШ (визуально-аналоговая шкала) на первые, третьи и пятые сутки, продолжительность применения опиоидных анальгетиков, частота и структура осложнений, длительность госпитализации.

Результаты. В группе БТА интенсивность боли была достоверно ниже на первые сутки (медиана ВАШ 18,0 [11,5; 26,0] мм против 43,5 [40,0; 52,8] мм в контроле, $p < 0,001$), на третьи сутки (11,0 [8,5; 13,0] мм против 41,5 [38,0; 42,8] мм, $p < 0,001$) и на пятые сутки (2,0 [1,0; 3,5] мм против 31,5 [29,0; 33,0] мм, $p < 0,001$). Общая частота осложнений в группе БТА составила 11,1% (гематома послеоперационной раны у одного пациента)

против 70,0% в контроле ($p=0,027$), при этом инфекционные осложнения в группе БТА зафиксированы не были (0% против 40,0% в контроле, $p=0,087$). Медиана длительности госпитализации в группе БТА составила 8,0 [7,0; 8,0] дня против 9,0 [8,0; 15,8] дня в контроле ($p=0,095$).

Закключение. Предоперационная ботулинотерапия является безопасным и эффективным методом, достоверно снижающим интенсивность по-

слеоперационной боли и частоту осложнений у пациентов с большими вентральными грыжами.

Ключевые слова: ботулинотоксин типа А, вентральная грыжа, предоперационная подготовка, послеоперационный период, химическая компонентная сепарация, боль.

Конфликт интересов: не заявлен.

Для цитирования:

Ахмадеева Л.Р., Галимов О.В., Гизатуллин Р.Р., Аллаяров Н.Д., Бакеев М.Р., Валитова Э.В. Применение ботулинотоксина типа А в предоперационной подготовке пациентов с вентральными грыжами: влияние на течение послеоперационного периода. *Наука и инновации в медицине*. 2026;11(1):63-68. DOI: <https://doi.org/10.35693/SIM699336>

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Список сокращений

БТА – ботулинотоксин типа А; ПОВГ – послеоперационная вентральная грыжа;

TAR – transversus abdominis release; EHS – European Hernia Society;

ВАШ – визуально-аналоговая шкала; УЗ – ультразвуковой.

Получено: 26.12.2025

Одобрено: 22.01.2026

Опубликовано: 26.01.2026

INTRODUCTION

Incisional ventral hernias (IVH) are a serious challenge of the modern medicine. Despite the advancements of low-invasive surgical interventions, the number of laparotomies remains quite high. IVH develop from disorders of tissue reparation in the anterior abdominal wall, infectious and inflammatory processes in the area of the surgical wound, and from technical defects in the closure of the fascia [1]. The incidence rate of IVH development is approx. 5% among adults [2].

The modern classification of IVH, according to the European Hernia Society, based on the stratification of defects of the anterior abdominal wall by localization, width of the hernia orifice and number of recurrences [3]. The repair of large IVH with the width of hernia defects more than 10 cm is a technically complicated task. The attempt of complete reconstruction of the anterior abdominal wall may require a wide mobilization of fascia and separation of components of the anterior abdominal wall. High tension of tissue is the key factor accounting for the rate of recurrence which, according to the literature data, may reach 54%. Each subsequent recurrence complicates surgical treatment and increases risks for the patient [4].

Progressive methods of repairing normal anatomy of the anterior abdominal wall in hernia repair is the TAR (*transversus abdominis* release) according to Y. Novitsky (2015) [5]. This surgical procedure involves mobilization of the retromuscular space of the *rectus abdominis* muscles, incision of their sheaths, and dissection of the plane between the *transversalis fascia* and the *transversus abdominis* muscle. Component separation increases the mobility of the anterior and posterior aponeurotic layers, thereby facilitating approximation of the hernia defect margins. The use of posterior component separation with TAR in the repair of large IVHs ensures complete abdominal wall reconstruction; however, this surgical technique is technically demanding and significantly traumatic [6].

The impossibility of primary closure of the fascial defect often stems from a marked retraction and tension of the muscles of the anterior abdominal wall. In 2009, a research team headed by Tomas R. Ibarra-Hurtado first used a

preparation of botulinum A toxin (BoNT-A is a neurotoxin that causes temporary chemical denervation of the muscles due to blockade of acetylcholine release in the neuromuscular synapse) to relax the lateral muscles of the abdomen and facilitate the approximation of the edges of the hernia defect. The authors reported successful results of the use of this method to facilitate the primary fascial closure of the hernia defect in ventral hernias [7]. Preoperative chemical component separation of the lateral abdominal muscles may reduce the invasiveness of hemioplasty and facilitate approximation of the hernia defect margins [4, 8]. This method is being investigated in the context of improving conditions for both open and laparoscopic surgery, enabling relaxation and elongation of the lateral abdominal muscles [8, 9].

The data on the safety of the method, especially in patients with concomitant pathologies, continue to accumulate. Large research demonstrate a good tolerance profile of the BoNT-A and its applicability for comorbid patients [10, 11].

Despite the available data on the effect of BoNT-A on intraoperative parameters, a comprehensive analysis of its impact on the early postoperative period remains insufficiently addressed in the literature.

AIM

To evaluate the effect of preoperative chemical denervation of muscles of the anterior abdominal wall with botulinum toxin type A (BoNT-A) on the early postoperative period in patients with large and giant incisional ventral hernias (IVH) compared to a control group.

MATERIAL AND METHODS

Study design and patients. The study is a retrospective analysis of our own clinical experience. It is an analysis of data of 19 patients (9 men and 10 women), average age of 59.5 ± 12.5 years (95% CI 53.4–65.5), divided into 2 groups. The main group (BoNT-A group) included 9 patients who had undergone preoperative treatment with BoNT-A and subsequent IVH repair. The control group ($n=10$) included the patients operated on without preliminary chemical

EHS			
Incisional Hernia Classification			
Midline	subxiphoidal	M1	
	epigastric	M2	
	umbilical	M3	
	infraumbilical	M4	
	suprapubic	M5	
Lateral	subcostal	L1	
	flank	L2	
	iliac	L3	
	lumbar	L4	
Recurrent incisional hernia?		Yes <input type="radio"/>	No <input type="radio"/>
length:	cm	width:	cm
Width	W1	W2	W3
	<4cm	≥4-10cm	≥10cm
cm	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Figure 1. EHS classification of incisional ventral hernia.

Рисунок 1. Классификация послеоперационных вентральных грыж EHS.

denervation. All hernias belonged to W3 class according to EHS classification (Fig. 1). This class includes the hernias the width of whose gates is 10 cm and more.

Formation of groups and selection criteria. For the purposes of this study, the patients were chosen retrospectively from the database of the Department of Surgery of the Clinics of the Bashkir State Medical University (Ufa, Russia). The resolution of administration of preoperative botulinum therapy was made by an interdisciplinary team including a surgeon and a neurologist specializing in botulinum therapy.

The main criterion for inclusion in the study was the presence of an incisional ventral hernia, EHS class W3 (Fig. 2).

Exclusion criteria: acute infectious processes and decompensation of chronic diseases at the moment of planning of surgery, patient's refusal from participation in the study.

Indications and decision-making algorithm. The use of BoNT-A was performed within chemical component separation off-label (outside registered indications) according to the approved internal clinical algorithm. The indications were the dystonia (hypersthneia) of the muscles of the anterior abdominal wall confirmed by clinical examination and loss of domain of the abdominal cavity, i.e. loss of volume of the abdominal cavity due to organs and tissues being permanently in the hernia sac. The resolution was initiated by the surgeon upon identification of the above mentioned indications. The patient was then routed to consult the neurologist for a detailed evaluation of the muscle tone and neurological status. The final decision of the team as to administration of the BoNT-A, choice of the drug, dosage and points of injection was then approved by the medical panel involving a surgeon and a neurologist. The procedure was performed upon obtaining of the patient's informed consent.

Technique. The injection was controlled by ultrasound 3–10 weeks before the planned surgery. The following drugs were

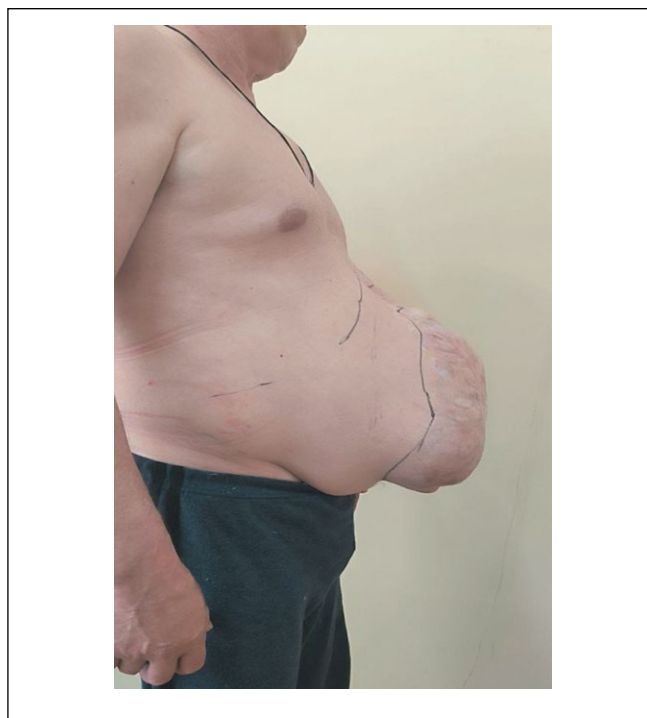


Figure 2. Preoperative appearance of a patient with a ventral hernia of the anterior abdominal wall before botulinum toxin type A injection.

Рисунок 2. Внешний вид пациента с вентральной грыжей передней брюшной стенки до инъекции ботулинического токсина типа А.

used: Dysport (IPSEN PHARMA, France) 900-1000 U or Xeomin (Merz Pharma GmbH & Co. KGaA, Germany) 200 U. The target muscles were the lateral abdominal muscles: external oblique, internal oblique and the transverse muscle of the abdomen. Three injections were made on either side (6 points in total). After administration of the BoNT-A, dynamic monitoring was performed for 3-4 weeks by the multidisciplinary team in order to evaluate the onset of muscular relaxation prior to surgery.

Choice of hernioplasty method. All patients underwent retromuscular hernioplasty whose method (TAR, Rives-Stoppa, TAR+bridge) was determined intraoperatively by the operating surgeon depending on the size of the defect, condition of the tissue and tension of the fascia. During approximation of the hernia defect margins, the surgeon subjectively assesses the tension of the tissue. To reduce tension, unilateral or bilateral posterior component separation is performed. If tissue tension persists after separation, corrective bridge repair is undertaken.

Evaluation of the pain syndrome. The intensity of postoperative pain was evaluated daily using the Russian language version of the visual analogue scale (VAS). The scale is a non-graded 10 cm horizontal line with finite points “no pain” and “worst pain imaginable”. The patients was asked to mark a point on the line that matched the intensity of their pain. The mark was measured in millimeters from zero and registered by the nurse of the Department of Surgery every day at 7:30 a.m. For the purposes of analysis, the values taken on days 1, 3 and 5 after the operation were used. In all cases, on the first day after the surgery, Promedol was administered.

Criteria of patient discharge after the surgery: lack of discharge in the drainage, regular spontaneous bowel movements and urination, lack of complications, lack of signs

Metric	Control group (n=10)	BoNT-A group (n=9)	Effect magnitude (95% CI)	p-value
Age, years (M ± SD)	56.50 ± 14.16	62.78 ± 10.24	MD = 6.28 (-5.73 to 18.29)	0.289
Sex, n (%)				
Male	6 (60.0)	3 (33.3)	OR = 0.33 (0.05 to 2.06) RD = -0.27 (-0.67 to 0.17)	0.370
Female	4 (40.0)	6 (66.7)	OR = 3.00 (0.49 to 19.60) RD = 0.27 (-0.17 to 0.67)	0.370
Defect width, mm (M ± SD)	115.00 ± 18.41	158.00 ± 32.86	MD = 43.00 (14.71 to 71.29)	0.002*
Repair method, n (%)				
TAR	3 (30.0)	9 (100.0)	RD = 0.70 (0.35 to 1.00)	0.001*
Rives Stoppa	5 (50.0)	0 (0.0)	OR = 0.04 (0.00 to 0.77) RD = -0.50 (-0.86 to -0.03)	0.026*
TAR + bridge	2 (20.0)	0 (0.0)	OR = 0.16 (0.01 to 3.61) RD = -0.20 (-0.58 to 0.26)	0.478

Notes: MD – Mean Difference; OR – Odds Ratio; RD – Risk Difference. For qualitative results with normal distribution data is presented as M ± SD; for categorical indicators, as n (%). * – statistically significant differences (p < 0.05).

Примечания: MD – разность средних (Mean Difference); OR – отношение шансов (Odds Ratio); RD – разность рисков (Risk Difference).

Для количественных показателей с нормальным распределением данные представлены как M ± SD; для категориальных показателей – как n (%).

* – статистически значимые различия (p < 0.05).

Table 1. Comparative characteristics of patients and treatment methods in the study groups

Таблица 1. Сравнительная характеристика пациентов и методов лечения в исследуемых группах

of inflammatory process. The minimum hospitalization period was 4 days.

Table 1 shows that the groups were comparable in the age (mean difference (MD) = 6.28 years, 95% CI: -5.73 to 18.29; p=0.289) and sex distribution (odds ratio (OR) = 0.33, 95% CI: 0.05 to 2.06; p=0.370). However, in the BoNT-A group, the patients had credibly larger hernia defects (MD = 43.00 mm, 95% CI: 14.71 to 71.29; p=0.002), and all of them (100%) underwent hernia repair according to the TAR method. In the control group, different methods were used: TAR (30.0%), Rives Stoppa (50.0%) and TAR + bridge (20.0%).

Assessed parameters: time of operation, pain syndrome intensity as per VAS on the first, third and fifth day after the surgery, duration of administration of opioid analgesics, incidence rate and structure of complications (hematoma of the surgical wound, wound infection) and duration of hospitalization (bed-days).

Statistical analysis. The analysis was performed in the StatTech v. 4.10.4 software suite (developer: StatTech LLC, Russia). The normality of the distribution of quantitative variables was assessed using the Shapiro–Wilk test. Data with a normal distribution are presented as arithmetic mean and standard deviation (M ± SD) with a 95% confidence interval

(CI) for the mean. For intergroup comparisons, Student's t-test was used, calculating the mean difference (MD) and its 95% CI. Data with a non-normal distribution are presented as median and interquartile range (Me [Q1; Q3]). Comparisons were made using the Mann–Whitney U test, calculating the Hodges–Lehmann shift estimator and its 95% CI. Categorical data are described as absolute numbers and percentages (n, %). For comparisons, Fisher's exact test was used, calculating the odds ratio (OR) and risk difference (RD) with 95% CIs. The statistical significance level was set at p < 0.05. Statistical analysis and reporting were performed in accordance with the SAMPL guidelines [12].

RESULTS

Surgical parameters and postoperative progress. The comparison of intra- and postoperative metrics between the groups revealed several significant differences.

It is seen from **Table 2** that the mean time of operation in the BoNT-A group was credibly longer than in the control group (MD = 84.78 min., 95% CI: 25.98 to 143.58; p=0.006). The intensity of pain syndrome in the BoNT-A group was statistically significant and clinically lower on all stages of the study: on day one (Hodges–Lehmann shift (H-L shift) = -25.5 mm, 95%

Metric	Control group (n=10)	BoNT-A group (n=9)	Effect magnitude (95% CI)	p-value
Time of operation, min. (M ± SD)	118.00 ± 46.32	202.78 ± 70.36	MD = 84.78 (25.98 to 143.58)	0.006*
Days until cessation of opioid administration, Me [IQR]	2.00 [1.00; 2.00]	2.00 [1.00; 2.00]	H-L shift = 0.0 (-0.5 to 0.5)	0.785
VAS day 1, mm, Me [IQR]	43.5 [40.0; 52.8]	18.0 [11.5; 26.0]	H-L shift = -25.5 (-30.0 to -20.0)	<0.001*
VAS day 3, mm, Me [IQR]	41.5 [38.0; 42.8]	11.0 [8.5; 13.0]	H-L shift = -30.0 (-34.0 to -26.0)	<0.001*
VAS day 5, mm, Me [IQR]	31.5 [29.0; 33.0]	2.0 [1.0; 3.5]	H-L shift = -29.0 (-32.0 to -26.0)	<0.001*
Bed-days, days, Me [IQR]	9.00 [8.00; 15.75]	8.00 [7.00; 8.00]	H-L shift = -1.0 (-3.0 to 0.0)	0.095
Any complications, n (%)	7 (70.0)	1 (11.1)	OR = 0.05 (0.00 to 0.64) RD = -0.59 (-0.89 to -0.09)	0.027*
Infectious complications, n (%)	4 (40.0)	0 (0.0)	OR = 0.10 (0.00 to 2.08) RD = -0.40 (-0.75 to 0.05)	0.087
Hematoma of the surgical wound, n (%)	3 (30.0)	1 (11.1)	OR = 0.30 (0.02 to 3.39) RD = -0.19 (-0.58 to 0.26)	0.582

Notes: MD – Mean Difference; H-L shift – Hodges – Lehmann shift; OR – Odds Ratio; RD – Risk Difference. The data are presented as M ± SD (normal distribution) or Me [IQR] (median and interquartile range). * – statistically significant differences (p < 0.05).

Примечания: MD – разность средних; H-L shift – сдвиг Ходжеса – Лемана; OR – отношение шансов; RD – разность рисков. Данные представлены как M ± SD (нормальное распределение) или Me [IQR] (медиана и межквартильный размах). * – статистически значимые различия (p < 0.05).

Table 2. Comparison of intra- and postoperative parameters

Таблица 2. Сравнение интра- и послеоперационных показателей



Figure 3. Intraoperative view after chemical component separation with botulinum toxin type A: condition of the anterior abdominal wall muscles after infiltration.

Рисунок 3. Интраоперационный вид после химической компонентной сепарации с применением ботулинического токсина типа А: состояние мышц передней брюшной стенки после инфильтрации.

CI: -30.0 to -20.0; $p < 0.001$), on day three (H-L shift = -30.0 mm, 95% CI: -34.0 to -26.0; $p < 0.001$) on day five (H-L shift = -29.0 mm, 95% CI: -32.0 to -26.0; $p < 0.001$). The median time to cessation of administration of opioid analgesics in both groups was 2.0 days, and no statistically significant differences were found (H-L shift = 0.0 days, 95% CI: -0.5 to 0.5; $p = 0.785$).

Incidence of complication and duration of hospitalization. The general incidence of postoperative complications in the BoNT-A group was credibly lower: 11.1% (1 patient) vs. 70.0% (7 patients) in the control group. The absolute risk difference (RD) was -0.59 (95% CI: -0.89 to -0.09), and OR was 0.05 (95% CI: 0.00 to 0.64; $p = 0.027$). In the BoNT-A group, no infectious complications were registered (0% vs. 40% in the control group, RD = -0.40, 95% CI: -0.75 to 0.05; $p = 0.087$). The incidence of hematomas of the surgical wound was not credibly different (11.1% vs. 30.0%, RD = -0.19, 95% CI: -0.58 to 0.26; $p = 0.582$). The median duration of hospitalization in the BoNT-A group was 1 day less, however, the difference did not reach statistical significance (H-L shift = -1.0 days, 95% CI: -3.0 to 0.0; $p = 0.095$).

DISCUSSION

This study demonstrates that preoperative botulinum toxin therapy is an effective and safe adjunct in the surgical treatment of complex ventral hernias, enabling superior outcomes even in patients with initially larger hernia defects.

The most significant findings include a reliable and clinically significant reduction in postoperative pain intensity in the BoNT-A group by 25–30 mm on the VAS, as well as a 59 percentage point reduction in the absolute risk of postoperative complications in the study group compared to controls. This result is consistent with the data reported by B. Zendejas et al. (2013) [13]. We believe that the key mechanism underlying the observed reduction in pain and complication rates is the achieved relaxation and increased length of the anterior abdominal wall muscles, which reduces tissue tension (**Fig. 3**). This pathogenetic effect of botulinum toxin therapy, leading to contraction of the hernia defect, is supported by the findings of our previously published systematic review [14].

The recorded incidence rate in the BoNT-A group (11.1%) was reliably lower than in the control group (70.0%), and there were no cases of infectious complications in the BoNT-A group. The decrease of the absolute risk of infection by 40 per cent points, while not reaching formal significance ($p = 0.087$), was an important clinical trend. The obtained data matches the favorable safety profile of the method described in the literature [10, 11], and emphasizes its potential role in the decrease of the risk of infectious processes, likely because of decrease of tissue tension and improvement of their perfusion.

The median operation time in the preoperative botulinum therapy group was reliably longer than in the control group (MD = 84.8 min., 95% CI: 26.0 to 143.6; $p = 0.006$). This difference is expected and can be explained by two factors: the TAR technique, which was performed in all patients in the study group, is more complex, and patients in the BoNT-A group had initially larger defects (MD = 43.0 mm, 95% CI: 14.7 to 71.3; $p = 0.002$).

Despite the greater complexity and longer duration of surgical intervention in patients with initially larger defects, the botulinum toxin therapy group demonstrated a trend toward a reduction in median hospital stay by 1 day. The lack of statistical significance ($p = 0.095$) is likely attributable to the limited sample size.

Limitations of the study include its retrospective character, small sample and initial differences between the groups in the width of the defect and in the surgical method applied, which could affect the results. However, this lack of balance reflecting the clinical practice of type A botulinum toxin in the most complicated cases, makes the demonstrated improvement of postoperative period in the BoNT-A group even more convincing.

CONCLUSION

Our findings demonstrate that preoperative botulinum toxin therapy significantly reduces postoperative pain intensity by 25–30 mm on the VAS and decreases the absolute risk of



Figure 4. Postoperative view after reconstruction of the anterior abdominal wall and repair of the ventral hernia.

Рисунок 4. Послеоперационный вид после реконструкции передней брюшной стенки и пластики вентральной грыжи.

complications by 59 percentage points. These data contribute to the growing body of evidence presented in a recent systematic review, indicating that the method is safe, significantly increases the length of the lateral abdominal muscles, and improves the likelihood of fascial closure in complex ventral hernia repair [15]. Despite the retrospective design and initial differences between the groups that might have affected the evaluation of certain outcomes, the observed positive effects were achieved in the patients with wider initial defects, which

emphasizes the clinical significance of the method. Thus, the use of type A botulinum toxin is an effective clinically justified adjuvant component of complex management of patients with complex ventral hernias, which significantly improves direct postoperative outcomes (Fig. 4).

The major advantages of the method are considerable reduction of intensity of postoperative pain syndrome and reduction of incidence rate of early postoperative complications. ■

ADDITIONAL INFORMATION	ДОПОЛНИТЕЛЬНАЯ ИНФОРМАЦИЯ
Ethical approval. The study was conducted in accordance with the ethical standards of the Helsinki Declaration and approved by the Local Ethics Committee of BSMU (Protocol No. 8 dated 24.12.2025).	Этическая экспертиза. Исследование выполнено в соответствии с этическими стандартами Хельсинкской декларации и одобрено ЛЭК ФГБОУ ВО «Башкирский государственный медицинский университет» (протокол № 8 от 24.12.2025).
Consent for publication. All study participants signed a written informed consent form.	Согласие на публикацию. Все участники исследования подписывали добровольное информированное согласие.
Study funding. The study was the authors' initiative without external funding.	Источник финансирования. Работа выполнена по инициативе авторов без привлечения финансирования.
Conflict of interest. The authors declare that there are no obvious or potential conflicts of interest associated with the content of this article.	Конфликт интересов. Авторы декларируют отсутствие явных и потенциальных конфликтов интересов, связанных с содержанием настоящей статьи.
Contribution of individual authors. Akhmadeeva L.R., Galimov O.V.: idea, concept. Gizatullin R.R., Bakeev M.R., Valitova E.V.: collecting material, writing of the article. Allayarov N.D.: collection of material, research design, writing of the article. All authors gave their final approval of the manuscript for submission, and agreed to be accountable for all aspects of the work, implying proper study and resolution of issues related to the accuracy or integrity of any part of the work.	Участие авторов. Ахмадеева Л.Р., Галимов О.В. – идея, концепция. Гизатуллин Р.Р., Бакеев М.Р., Валитова Э.В. – сбор материала, написание статьи. Аллаяров Н.Д. – сбор материала, дизайн исследования, написание статьи. Все авторы одобрили финальную версию статьи перед публикацией, выразили согласие нести ответственность за все аспекты работы, подразумевающую надлежащее изучение и решение вопросов, связанных с точностью или добросовестностью любой части работы.
Statement of originality. No previously published material (text, images, or data) was used in this work.	Оригинальность. При создании настоящей работы авторы не использовали ранее опубликованные сведения (текст, иллюстрации, данные).
Data availability statement. The editorial policy regarding data sharing does not apply to this work.	Доступ к данным. Редакционная политика в отношении совместного использования данных к настоящей работе не применима.
Generative AI. No generative artificial intelligence technologies were used to prepare this article.	Генеративный искусственный интеллект. При создании настоящей статьи технологии генеративного искусственного интеллекта не использовались.
Provenance and peer review. This paper was submitted unsolicited and reviewed following the standard procedure. The peer review process involved 2 external reviewers.	Рассмотрение и рецензирование. Настоящая работа подана в журнал в инициативном порядке и рассмотрена по обычной процедуре. В рецензировании участвовали 2 внешних рецензента.

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