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## A NEW METHOD OF SURGICAL TREATMENT OF DIAPHRAGM RELAXATION

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### Abstract

**Introduction.** At the heart of the occurrence of relaxation of the diaphragm is a disorder of its innervation, which often occurs in malignant tumors of the mediastinum with germination in the phrenic nerve. With the relaxation of the entire dome of the diaphragm, the active motor ability is completely lost. The diaphragm shifts into the pleural cavity, which leads to a decrease in lung volume, to a restrictive syndrome, and stable hypoxemia. Due to this, the abdominal organs on the left move up, as if into the "pleural cavity", causing heartburn, belching. The clinic intensifies after eating, the patient feels a heartbeat, which indicates a violation of the heart, up to the manifestation of arrhythmia. The surgeon faces the following task: to perform a surgical correction of the dome of the diaphragm, which stops the paradoxical movement of the diaphragm and returns the patient to normal life and profession.

**Aime:** to present the result of the application of a new method of surgical treatment of diaphragm relaxation in the conditions of the Department of Thoracic Surgery "City Hospital No. 5", Barnaul.

**Materials and methods:** a clinical case of relaxation of both domes of the diaphragm, which occurred 13 years after surgery on the mediastinum, is presented. Operations were performed on plastics of both domes of the diaphragm with an interval of 1 year, by the author's method.

**Results:** the location of the synthetic prosthesis between the sheets of the diaphragm and the U-shaped sutures are the optimal choice in patients with relaxation of the entire dome of the diaphragm. In the given clinical example, the use of the author's method of diaphragm relaxation plasty showed good results in the postoperative and long-term period.

**Conclusions:** the described author's method for the treatment of diaphragm relaxation using a synthetic prosthesis between the sheets of the diaphragm and U-shaped sutures gave a good result in the postoperative and long-term period and requires further study on a large number of patients.

**Key words:** diaphragm, relaxation, plastic surgery, clinic, iatrogenic injury, correction.

### Резюме

## НОВЫЙ МЕТОД ХИРУРГИЧЕСКОГО ЛЕЧЕНИЯ РЕЛАКСАЦИИ ДИАФРАГМЫ

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**Введение.** В основе возникновения релаксации диафрагмы лежит нарушение её иннервации, которая часто возникает при злокачественных опухолях средостения с прорастанием в диафрагмальный нерв. При релаксации всего купола диафрагмы, активная двигательная способность утрачивается полностью. Диафрагма смещается в плевральную полость, что приводит к уменьшению лёгочного объёма, к рестриктивному синдрому, устойчивой гипоксемии. За счёт этого, органы брюшной полости слева перемещаются вверх, как бы в «плевральную полость», вызывая изжогу, отрыжку. Клиника усиливается после еды, пациент чувствует сердцебиение, что указывает на нарушение деятельности сердца, вплоть до проявления аритмии. Перед хирургом стоит следующая задача:

провести хирургическую коррекцию купола диафрагмы, что купирует парадоксальное движение диафрагмы и вернет пациента к нормальной жизни и профессии.

**Цель:** представить результат применения нового метода хирургического лечения релаксации диафрагмы в условиях отделения торакальной хирургии «Городская больница №5» г. Барнаула.

**Материалы и методы:** представлен клинический случай релаксации обоих куполов диафрагмы, возникший через 13 лет после операции на средостении. Проведены операции по пластике обоих куполов диафрагмы с интервалом 1 год, авторским способом.

**Результаты:** расположение синтетического протеза между листками диафрагмы и П-образные швы, являются оптимальным выбором у пациентов с релаксацией всего купола диафрагмы. В приведённом клиническом примере использование авторского способа пластики релаксации диафрагмы показало хорошие результаты в послеоперационном и отдалённом периоде.

**Выводы:** описанный авторский способ лечения релаксации диафрагмы с использованием синтетического протеза между листками диафрагмы и П-образные швы, дал хороший результат в послеоперационном и отдалённом периоде и требует дальнейшего изучения на большом количестве пациентов.

**Ключевые слова:** диафрагма, релаксация, пластика, клиника, ятрогенная травма, коррекция.

Түйіндеме

## ДИАФРАГМАЛАРДЫ БОСАҢСЫТУДЫ ХИРУРГИЯЛЫҚ ЕМДЕУДІҢ ЖАҢА ӘДІСІ

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**Кіріспе.** Диафрагма релаксациясының пайда болуының басты себебі оның иннервациясының бұзылуында жатыр, ол диафрагмалды нервке өтіп кететін көкірек қуысының қатерлі ісігі кезінде жиі кездеседі. Барлық диафрагма күмбезінің релаксациясы кезінде, белсенді қимыл қозғалыс әрекеті толықтай бұзылады. Диафрагма плевральды қуысқа ығысып, өкпе көлемінің кішіреюіне, рестриктивті синдромға, тұрақты гипоксемияға алып келеді. Осының әсерінен ішкі ағза мүшелері солдан жоғарыға ығысып, көкірік пен қызыл тудырады, плевральды қуысқа ығысқандай. Клиникасы тамақтанғаннан кейін күшейе түседі, науқас жүрек қағысының қарқындылығын сезе бастайды, яғни ол жүрек жұмысының бұзылысына меңзейді, тіпті аритмияға да алып келуі мүмкін. Хирургтың алдын келесідей міндет тұрады: диафрагма күмбезіне хирургиялық түзету енгізу, ол диафрагманың парадоксальды қозғалысын басады және науқасты қалыпты өмірге және жұмысына әкеледі.

**Мақсаты:** Барнауыл өаласының «№5 қалалық ауханасында» торакальды хирургия бөлімі ішінде жаңа хирургиялық әдістердің мүмкіншіліктерін қолдана отырып диафрагма релаксациясының емінің нәтижесін көрсету.

**Зерттеудің материалдары:** средостенияға 13 жыл бұрын жасалған операциядан кейін пайда болған екі диафрагмалық күмбездің релаксациясының клиникалық көрінісі берілген. Авторлық әдіспен арасы бір жыл интервалмен пластика жасау арқылы екі диафрагмалық күмбезге операция өткізілді.

**Нәтижесі:** диафрагма жапырақтары арасына синтетикалық протездердің орналасуы және П-тәрізді тігіс, барлық диафрагма күмбезінің релаксациясы бар науқастарда ең тиімді әдіс болып келеді. Берілген клиникалық мысалда авторлық әдіспен жасалған диафрагма релаксациясының пластикасы операциядан кейінгі уақытта және одан кейінгі ұзақ уақытта жақсы нәтиже көрсетті.

**Қорытынды:** Диафрагма релаксациясын емдеуде бейнеленген авторлық әдіспен жасалған П-тәрізді тігіс және аралық синтетикалық протез дан кейінгі уақытта және одан кейінгі ұзақ уақытта жақсы нәтиже көрсеттіп, ары қарай ауқымды науқастар көлемінді зерттеуді көздейді.

**Негізгі сөздер:** диафрагма, релаксация, пластик, клиника, ятрогендік жарақат, түзету.

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### Introduction.

The diaphragm is an important organ that anatomically separates the thoracic and abdominal cavities from each other, and functionally, take part in lung ventilation. [1,2,5,6].

The diaphragm relaxation of the was first described by J.L. Petit in 1774 a patient suffering from dyspnea after meal. An autopsy revealed a "hernial sac" containing abdominal organs and was represented by J.L. Petit as the peritoneum, diaphragm and pleura together without the slightest rupture of the membrane or any hole in the muscle or tendon fibers of the diaphragm [9,20].

On the present day, originally supposed that diaphragm relaxation is the disruption of its innervation of various origins, cause its degenerative changes. Malignant tumors that invades the phrenic nerve, or iatrogenic injury of the phrenic nerve during mediastinal surgery– are the most often causes of diaphragm relaxation [7,10,12,17,18].

Clinical manifestations of diaphragm relaxation are associated with excessive displacement of the dome of the diaphragm into the pleural cavity, which causes lung volume reduction of pulmonary and restrictive lung disease, hypoxemia. The organs of the abdominal cavity on the left move upwards, as if into the "pleural cavity", that changes the antireflux mechanism and causes heartburn and belching. The clinical manifestations increase after meal, the patient feels a heartbeat, which indicates cardiac dysfunction, up to the arrhythmia occurs. In turn, these symptoms combined have led to the patient experiencing an overall decreased quality of life. Due to the small number of observations of this pathology, current treatment tactics remains controversial [3,4,8,11,13,14,15,16,19].

Only partial the diaphragm relaxation used in conservative treatment is able to set up the mobility of the affected area. With the relaxation of the entire dome of the diaphragm, the motor ability is completely lost. Therefore, only surgical correction of the dome of the diaphragm prevents the diaphragm paradox movements of and improves the quality of patient's life.

**The purpose of the publication** is to present a new surgical method of plastic repair of the diaphragm in relaxation.

**Materials and methods.** A Medline search was conducted using the search terms "diaphragm relaxation, mediastinal surgery, surgical treatment, early and late complications" and "case report" to examine the case report for the surgical treatment of diaphragmatic relaxation.

The literature on the treatment of diaphragmatic relaxation was reviewed. The article reports on a new surgical method of plastic repair of the diaphragm in relaxation of the patient with bilateral diaphragm relaxation observed in the City Hospital №5, Barnaul, where at the first treatment stage, plastic of the left dome of the diaphragm was performed in 2017, and the right dome of the diaphragm in 2018. The patient's written informed consent was obtained for publication of the results of the observation in the press. The patient underwent standard clinical, laboratory, instrumental studies on February 9, 2020.

### Description of the clinical case.

A 26-year-old patient, on May 1, 2004, underwent surgical treatment: "Incomplete sternotomy. Combined with

removal of tumor of the anterior upper mediastinum, with resection of the pericardium" because of malignant tumor. In the postoperative period, a special treatment was carried out using chemotherapy.

In 2013 appeared dyspnea during physical exertion, the patient's condition worsened, there were unpleasant sensations after meal, pain in the epigastric region. The patient was observed in the clinic at the place of residence, received conservative treatment. Complaints have intensified - discomfort after meal in the upper half of the abdomen began to disturb, which forced patient to take a sitting, leaning back position. This condition caused the patient to restrict herself in eating. Complaints have intensified - a heartbeat appeared, a feeling of lack of air after meal, patient started sleeping in a sitting position, all this led her to seeking for the medical help. Hospitalized in the thoracic department for treatment. Examination was carried out: X-ray of the chest revealed a high standing of both domes of the diaphragm: on the left, the dome of the diaphragm is at the level of the III rib, the stomach, transverse colon and small intestine located under it. (Figure 1).



**Figure 1. Relaxation of the diaphragm dome to the III rib on the left.**

Due to the patient's complaints and relaxation of both domes of the diaphragm, 2-stage surgical treatment is indicated. Because of the more pronounced changes on the left, it was decided to perform the first stage the operation on the left dome of the diaphragm, and after 1 year the second stage operation on the right dome of the diaphragm. The modified method of surgical treatment of diaphragm relaxation is carried out as follows (*patent for invention RU2744533C1 Method for surgical treatment of diaphragm relaxation. Fokeev S.D., Kapitulin S.Yu., Kazantseva E.S.*).

The patient is laid on a healthy side, arm abduction. Anterior-lateral thoracotomy is performed in the 5th intercostal space. After the surgical wound dilution, a thinned dome of the diaphragm is found, often with a compressed edge of the atelectatic lung. In the case of absence of adhesions in the pleural cavity, the diaphragm is taken on holders and dissected in the sagittal direction to the places of its attachment to the chest wall in such a way

that two diaphragmatic flaps are formed. In the case of an adhesive process in the abdominal cavity, the diaphragm is mobilized from the internal organs, thereby creating its free surface to create duplications. After lowering the abdominal organs to their usual position, proceed to the plastic of the diaphragm. At the first stage, cut out a prosthesis of a synthetic material (Teflon or propylene) corresponding to the size of the future diaphragm. The completed prosthesis is placed on the inner leaf of the diaphragm and begins with stitching with U-shaped sutures of the prosthesis, then the base of the inner leaf of the diaphragm, along the line of attachment of the dome of the diaphragm, where the muscles of the diaphragm are preserved, 8-10 mm away from the first puncture, the leaf of the diaphragm is stitched and then the prosthesis, with the interval between suturing is 8-10 mm, along the entire length. The threads are not tied. At the second stage, the inner leaf of the diaphragm is covered with a prosthesis. The prosthesis and the inner leaf of the diaphragm is stitched along the edge with U-shaped seams, along the entire length, the threads are not tied. Next, the anterior leaf of the diaphragm is lifted up, thereby creating the appearance of the line of the beginning of the diaphragm and its muscles. The inferior leaf of the diaphragm is brought under it along with the prosthesis. The threads with which the U-shaped sutures were applied to the inner leaf and the prosthesis are stitched at the base, the anterior leaf of the diaphragm throughout, where the muscles of the diaphragm are preserved. U-shaped seams are obtained, which are tied. Next, the prosthesis is covered with an anterior leaf, and threads are used to apply U-shaped sutures (these are the threads that stitched the inner sheet of the diaphragm together with the prosthesis at the first stage) along the edge of the anterior leaf of the diaphragm along its entire length, followed by tying them, thereby completing the plastic of the diaphragm. The two surgical drains placed into the pleural cavity, layer-by-layer sutures and an aseptic sticker are applied on the wound.

06.04.17 operation: plastic of the left dome of the diaphragm according to the our proposed method. The operation had a positive effect - the patient no longer complained of pain during the meal and began to sleep in a horizontal position, her well-being and appetite improved significantly.



Figure 3.4 Condition after plasty of both diaphragm domes.

In April 2018 the examination of the patient. MSCT chest №. 24783 dated April 21, 2018: the diaphragm on the right was displaced to the IV rib, the contour was even, the right middle lobe collapse. On the left is the diaphragm up to the VI rib. Conclusion: the diaphragm relaxation on the right. Compression atelectasis of the middle lobe. Congestion in the right lung. (Figure 2).

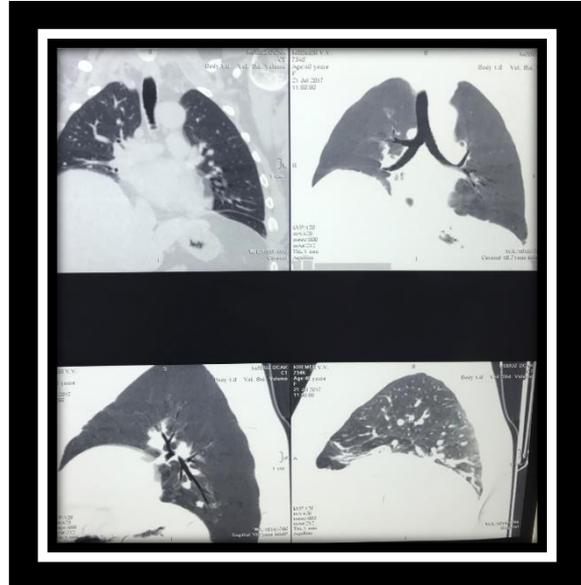


Figure 2. Relaxation of the right dome of the diaphragm. Atelectasis of the middle lobe.

Atelectasis the right middle lobe and congestion are absolute indications for surgical treatment - plastic of the right dome of the diaphragm.

05.31.18 Operation: plastic of the right dome of the diaphragm, according to the our proposed method. Intraoperatively, the right dome of the diaphragm reaches the third rib. The right middle lobe collapse. Intraoperatively, the lung expanded and occupied the entire pleural cavity.

Examination on 09.02.2020 Satisfactory condition, no complaints. February 9, 2020, X-ray of the chest on the right is the dome of the diaphragm at the level of the VI rib, on the left at the level of the V rib. In the lungs, pathology is not determined. Conclusion: Condition after plastic of both domes of the diaphragm. (Figure 3.4).



### Discussion

The proposed method of treatment of the diaphragm relaxation creates favorable conditions for the reconstruction of the thinned dome of the diaphragm, prevents the recurrence and pronounced adhesions in the chest and abdominal cavities: the location of the prosthesis between the leafs of the diaphragm and U-shaped sutures cause relieve tension on the thinned leafs of the diaphragm in the suture area; the prosthesis located between the sheets of the diaphragm, takes on itself the increased intra-abdominal pressure after surgery, thereby removing the negative effect on the thinned leafs of the diaphragm, and also excludes contact with the organs of the pleural and abdominal cavities, which prevents the development of the pronounced adhesive process in them.

A known method of surgical treatment of relaxation of the diaphragm by creating a duplication of tissues of the diaphragm under the control of diaphanoscopy (patent RU 2 245 106 C2 02.05.2003).

The disadvantage of the known method is the complexity in execution and the use of altered, thinned diaphragm tissues for duplication. The closest in terms of the achieved result /prototype/ is a method for the treatment of relaxation of the diaphragm, by strengthening the dome of the diaphragm with synthetic material (teflon, polypropylene) [5,6].

The disadvantages of the known method include the following: the formation of a new dome of the diaphragm increases intra-abdominal pressure in the early postoperative period, which negatively affects the newly formed diaphragm, which has weak points - this is the fixation of thin sheets of the diaphragm with separate interrupted sutures. Thus, there is a high risk of suture eruption in the early postoperative period, with the subsequent development of relapse.

The authors propose an effective method for the surgical treatment of diaphragmatic relaxation.

A positive result of this method is its simplification, increasing the reliability of the formed dome of the diaphragm: by eliminating the failure of the seams; reduction of abdominal pressure on the sheets of the diaphragm, prevention of the development of a pronounced adhesive process in the pleural, abdominal cavities and relapse.

A positive result is achieved by taking the diaphragm on holders and dissecting it in the sagittal direction to the places of its attachment to the chest wall in such a way that two diaphragmatic flaps are formed. Diaphragm dome plasty begins with cutting out a prosthesis from a synthetic material (Teflon or propylene) of the appropriate size for the future diaphragm. The first stage - the formed prosthesis is placed on the inner leaf of the diaphragm and the prosthesis, the base of the inner leaf of the diaphragm, is stitched with U-shaped sutures along the attachment line of the dome of the diaphragm, where the muscles of the diaphragm are preserved (the prosthesis was sewn with U-shaped seams, then the base of the inner leaf of the diaphragm, where the muscles were preserved diaphragm, retreating 8-10 mm, the sheet of the diaphragm and the prosthesis are stitched, the seams are not tied, the distance between the U-shaped seams is 8-10 mm, throughout). The second stage - the inner leaf of the diaphragm is covered with a prosthesis and stitched along the edge with U-

shaped seams, similarly to the above - the prosthesis with an inner leaf of the diaphragm, along the entire length, the seams are not tied. Next, the outer sheet is lifted up, thereby creating the appearance of the base line of the dome of the diaphragm, where its muscles are preserved, the inner sheet of the diaphragm with the prosthesis is brought to the base of the outer sheet of the diaphragm and the threads used to put U-shaped seams on the inner sheet and the prosthesis is stitched at the base - the outer sheet of the diaphragm throughout, where the muscles of the diaphragm are preserved. U-shaped seams are obtained, which are tied. Next, the prosthesis is covered with an outer sheet, and threads are used to apply U-shaped sutures (these are the threads that stitched the inner leaf of the diaphragm together with the prosthesis at the first stage) along the entire length of the outer leaf of the diaphragm with tying them, thereby due to the prosthesis and P-figurative sutures relieve stress on the diaphragm tissue in the suture zone, the location of the prosthesis between the sheets of the diaphragm leads to a decrease in abdominal pressure and load on the sheets of the diaphragm and excludes contact with the organs of the pleural and abdominal cavities, which prevents the development of a pronounced adhesive process in both cavities.

The proposed method is highly effective, which allows you to solve the problem of diaphragm relaxation treatment - by creating a strong "new dome" of the diaphragm, which excludes it in the future.

### Conclusion

The proposed method is highly effective, which allows to solve the problem of diaphragm relaxation treatment - by creating a strong "new dome" of the diaphragm, which prevents the recurrence in the future and will be widely used in the surgical treatment of the diaphragm relaxation.

**The authors contribution:** All authors equally took part in the study of the clinical case and writing the article.

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