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CLINICAL CASE REPORT

Tactics of preventive correction of critical respiratory failure in patients with resectable forms of lung cancer in combination with chronic obstructive pulmonary disease

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ABSTRACT

The article describes clinical examples of the effectiveness of preventive puncture-dilatation tracheostomy (PDT) in preventing critical respiratory complications and improving the immediate results of radical surgical treatment of patients with severe manifestations of chronic obstructive pulmonary disease (COPD) and resectable forms of lung cancer (LC). According to the generalized literature data, the incidence of LC and COPD is 72.8 % among the male population and 52.5 % among women. The combination of LC and COPD causes a significant decrease in respiratory reserves in cancer patients, which leads to an increase in the frequency of complications and an increased risk of death during their treatment. For resectable forms, LC surgical treatment involves removal or resection of the lung, which reduces the total area of the respiratory surface of the lung tissue and oxygen supply to the lungs. These changes are accompanied by a critical violation of the ventilation-perfusion ratio, i. e. alveolar ventilation and cardiac output with an aggravation of hypoxia. This situation is most dangerous for patients with COPD, who after radical surgery have an aggravation of obstructive manifestations in the lungs with an already initially altered gas exchange. As a result, insufficient oxygen enrichment of the organs leads to a cascade of uncontrolled reactions with an intensification of lipid peroxidation and an imbalance in the antioxidant system with fatal consequences for the patient. These clinical examples demonstrate the obvious advantage of preventive PDT, which allows timely changes in the tactics of respiratory support in the early postoperative period and treatment in general (clinical case 1). Routine PDT allows avoiding emergency measures to replace the respiratory function with reintubation, and the use of adapted intelligent artificial lung ventilation modes eliminates additional sedation, muscle relaxation and analgesia in patients LC with severe forms of COPD. Clinical case 2 shows that emergency replacement of the patient's respiratory function has significant difficulties in terms of treatment and prognosis of the course of the disease, and increases the duration of his stay in the intensive care unit.

Keywords: lung cancer, chronic obstructive pulmonary disease, respiratory failure, preventive puncture tracheostomy, modes of assisted ventilation

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КЛИНИЧЕСКИЙ СЛУЧАЙ

Тактика превентивной коррекции критической респираторной недостаточности у больных резектабельными формами рака легкого в сочетании с хронической обструктивной болезнью легких

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РЕЗЮМЕ

Описаны клинические примеры эффективности применения превентивной пункционно-дилятационной трахеостомии (ПДТ) в предупреждении критических респираторных осложнений с улучшением непосредственных результатов радикального хирургического лечения больных с тяжелыми проявлениями хронической обструктивной болезни легких (ХОБЛ) и резектабельными формами рака легкого (РЛ). По данным литературы, частота встречаемости РЛ и ХОБЛ составляет среди мужского населения 72,8 % и 52,5 % среди женщин. Сочетание РЛ и ХОБЛ является причиной значительного снижения респираторных резервов у онкологического больного, что приводит к увеличению частоты осложнений и повышению риска летального исхода в ходе их лечения. При резектабельных формах РЛ хирургическое лечение предусматривает удаление или резекцию легкого, что снижает общую площадь дыхательной поверхности легочной ткани и оксигенацию. Данные изменения сопровождаются критическим нарушением вентиляционно-перфузионного отношения, т. е. альвеолярной вентиляции и сердечного выброса с усугублением гипоксии. Эта ситуация наиболее опасна для пациентов с ХОБЛ, у которых после радикальной операции имеет место усугубление обструктивных проявлений в легких с уже исходно измененным газообменом. В результате недостаточное обогащение органов кислородом приводит к каскаду неконтролируемых реакций с интенсификацией перекисного окисления липидов и дисбалансом в антиоксидантной системе с фатальными последствиями для больного. Данные клинические примеры демонстрируют очевидное преимущество превентивной ПДТ, которая позволяет своевременно менять тактику респираторного обеспечения в раннем послеоперационном периоде и лечения в целом (клинический случай 1). Плановое проведение ПДТ позволяет избежать экстренных мероприятий по замещению респираторной функции с реинтубацией, а применение адаптированных-интеллектуальных режимов искусственной вентиляции легких исключает дополнительную седацию, миорелаксацию и анальгезию у больных РЛ с тяжелыми формами ХОБЛ. Клинический случай 2 показывает, что экстренное замещение дыхательной функции больного имеет значительные сложности в плане лечения и прогноза течения заболевания, а также увеличивает продолжительность его нахождения в отделении интенсивной терапии.

Ключевые слова: рак легкого, хроническая обструктивная болезнь легких, респираторная недостаточность, превентивная пункционная трахеостомия, режимы вспомогательной вентиляции легких

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Соблюдение этических стандартов: в работе соблюдались этические принципы, предъявляемые Хельсинкской декларацией Всемирной медицинской ассоциации (World Medical Association Declaration of Helsinki, 1964, ред. 2013). Исследование одобрено Комитетом по этике ФГБУ «Национальный медицинский исследовательский центр онкологии» Министерства здравоохранения Российской Федерации (выписка из протокола заседания № 19 от 22.11.2021 г.). Информированное согласие получено от всех участников исследования

Финансирование: финансирование данной работы не проводилось

Конфликт интересов: все авторы заявляют об отсутствии явных и потенциальных конфликтов интересов, связанных с публикацией настоящей статьи

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BACKGROUND

Multimodal antitumor therapy of lung cancer (LC) using an organ-preserving surgical approach in combination with various radiation and drug techniques undoubtedly creates prerequisites for improving patient survival rates at virtually all stages of the disease [1]. Nevertheless, LC is consistently leading in terms of morbidity and mortality among the population of Russia and the world. It is known that the effectiveness of antitumor therapy depends on the morphological characteristics, the stage of the disease, as well as on the presence of concomitant pathology and the degree of compensatory capabilities of the body [2]. In this context, the combination of LC and chronic obstructive pulmonary disease (COPD) is often the reason for the rejection of radical surgical treatment, which is associated with a high risk of death in these patients [3].

The Global strategy for the diagnosis, management and prevention of chronic obstructive pulmonary disease (2023) information source notes that COPD is diagnosed in 15–25 % of the adult population and ranks 4th among the leading causes of death in the world [4]. COPD is a progressive disease characterized by a prolonged inflammatory process, persistent bronchial obstruction with marked changes in respiratory function and significant extrapulmonary complications [5].

According to generalized literature data, the incidence of LC and COPD is 72.8 % among the male population and 52.5 % among women. Complex pathology consists of two comorbid diseases with similar pathogenetic mechanisms of formation of pathological processes in the bronchopulmonary system caused by induced inhalation exposure to damaging factors [3, 5]. The combination of LC and COPD is the reason for a significant decrease in respiratory reserves in cancer patients, which undoubtedly leads to an increase in the frequency of complications and an increased risk of death during their treatment [6]. The presence of severe forms of COPD of stages III and IV in these patients actually puts them in the category of incurable. According to the clinical recommendations for the treatment of LC, patients with limited parameters of forced lung capacity less than 50 % and forced exhalation volume in 1 second less than 50 % of the required value are considered functionally inoperable. In such cases, radical surgical treatment is recommended only in small amounts – atypical lung resection or segmentectomy, which undoubtedly does not exclude the recurrence of the tumor and does not guarantee a complete cure for these patients [7]. It was found that in the early postoperative period, COPD progression is observed in 34 % of cases. In addition, postoperative pneumonia leads to severe respiratory deficiency in 17–39 % of cases, pleurisy and pleural empyema in 5–13 % of cases, acute lung injury in 3 % of cases. A significant proportion of complications in 38 % of cases is represented by cardiac decompensation with clinical manifestation in the form of a respiratory component [6].

In cases of full-fledged surgical treatment, the primary cause of the severity of COPD should be taken into account and the development of postoperative complications and death in these patients should be prevented as much as possible. Of particular importance is the occurrence of respiratory failure (RF) in the first hours of the postoperative period, when the patient's body must compensate for respiratory deficiency in the short term [8].

It is known that RF in patients with LC with COPD in the postoperative period, against the background of these pathological changes, most often develops rapidly and requires urgent measures to adequately replace respiratory function. According to Burton BN, et al. (2018) the presence of COPD in men over the age of 65, with a history of smoking, the state of physical status according to the scale of the American Society of Anesthesiologists (ASA) 4 or more points, shortness of breath with little physical exertion, as well as the duration of surgery significantly affect the frequency of unplanned/emergency intubations in patients after thoracotomy operations. At the same time, there are research results stating that unscheduled intubation increases the patient's stay in the intensive care unit and hospital, may be the cause of repeated surgery, and is also significantly associated with a 30-day mortality rate [9].

At the same time, it should be borne in mind that artificial ventilation with emergency tracheal intubation is an extremely aggressive procedure for any patient. Research by Ramachandran SK, et al. (2011) showed that reintubation after noncardiac surgeries is directly related to a 9-fold increase in mortality in these patients [10]. The high probability of developing decompensated RF with possible adverse con-

sequences for patients with severe forms of COPD leads to the search for methods of commensurate replacement of respiratory function in the early postoperative period, preferably with immediate implementation and high efficiency.

The aim of the study was to demonstrate the effectiveness of preventive puncture-dilated tracheostomy (PDT) and adapted intelligent ventilation modes in preventing critical respiratory complications in patients with severe COPD (stages III and IV).

Clinical case 1

Patient V., 66 years old, was admitted to the clinical diagnostic department of the National Medical Research Center for Oncology, for examination and treatment purposes. The main complaints of the patient were the following: periodic rise in body temperature, prolonged cough, shortness of breath. Examination of the patient: 1. Fibrobronchoscopy showed a tumor of the upper lobe of the left lung. 2. The result of histological examination of the tumor biopsy identified a squamous cell carcinoma. 3. Positron emission tomography of the chest visualized a 6.2 × 6.6 cm tumor of the upper lobe of the left lung with disintegration and damage to the upper lobe bronchus. 4. Assessment of the function of external respiration – vital lung capacity 40.69 %, forced vital lung capacity 40.76 %, forced air volume during exhalation in 1 second 41.29 %, a significant decrease in all indicators. 5. Echocardiography showed ejection fraction 52 %; left ventricular myocardial hypertrophy, left ventricular systolic function is compensated, aortic wall thickening, left atrium dilation, mitral valve arrhythmogenic insufficiency. The main clinical diagnosis was established as central cancer of the upper lobe of the left lung cT2aN2Mo st IIIa, clinical group 2. Concomitant diagnosis: COPD stage III; coronary heart disease: arrhythmic variant, permanent normosystolic type of atrial fibrillation with episodes of asystole over 3500 ms (implanted pacemaker); Chronic heart failure II A, functional class 2; Hypertension stage 3, risk 3.

By the decision of the council of doctors of the National Medical Research Center for Oncology of the Russian Federation Ministry of Health, in accordance with clinical recommendations and treatment standards, surgical treatment in the amount of an upper lobectomy on the left was recommended for the patient V. Taking into account the initial respiratory deficiency associated with the subcompensated course of COPD, preventive PDT was agreed with the patient immediately after thoracoplastic surgery. The patient has received voluntary informed consent to the treatment and use of personal data for scientific purposes. Under conditions of multimodal combined anesthesia, the patient underwent an upper lobectomy on the left. Previously, catheterization of the epidural space at the Th3-Th4 level was performed under aseptic conditions for the dosed administration of 0.25 % ropivacaine solution with an elastomer pump at a rate of 7 ml/hour. After the upper lobe of the left lung was removed and adequate pneumostasis was performed, the patient was transferred to a double-lung ventilator in pressure control mode with constant forced ventilation. The set respiratory volume was 460 ml, respiratory rate (RR) 16 per minute, minute respiratory volume (MRD) 4.9 l/min, fraction of oxygen in the inhaled mixture (Fraction of Inspired Oxygen FiO_2) 45 %, SpO2 saturation 97 %. The gas composition of arterial blood corresponded to normal parameters: pCO_2 4.2 mmHg, pO_2 135 mmHg, pH 7.332, BE 5.4 mmol/l, HCO_3 29.2 mmol/l, SpO_2 92 %. These parameters were monitored in connection with the initial severe COPD disease, as well as due to a significant decrease in the area of the oxygenating surface, as a result of complete resection of the anatomical lobe of the left lung. After the lung surgery was completed, an additional surgical intervention, preventive PDT, was performed under ongoing anesthesia. To do this, a small incision was made in the anatomical area above or below the isthmus of the thyroid gland, followed by puncture with an adapted 14 G needle with a cannula. Then, a screw-shaped buge was inserted into the trachea through a thin conductor and a stoma was formed [11] (Fig. 1). The advantages of PDT should be indicated. This minimizes tracheal injury and infection of surrounding tissues. Dilated tracheostomy significantly reduces the development of lung infections, reduces the time of hospitalization of patients in the intensive care unit [12].

At the end of the operation, due to the high probability of developing a critical RF, the patient's respiratory care was continued in the mode of auxiliary-forced ventilation (Pressure support ventilation (PSV)). In this ventilation mode, the device initiates an auxiliary inhalation for each respiratory effort of the patient. Under the control of the dynamics of the

blood gas composition, 6 hours after the operation, the patient was switched to Synchronized Intermittent Mandatory Ventilation (SIMV) mode. In this mode, if the patient is not breathing independently enough, an extraordinary hardware inhalation is programmed. The absence of an orotracheal intubation tube provided more comfortable and functionally adequate ventilation without additional sedation of the patient. The patient was on a ventilator in full consciousness, there were no signs of discomfort. However, according to the indicators of the gas composition of the patient's blood, a certain deficiency of gas exchange was detected. When individually selecting the parameters of an auxiliary ventilator, the patient was most comfortable in the Synchronized Intermittent Mandatory Ventilation-Volume Guarantee (SIMV–VG) mode. This ventilation mode is susceptible to minimal respiratory efforts of the patient with the possibility of maximum correction of respiratory support. At the same time, the patient did not experience excessive muscle tension and functional discomfort. There were no signs of an increase in hypoxia and hypercapnia for two days. With the appearance of stable dynamics of independent inspiratory efforts without signs of muscle exhaustion, the patient was transferred to spontaneous ventilation mode with constant positive airway pressure at the end of exhalation. The advantage of this ventilation mode is the guaranteed provision of gas exchange, which is ensured by the initiation of respiratory support equipment in cases of changes in the patient's breathing mechanics. When conducting a spontaneous breathing test for patients with COPD (BH 24 per minute, SpO_2 >88 % and PaO_2 ≥ 65 mmHg absence of negative dynamics of hemodynamic parameters and muscle fatigue) patient V. was excommunicated from the ventilation system. Further, the oxygen-air mixture under tracheostomy conditions was supplied by a high-flow AIRVO-2 generator (flow 5 l/min, temperature 35 degrees, FiO_2 45 %) against this background, blood oxygen saturation was 97 %. In the early postoperative period, the patient received standard drug therapy, which included liberal infusion, antibacterial and inhalation therapy (mucolytics and bronchodilators), prevention of thrombogenic complications. During the entire period of the patient's stay on respiratory replacement support, no life-threatening complications were recorded. Several episodes of rhythm disturbance were stopped in a short time, there were no thrombogenic complications. On the 8th day, the patient was transferred to the surgical department to continue the planned treatment.

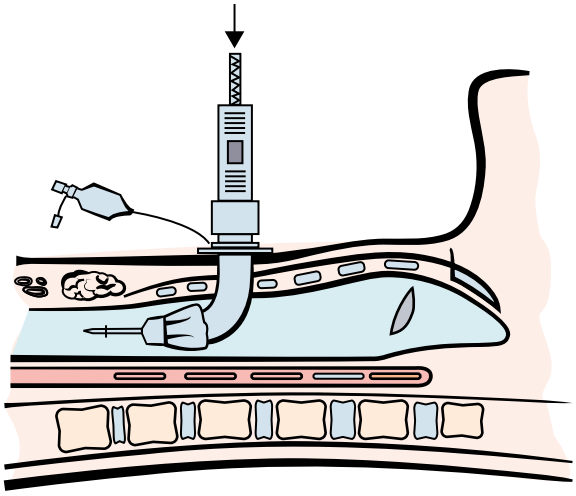

Fig. 1. The scheme of puncture-dilated tracheostomy [11]

Clinical case 2

Patient P, 68 years old, was admitted to the clinical diagnostic department of the National Medical Research Center for Oncology, with complaints of prolonged and unproductive cough and shortness of breath. After a comprehensive examination, central cancer of the left lung, cT3N2M0 st IIIb, clinical group 2 was detected. Concomitant diagnosis: COPD stage III; Angina pectoris, functional class 3. Hypertension stage 3, risk 3. According to the treatment standards, surgical treatment in the amount of upper lobectomy on the left is recommended. Some research data: 1. Histological analysis: squamous cell carcinoma. 2. Significant impairment of respiratory function. 3. Echocardiography: multifocal atherosclerotic lesion of the coronary arteries, stenosis of the mouth of the left coronary artery up to 50 %. After a comprehensive examination, the patient underwent surgery: thoracotomy, upper lobectomy on the left. The stages of the operation and anesthetic care met the standards of medical care for patients with LC. Taking into account the initial cardiac disorders and a clear deficit in respiratory function, the patient was on an extended ventilator for the first day after surgery. Ventilation was provided by means of standard intubation of

the tracheobronchial tree with a single-light intubation tube. On the second day after the operation, with full recovery of consciousness and muscle tone, as well as normal parameters of the arterial blood gas composition, the patient was extubated and transferred to non-invasive ventilation (NIV). There were no clinical and laboratory violations during the day. Nevertheless, by the end of the third day after surgery, an episode of sinus tachysystole was noted, which was accompanied by critical hypotension and severe respiratory deficiency. Despite active oxygen therapy, blood oxygen saturation decreased rapidly. Intensive therapy aimed at restoring normal heart rhythm and blood pressure parameters was performed. To prevent critical respiratory failure, tracheal intubation with an endotracheal tube was performed on an emergency basis. During the day, the patient's condition was extremely severe, with no signs of stabilization. By the decision of the council of doctors of the National Medical Research Center for Oncology, it was recommended to perform an additional intervention in the amount of tracheostomy. For the next 16 days, the patient was on a ventilator with various adapted regimens. With independent respiratory support without a pronounced clinical and laboratory deficiency, the patient was weaned from the ventilator and transferred to a NIV AIRVO-2 generator under tracheostomy conditions. On the 20th day, the patient was transferred to the surgical department in a stable condition. However, on the 22nd day, he had an episode of cardiac arrhythmia with signs of hemodynamic and respiratory deficiency. The patient was urgently hospitalized in the intensive care unit for correction of critical disorders. Objective data: consciousness stunning I, skin pale, cyanotic, hemodynamics with a tendency to hypotension, blood pressure 67/52 mmHg, heart rate 128 per minute, atrial fibrillation, SpO_2 76 %. After emergency insufflation with a moistened oxygen-air mixture by a high-flow AIRVO-2 device with preset parameters: flow 38 l/min, temperature 32 degrees, FiO_2 75 %, a rapid recovery of SpO_2 to 93 % was noted. The following day, the Airvo parameters were: FiO_2–40 %, flow-26 l/min, while SpO_2 was 98 %. The patient was in the intensive care unit for another 3 days, then, with complete stabilization of his functional state, he was transferred to a specialized department to continue treatment.

DISCUSSION

The above clinical examples consider approaches to radical surgical treatment of LC in patients with extremely low functional respiratory reserves due to the sub- and decompensated course of COPD (stages III and IV).

In resectable forms of LC, standard surgical treatment involves removal or resection of the lung, which reduces the total respiratory surface area of the lung tissue and oxygenation. This situation is most dangerous for patients with COPD, who have bronchoconstriction and worsening of obstructive pulmonary manifestations in the postoperative period with an already initially altered gas exchange. These changes are accompanied by a critical violation of the ventilation-perfusion ratio, i. e. alveolar ventilation and cardiac output with worsening hypoxia [3]. In addition, any factors that cause increased stress on the respiratory muscles (impaired evacuation of bronchial secretions, increased hyperinflation of the lungs) reduce alveolar ventilation and lead to an increase in hypercapnia. Increased pulmonary hyperinflation leads to an increase in positive pressure at the end of exhalation, which also increases the load on the respiratory apparatus and increases respiratory effort. A closed chain of pathological reactions occurs with the lack of adequate gas exchange and the development of tissue hypoxia [8]. The insufficiency of the active drainage function of the bronchopulmonary system against the background of a prolonged inflammatory process in the bronchi, a change in the architecture of normal blood flow and the formation of atelectated areas in the lung tissue further complicates the situation. As a result, ineffective oxygen enrichment of organs leads to a cascade of uncontrolled reactions with fatal consequences for the patient [3]. In our opinion, it is possible to avoid a life-threatening respiratory complication in the early stages after surgery and, at the same time, reduce mortality with the rational use of artificial ventilation support in conditions of proactive PDT.

These clinical examples demonstrate the obvious advantage of preventive PDT, which allows timely changes in the tactics of respiratory care in the early postoperative period and treatment in general (clinical case 1). Routine PDT avoids emergency measures to replace respiratory func-

tion without repeated and aggressive translaryngeal tracheal intubation, and the use of adapted intelligent ventilation modes eliminates additional sedation, muscle relaxation, and analgesia in patients with severe COPD. Clinical case 2 shows that emergency replacement of the patient's respiratory function has significant difficulties in terms of treatment and prognosis of the disease, and also increases the duration of his stay in the intensive care unit.

According to open sources in the Russian Federation, we have not found a description of such a medical technique. In this regard, the authors proposed and patented a "Method for the prevention of decompensated respiratory failure after radical surgical treatment of lung cancer in patients with severe forms of chronic obstructive pulmonary disease" (Patent for invention No. 2829259 dated 10/30/2024).

CONCLUSION

Clinical cases have demonstrated the effectiveness of preventive puncture-dilated tracheostomy and adapted intelligent ventilation modes in the occurrence of urgent respiratory conditions with respiratory decompensation in patients with resectable forms of LC in combination with COPD. The use of the method seems promising in the full-fledged antitumor treatment of patients with LC with extremely low functional reserves due to the sub- and decompensated course of COPD.

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