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MULTI-STAGE OPERATIONS IN SURGERY OF CICATRICIAL STENOSES OF THE TRACHEA

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Abstract.
Aim. Improving the results of treatment of patients with persistent defects of the anterior wall of the trachea and soft tissues of the neck.
Materials and methods. 260 patients with tracheal cicatrical stenosis were treated, of which 130 patients had defects of the anterior wall of the trachea of various sizes. All patients underwent mandatory endoscopic and MSCT examinations.
Results. According to the nature of the elimination of the defect of the anterior wall of the trachea, patients were divided into several groups. Circular resection of the trachea with the elimination of the defect was applied in 5 cases. In 2 cases, in the presence of an extensive persistent defect with a size of more than 6 cm, a complex-composite pre-fabricated delto-pectoral skin-fascial-cartilaginous flap was used.
Conclusion. The choice of a method for eliminating a persistent open defect of the anterior wall of the trachea is determined individually in each case, it depends on its size, the depth of the airway lumen, and the condition of the surrounding tissues. The use of displaced skin-fascial flaps on the vascular pedicle to close the tracheal defect allows you to restore the mucous membrane of the tracheal defect area without using the surrounding scar tissue and close the defect with a second flap without stretching the edges of the wound.
Key words: cicatrical stenosis, defect of the anterior wall of the trachea, plastic, displaced flaps.

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INTRODUCTION

Despite the detailed methods developed to prevent damage to the walls of the respiratory tract during prolonged artificial ventilation, the number of patients with iatrogenic post-resuscitation cicatrical stenosis of the trachea (CST) is not decreasing at present. Moreover, there is a tendency to increase the proportion of patients with extensive and multifocal lesions [1, 2, 3].

In the treatment of patients with CST, a complex of endoscopic, surgical measures, as well as methods of reconstructive and plastic surgery are used. When patients with critical and decompensated forms of CST are admitted, endoscopic methods of expanding and maintaining the tracheal lumen in the narrowing area are used as the first stage. In the case of plastic surgery of the tracheal lumen on a T-shaped stent after prolonged exposure, the question of the method of eliminating the open defect arises in the future.

In recent years, great progress has been made in the treatment of patients with chronic tracheal stenosis, but the issues of plastic surgery and defect closure remain controversial, which is confirmed by the analysis of literature data [4, 5, 6, 7].

Circular resection of trachea (CRT) belongs to the category of complex reconstructive interventions, requires the coordinated work of specialists of thoracic surgeons, endoscopists and anesthesiologists-resuscitators and should be performed in specialized clinics. Simultaneous resection of the trachea with end-to-end anastomosis and elimination of the defect of the anterior wall of the trachea from the cervical access can be performed only in the absence of a pronounced neurological deficit, a non-extensive tracheal defect with the presence of tracheomalacia, which does not allow for skin-muscle plasty with local tissues.

Plastic surgery of extensive defects of the cervical trachea involves the restoration of not only a soft-tissue defect, but also the mucous lining and the skeleton function of the trachea [8, 9]. It requires a sufficient supply of full-fledged, hairless skin in the reconstruction area. The absence of such areas near the tracheal defect (sharp dystrophic or scarring changes) requires the use of tissues with skin taken from other areas of the patient's body (the formation of the Filatov's stem, the movement of skin-fascial flaps on the vascular pedicle, autotransplantation of complex flaps on microvascular anastomoses) [10, 11].

A large number of possible tissues and materials have been proposed, as well as options for operations aimed at eliminating the defect of the

the cervical trachea. The main requirements for them are clearly formed: they must be of sufficient size, provide a frame function and the possibility of evacuation of the secret, as well as be resistant to infection [1, 5, 7, 12, 13, 14]. Despite this, the problem is urgent and continues to be the subject of research and discussion by thoracic surgeons, plastic surgeons and otolaryngologists. The choice of a method for eliminating a tracheal defect depends on its size, the depth of the airway lumen and the condition of the tissues surrounding the defect [8, 11, 14, 15].

The aim is to improve the results of treatment of patients with persistent defects of the anterior wall of the trachea and soft tissues of the neck.

MATERIAL AND METHODS

In SI "RSSPMCS named after academician V.V. Vakhidov" 260 patients with CST were treated from 2008 to 2022. If until 2013, cases of endoscopic treatment with coagulation, expansion of the tracheal lumen, augmentation and installation of internal Dumont-type stents prevailed, while the number of circular resections of the trachea increased, then later with the accumulation of treatment experience, in which we noted a large number of relapses of stenosis due to migration of internal stents or the development of granulations at their ends, as well as from-due to the increase in the number of patients with multifocal and extended stenoses, staged reconstructive plastic surgery (SRPO) has become more common. With SRPO, after the first stage of plastic surgery of the tracheal lumen on a T-shaped stent, the question of the method of eliminating an open tracheal defect always arises. 130 patients had defects of the anterior wall of the trachea of various sizes. The age of the patients ranged from 6 to 70 years. The average age was 30.1±1.22 years. In 70% of cases, CST was post-intubation/post-tracheostomy.

Stenoses were localized in the cervical trachea in 118 (90.7±0.29%) cases, in 12 (9.3±0.32%) patients there was a narrowing of the thoracic trachea. Tracheolaryngeal localization was found in 56 (43.1±1.21%) patients, combined laryngeal and thoracic tracheal lesions were present in 6 (4.6±1.4%) patients, in 6 (4.6±1.49%) patients, the cervical and thoracic trachea were scarred, in a total of 49 (37.7±2.11%) in some cases, multifocal lesion was noted. In particular, CST was complicated by esophageal-tracheal fistula (ETF) in 11 (8.46±1.5%) patients. 9 (6.9±1.3%) patients had complete cicatrical obliteration of the tracheal lumen above the tracheostomy cannula. From other medical centers, 2 patients (1.53±1.2%) were admitted with postoperative stenosis of tracheal anastomoses after CRT.

At the same time, in patients with persistent extensive defects of the anterior wall of the trachea and soft tissues of the neck, with defect sizes not exceeding 18 mm in width and up to 35 mm in height, musculo-skin plastic surgery was performed with simultaneous elimination of the defect by local tissues. In the presence of an open defect of trachea (ODT), but also with tracheomalacia, restenosis and a defect in the anterior wall of the trachea after laryngotracheoplasty, as well as the presence of ETF in combination with cicatrical stenosis of the trachea after ineffective attempts to eliminate endoscopic and surgical methods, CRT was performed in 5 cases.

15 patients had extensive defects in the antero-lateral walls of the cervical trachea and the sublingual larynx, as well as a shortage of soft neck tissues around the stoma. It should be noted that due to the fact that most of the patients were admitted to the hospital 2, 3 or more times, the total number of hospitalizations in our hospital exceeded 460.

After a routine examination, including endoscopic examination (bronchofibroscopy, esophagogastroduodenoscopy), chest MSCT with seizure of the cervical region and general clinical diagnostic methods, the patients underwent surgical treatment. The choice of the method of plastic surgery or reconstruction of the tracheal defect is determined individually in each case. Local skin-muscle flaps can be used, as well as complex skin-bone-muscle grafts from the adjacent neck area and various parts of the chest. The indication for this operation is the presence of a persistent defect and a formed tracheal lumen at this level, without signs of restenosis of the respiratory tract, the absence of inflammation and infection of the tissues around the stoma. The main urgent and defining problem remains the recurrence of tracheal stenosis and rejection of implants, which requires further improvement of therapeutic and diagnostic tactics.

A large number of possible tissues and materials, as well as options for operations in this pathological process, have been proposed. Many of them have only historical value and are not currently used. The basic requirements for them are clearly formed: they

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must be of sufficient size, provide a skeleton function and the possibility of evacuation of the secret, as well as be resistant to infection. Preference should be given to patient own tissue. When determining the strategy for eliminating defects in the trachea and soft tissues of the neck, there are no, and there can be no absolutely established dogmas. In each case, we have to choose one or another reconstruction option. Even fundamentally identical interventions in technical aspects can differ significantly from each other. In most cases, after decanulation, the external tracheal fistula or tracheal defect heals on its own and no surgical interventions are required. However, when forming a persistent tracheostomy, it is necessary to suture the formed external tracheal defect. The conditions for the formation of a persistent tracheostomy are considered to be a long-term presence of a tracheostomy tube in the trachea with epithelization of the tracheostomy canal, skin-tracheal sutures during tracheostomy, purulent-inflammatory wound complications that have occurred.

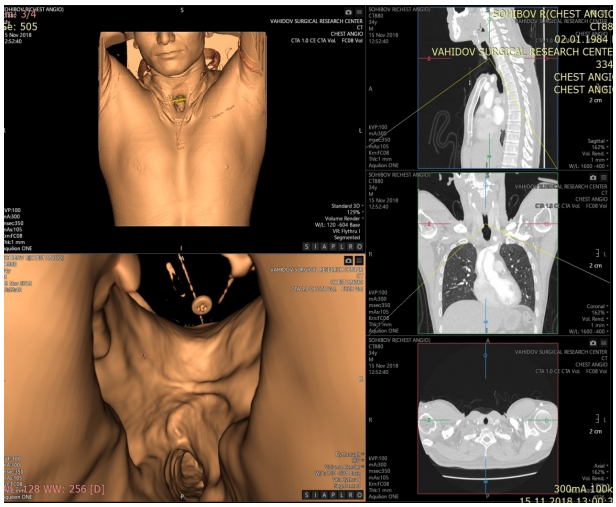

Fig. 1 MSCT 3D-reconstruction of the tracheobronchial tree.

The choice of the method of plastic elimination of the defect of the anterior wall of the trachea depends on the size of defect (length, width, depth of the airway lumen) and the condition of the donor skin in the area of surgery. The depth of the lumen is determined by measuring the distance from the anterior edge of the tracheal defect to the posterior wall of the trachea. This indicator is important for determining the sufficiency of the lateral walls of the trachea.

With a small size of the defect, a depth of the respiratory tract of more than 1.5 cm, and an unexpressed scarring process around the defect, it is possible to use local plastic surgery. The team of our department modified the Bokstein method by applying a four-layer musculo-skin plasty of an open defect of the anterior wall of the trachea and continuous sutures with an atraumatic thread 3/0 - "Method of plastic closure of the defect of the anterior wall of the trachea and soft tissues of the neck after laryngotracheostomy" patent No. IAP 20180549 dated 16.11.2018 issued by the Agency for Intellectual Property of the Republic of Uzbekistan.

a b

Fig. 2 Inspection of the ODT in a straight projection (a) and at an angle of 45 (b). (the arrows indicate the length, width and depth of the ODT).

The method consists in closing the ODT with local tissues, while strengthening due to a larger number of stitched layers of homogeneous tissues and reducing the likelihood of developing postoperative complications such as failure of anastomosis sutures and recurrence of fistula in the long term. The solution of the task, namely, that the probability of developing such postoperative complications as the failure of the sutures of the newly created anterior wall of the trachea, the formation of tracheo-cutaneous fistulas or scar stricture along the suture line in the long term is reduced, is achieved due to the following distinctive features.

The application of the first row of sutures is carried out by intradermal continuous wrapping sutures, this maximizes the tightness of the seam on the one hand, and minimizes the risk of recurrence of cicatrical stenosis of the trachea on the other hand. The imposition of 4 rows of sutures, namely, the first intradermal "coupling" of mobilized skin strips inverted into the tracheal lumen, the second

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intermuscular suture with fascia capture, the third subcutaneous fat, and only then the skin-skin suture, corresponds to the principle of homology of the connected tissues, forms a strong connection line. The implementation of the claimed method consists of several stages:

Modification of the "skin-muscle-skin plastic" is performed to close the defects of the larynx and trachea. The technique of the operation is to step back from the edges of the post-tracheostomy defect by about 0.7-1.0 sm, an arcuate incision of the skin is made on both sides, the skin, subcutaneous tissue and adjacent muscles are separated to a depth of 0.6-0.9 sm.

The resulting flaps are separated towards the edges of the stoma, wrapped with a skin surface to the lumen of the trachea, that is, a skin insert is created that replaces the defect. Suturing of the skin edges is performed with a submucous continuous winding suture with a absorbable thread (Vicryl 3/0). Suturing submucosally excludes further adhesion of bronchial secretions to the thread due to the absence of suture material in the tracheal lumen (Fig. 3).

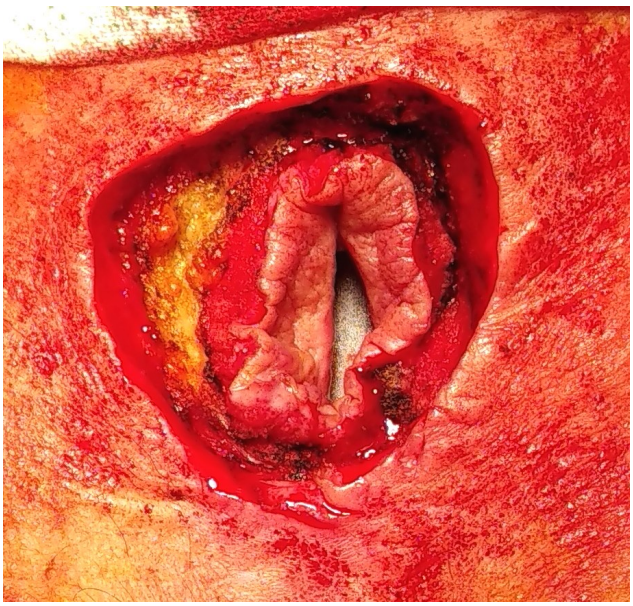

Fig. 3. Patient M., 34 years old. Skin flaps have been prepared for inversion inside and suturing with a submucous continuous suture.

At the same time, on the one hand, the release of skin flaps, i.e. their mobilization should be as sufficient as necessary in order to prevent the tension of the first layer being created. On the other hand, excessive mobilization of the cut-out flaps can lead to flotation of the stitched edges, which is fraught with a lack of airway frame in this area after plastic surgery during breathing, phonation and coughing. The next layer is applied to the second row of transverse nodular sutures on the separated muscles (m. sternocleidomastoideus, m. sternothyroideus, m. sternohyoideus) and fascia.

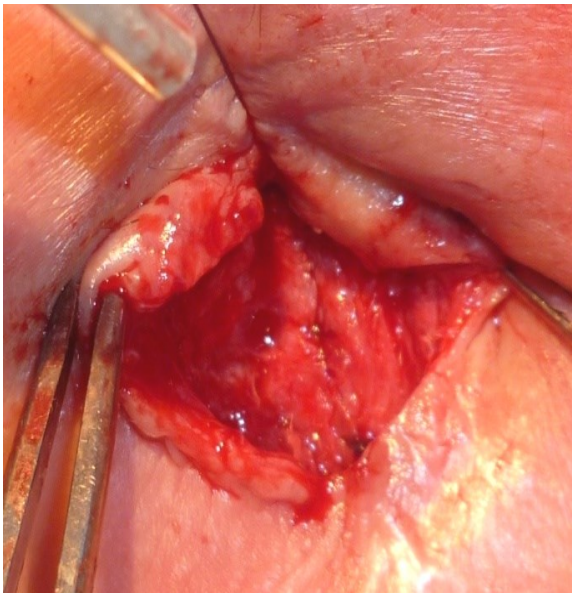

Fig. 4. Patient N. 32 years old. The second row of stitches is sutured.

The third layer is sutured subcutaneous tissue. The skin edges of the flap are sutured with the fourth layer, the formed skin defect is tightened and eliminated with the atraumatic nodular threads, leaving a rubber strip (Fig. 5).

Fig. 5. Patient M., 34 years old. The final type of SMS plastics

When applying each subsequent seam, the wall of the underlying one was captured in the seam in order to further strengthen the wall, to exclude flotation of layers during coughing shocks, and also to avoid the formation of cavities between the layers.

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After finishing of defect plasty, intraoperative fibrobronchoscopy was performed through an intubation tube with its pulling into the sub-vocal larynx for visual assessment of the sutured defect area. Bronchoscopic control is mandatory, the area of plastic defect must be sealed, represented by a skin insert without narrowing the tracheal lumen at this level. Control bronchoscopic examinations were performed on patients on the 5th-7th day after surgery. Then 1 month, 3 months, 6 months and a year after the operation.

With a pronounced scarring process around the defect (as a result of repeated surgical interventions) and the inability to use plastics by local tissues, the use of skin-fascial displaced flaps on the vascular pedicle is effective. When using a displaced flap to form a mucous lining in the area of a tracheal defect, it is advisable to use this flap as the first stage of biological training, consisting in its separation and re-fixation with sutures to the maternal bed. The task of this stage is to strengthen axial blood circulation and increase the engraftability of the flap. The main stage is carried out on 12-14 days after the first stage. A complex composite prefab flap (delto-pectoral skin-fascial-cartilaginous flap) can be used in the presence of a persistent defect and a formed tracheal lumen at this level, without signs of restenosis of the respiratory tract, absence of inflammation and infection of tissues around the defect.

A clinical example. Patient A.D., 22 years old, 13.02.2014 received a catatrauma (falling from a height of 3-4 meters). He was hospitalized in the neurosurgical intensive care unit. He was in a coma for 18 days on an extended ventilator. On the 4th-5th day, a tracheostomy was performed, after stabilization and restoration of breathing, the tracheostomy tube was removed, the patient was transferred to the department of neurosurgery, where after conservative therapy and lumbar puncture (till clearance of the cerebrospinal fluid), the patient was sent to a branch of the Surkhandarya region of the center of urgent ade. He was hospitalized in the department of traumatology, but his parents refused further treatment and turned to the regional multidisciplinary hospital of Surkhandarya region. The patient was hospitalized on 11.03.2014 in the intensive care unit with a lack of air, stridorous breathing. On 12.03.2014, a retracheostomy was urgently applied. On 13.03.2014, the patient was discharged for further observation and treatment in the RSCS named after acad. V. Vakhidov. He was examined in the polyclinic of the RSCS, a diagnostic bronchoscopy was performed, on which: - the vocal cords are thinned, mobile, closing. The lumen of the glottis is not changed. Hemorrhagic erosions in the area of ligaments, on the walls of the larynx. At a distance of 2.0 cm below the vocal cords, cicatrical narrowing of the tracheal lumen with elements of mucosal hyperplasia in the form of granulation, grains with a diameter of 0.6x1.0cm, the device is passed with light resistance. The length of the narrowing is 2.0 cm, the lumen of the tracheostomy tube is partially obstructed by thick, mucopurulent sputum, which makes breathing difficult. The tracheostomy tube is completely cleaned. 2-sided catarrhal endobronchitis. The patient was hospitalized in the department for further examination and decision of treatment tactics. On 20.03.2014, an operation was performed: Circular resection of the upper third of the trachea with tracheolaryngeal anastomosis. In the postoperative period, the patient had symptoms of encephalopathy. On the 4th day after the operation, the patient had a detachment of the annular cartilage from the larynx above the anastomosis, suppuration after the surgical wound. On an emergency basis, on 25.03.2014, an operation was performed: opening, sanation of the postoperative wound, lower terminal retracheostomy. The postoperative period proceeded relatively satisfactorily, there were daily bandagings (2 times a day) of the postoperative wound and replacement of the tracheostomy tube No. 8. After stabilization of the condition as planned on 02.04.2014, the following was performed: Plastic surgery of the tracheal lumen on a T-shaped stent. 07.12.2015 performed: Open coagulation of granulations of the bed of the T-shaped stent under general anesthesia. Breathing was restored through the natural respiratory tract, with the closed state of the T-shaped stent, the phonation is clear. Dynamic observation for 4 years. In November 2020, a consilium was created, it was decided: due to the absence of tracheal cartilage rings in the defect zone, stage 1 is planned to implant autocostal cartilages along the lateral edges of the defect. On 01.12.2020, an operation was performed: Implantation of autocostal cartilages in the area of reconstruction of a tracheal defect. In order to prevent tracheal restenosis, the patient underwent surgery on 09.12.2020: tracheal replasty with the formation of a lumen on a T-shaped stent. The postoperative period was satisfactory.

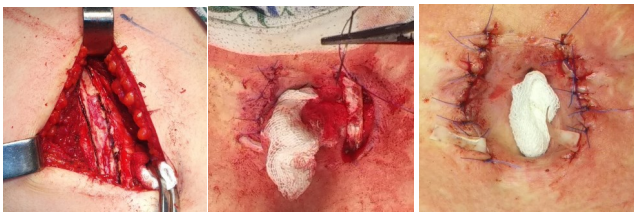

Fig. 6. Implantation of autorib cartilages in the edges of the tracheal defect. A- taking autorib. B-Implantation of the second cartilage. C- is the final view at the end of the operation.

The patient was admitted to the next stage of the operation on 21.12.2021. On the control TBFS, the tracheal lumen is stable, on the 15th day after decanulation of the T-shaped tube, there is no data for restenosis. A consultation was created, taking into account the size of the defect and the short trachea, it was decided to perform the formation of a skin-fascial flap. On 01.13.2022, an operation was performed: The formation of a skin-fascial pre-fabricated supraclavicular-cervical flap on both sides. Under potentiated anesthesia, infiltrative anesthesia was performed in the area of the intended flaps. Two skin-fascial flaps were formed to the left and right of the defect in the form of a "daisy petal", the base to the defect. Flaps on the vascular pedicle. In the corner of the upper edge of the left flap, several

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arterial branches with a diameter of up to 1.5 mm pass superficially. The test for the adequacy of blood supply to the flaps is positive. The pre-fabricated flaps are sewn on the edges to the skin with nodular seams with the leaving of rubber strips.

a b

Fig. 7. The formation of pre-fabricated neck flaps.

The next stage on 21.01.2022 was the elimination of an open defect of the anterior wall of the trachea and soft tissues of the neck. Moving pre-fabricated flaps. Postoperative period without complications.

Fig. 8. Closing the defect with pre-fabricated flaps and final view.

RESULTS

A comparative analysis of the use of 3- and 4-layer modified SMS plastics was carried out. In the comparison group, 47 patients underwent 3-layer plastic surgery. As a result of the use of an improved algorithm for diagnosis and treatment, 4-layer plastic surgery, we were able to significantly reduce the number of complications in the early postoperative period and reduce the number of repeated interventions aimed at expanding the tracheal lumen.

In 13 patients, there was partial insufficiency of the postoperative suture, with the intake of air from the area of the created musculoskin anterior wall without divergence of internal sutures, in all cases, conservative methods with the application of aseptic ointment bundages achieved the elimination of signs of suture failure with the cessation of air intake during phonation and cough with hermetic closure of the defect. Restenting with a T-shaped prosthesis was required in 6 cases of early acute respiratory insufficience due to the prolapse of the flap into the tracheal lumen and in 1 case 6 months after after SMS plasty as a result of restenosis. Subsequently, these patients were subjected to repeated surgical intervention, the choice of the method of closing the ODT depended on the size of the tracheal defect and the condition of the surrounding tissues.

The use of displaced skin-fascial flaps on the vascular pedicle to close the tracheal defect allows you to restore the mucous membrane of the tracheal defect area without using the surrounding scar tissue and close the defect with a second flap without stretching the edges of the wound. In the group of patients with tracheal defects, as a result of improving the algorithm of diagnosis and treatment, it was possible to reduce the frequency of postoperative complications to 12.3%, the mortality rate per 130 people was 0.77%.

Discussion: In CST 3 treatment options are generally recognized: CRT, SRPO, endoscopic intraluminal treatment. Each of them has its advantages and disadvantages, which continues to be discussed on the pages of specialized publications and scientific forums. Further progress of tracheal surgery is associated with a multidisciplinary approach, when one team of specialists has the opportunity to apply all 3 types of treatment. SRPO is used for contraindications to CRT and, along with endoscopic options, is a palliative option and is associated with a greater likelihood of relapse of the disease. The effectiveness of SRPO at the final stage of surgical treatment ranges from 82% to 86.8% (Parshin V.A., 2020). Compliance with the principle of "each patient has his own version of the operation" and the management of the postoperative period by an experienced team of surgeons, resuscitators and endoscopists allows to stop adverse events. Our data correlate with the data of the Clinic of Faculty surgery of UKB No.1 of Sechenov University and the Department of Lung and Mediastinal Surgery of the Russian National Research Center named after acad. B.V. Petrovsky, where in the period from 2001 to 2017, 976 patients with non-tumor cicatrical stenosis of the trachea of various localization and severity were treated, 107 cases with complications (10.96%), 7 deaths (0.7%), purulent-inflammatory complications remain the main ones in their structure, which ultimately affects the final outcome of treatment.

CONCLUSIONS

1. At the stage of endoscopic treatment in some patients, it is possible to achieve the formation of a

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tracheal lumen sufficient for breathing, i.e. to transfer CST from the critical, decompensated and subcompensated stage to a compensated form. At the same time, the effectiveness of endoscopic methods is 54.3% in patients with short CST, 8% with extended, 17% with tracheolaryngeal, 16.7% with multifocal CST. In the case of restenosis, circular resection of the narrowed trachea is required, if there are contraindications, T-plasty is performed.

2. Reconstruction on a T-shaped endoprosthesis in patients with tracheolaryngeal and extended CST allows to rehabilitate patients with severe concomitant pathology, eliminate signs of bronchial expectoration disorders, preserve the ability to breathe through natural airways and restore phonation, eliminates the risk of migration and obturation of the endoprosthesis and allows to form a stable and sufficient tracheal lumen with subsequent plastic surgery for closing the defect.

3. With multifocal constrictions (2-3 level tracheal stenoses), in combination with stenoses of the sublingual larynx, as well as with cicatrical obliteration of the lumen above the tracheostomy, lumen plasty on a T-shaped endoprosthesis is the method of choice, allowing intraoperatively to form a lumen at all levels with the possibility of prolonged dilation.

4. In the absence of contraindications from concomitant diseases, circular resection of the trachea can be performed at the first stage of treatment. In case of contraindications to its implementation, the need for rehabilitation of the patient, it is possible to perform tracheal resection at the next stage of treatment. At the same time, endoscopic interventions and T-plasty do not increase the extent of narrowing, and in case of multifocal stenoses, on the contrary, they allow reducing the number of levels.

5. To close persistent defects of the trachea and soft tissues of the neck after laryngotracheoplasty, local skin-muscle flaps are effective with defect sizes not exceeding 18 mm in width and up to 35 mm in height, with extensive defects, complex skin-bone-muscle grafts from the adjacent neck area and various parts of the chest can be effectively used.

6. When determining the narrowing diameter, TFBS is more specific than MSCT, 92.3% and 83.8%, respectively, while in assessing the extent of the stenosed tracheal zone, the specificity of MSCT is higher than TFBS, 92.6% and 84.2, respectively. The relative discrepancy rate according to the MSCT parametric data was 5.8±1.51% when calculating the area of the ODT (t=0.57; P=0.568) and 4.3±0.03% for the depth of the ODT (t=1.94; P=0.057), respectively, the percentage of coincidence was 94.2±1.51% and 95.7±0.03%.

7. Among patients with ODT, men are 2.87 times ($p<0.05$) more than women. Patients in the age groups from 19 to 44 years, i.e. representing the most active, able-bodied and socially significant segment of the population, made up the vast majority - 65.8% ($p<0.05$).

8. The final decision on the timing of closure of the laryngotracheostomy is based on morphological examination of biopsies of the lateral walls of the tracheal defect, the criterion is the restoration of a multi-row epithelium with highly specialized ciliated and goblet cells. The minimum duration of laryngotracheostomy is 5 months, in the presence of pronounced tracheomalacia and the proliferation of coarse-fibrous connective tissue in the tracheal wall, even after 10 months of stenting, the elimination of ODT should not be carried out due to the high risk of repeated stenosis. In these cases, prolongation of T-shaped tracheal stenting is necessary.

9. The modified Bokstein method reduces the risk of suture insufficiency, restenosis and flap prolapse into the tracheal lumen from 28.8% to 13.04%, which reduces the number of repeated interventions from 25.53% to 6.52% ($P<0.05$).

10. In patients with ODT, a multidisciplinary approach should be carried out, depending on the parameters of the defect, the degree of residual tracheal narrowing, the severity of concomitant pathology and the existing neurological deficit, with the optimal use of a complex of endoscopic, resection and reconstructive plastic methods of treatment and rehabilitation, which allows the patient to fully recover both medically and socially up to 87.85%.

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