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Improvement of Technical Aspects in Performing Dilatational Tracheostomy

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Abstract The article presents a basic technique for performing a percutaneous dilatational tracheostomy in the face of difficulties with determining anatomical landmarks by using the advanced Howard-Kelly forceps, which ensures, due to the stable fixation of the guidewire the risk of injury to surrounding tissues decrease. The effectiveness of the modified technique was studied. This modification of percutaneous tracheostomy can be used in patients with a risk of specific complications. The prospects of using the improved method of percutaneous dilatational tracheostomy in patients who were on prolonged mechanical ventilation (PMV) were essessed.

Keywords Prolonged mechanical ventilation (PMV), Percutaneos tracheostomy, Bronchoscopy, Tracheal stenosis

1. Introduction

As shown, the analysis of the most significant world publications (Social Sciences Citation Index, SSCI ≥ 10) in the National Library of Medicine database of National Institutes of Health determined the high importance of the problem of tracheostomy and post tracheostomy complications [1] [2].

C. G. Durbin (2010) states that at least ten percent of patients requiring at least three days of mechanical ventilation must undergo a tracheostomy to ensure airway patency and PMV [3], confirming which is the opinion of V.D. Parshina (2008), "... after 7 days of translaryngeal intubation, pronounced (3-4 degree) lesions of the larynx and vocal folds form on the Lindhom C.E. scale. (1969)".

To date, only a few absolute indications for a tracheostomy have been identified [2] [4] [5] [6] namely:

- the procedure is mandatory in patients with respiratory failure;
- during life threatening obstruction of the upper respiratory tract;
- the need for PMV;
- and difficulties with weaning from a respirator.

To date, there are numerous methods of percutaneous dilatational tracheostomy (PDT), however, the advantages of any technique are doubtful, since each of them has its own technical difficulties of implementation, which requires further improvement [7] [8] [9].

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A survey of 231 heads of intensive care units in England revealed the following data on the use of percutaneous tracheostomy: preferred - 73.3%; limited use –5.1%; finished using –3.4%; never used –18.2%. Moreover, the preferences of the applied methods were distributed as follows: Griggs (Portex) - 72%; Ciaglia (Cook) - 43%; Rapitrach - 2% (refused due to a large number of complications). Overall, 78.6% of respondents considered PDT safe method and only 8.7% - dangerous.

A counterargument to this opinion was published in a recent issue of Critical Care magazine, where Simon M. (2013) and colleagues presented a systematic review of risk factors for PDT complications, which coincides with the opinion of a large number of researchers "... this procedure is highly risky" in connection with which the search continues proposals to improve the safety of tracheostomy in patients on PMV [1] [2].

In this regard, in this article we cited developed in RSSPCS named after acad. V. Vakhidova improved technique for conducting standard options for dilatational tracheostomy, the priority of which was not only to achieve maximum safety of the procedure, but also to avoid subsequent complications, such as bleeding and the occurrence of cicatricial tracheal stenosis.

There are many methods used today for conducting a tracheostomy, which made it possible to improve these techniques, taking into account the advantages and disadvantages of their implementation.

In this connection, we have developed the author's models (utility model No. 1 and No. 2) of the Howard-Kelly forcep modification for the conducting PDT.

2. Advanced Tool Options for Performing Percutaneous Dilatational Tracheostomy

The purpose of the development of the modified forcep was to simplify and increase ease of use. To solve this goal, we proposed a clamp for clamping and holding organs and tissues during a tracheostomy, containing jaws with a rack and working jaws with longitudinal grooves along the width of the jaws and applying mesh knurling on the side surfaces of the working jaws, and grooves are made in the working jaws, and in the longitudinal a groove in the second working jaw has a side hole for conducting a guidewire.

Comparative analysis with the prototype (Howard-Kelly forceps) showed that the claimed device differs from the known one in that grooves are made in the working jaws, and a side hole for conducting guidewire is made in the longitudinal groove of the second working jaw. These distinctive features allow us to conclude that the technical solution is new.

Performing grooves in the working jaws and placing the first working jaw guidewire in the longitudinal groove makes it easier to insert and guides the guidewire to the necessary direction during tracheostomy.

The execution on the longitudinal groove of the second working jaw of the side hole allows to increase the usability when fixing the guidewire.

Thus, the proposed device has a novelty and may be applicable in wide surgical practice.

In Fig. 1 is a layout of utility model No. 1 for performing percutaneous dilatational tracheostomy.

In Fig. 2 shows a real view of the clamps for performing a percutaneous dilatational tracheostomy with and without a guidewire.

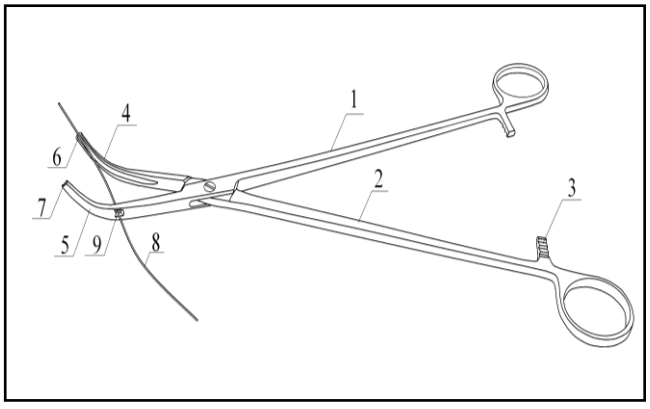

Figure 1. Layout of utility model No. 1 of the author's forceps for performing a modified percutaneous dilatational tracheostomy

Description of the forceps for holding organs and tissues during tracheostomy (Fig. 1): The clamp contains jaws 1 and 2 with a rack 3 and working jaws 4 and 5 with longitudinal grooves 6 and 7 along the width of the jaws. Grooves are made on 2/3 of the length of the jaws. A mesh knurling is applied on the lateral surfaces, and a guidewire 8 is placed in the longitudinal groove 6 of the first working jaw 4 (for convenience of fixing the string when unclenching the jaw clamps), and a longitudinal side hole 9 for the guidewire is made in the longitudinal groove 7 of the second working jaw 5.

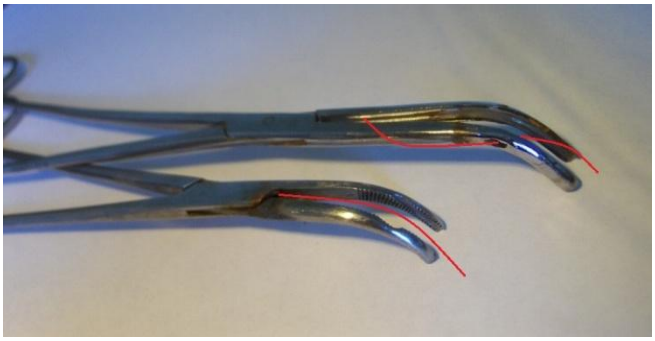

Figure 2. Appearance of utility model No. 1 of the author's clip in comparison with the Howard Kelly forceps

Tracheostomy using utility model No. 1 was performed with the same sequence as when performing any method.

Considering that mainly tracheostomy was performed by a patient for PMV, the method was performed with bronchoscopic support and control. Therefore, at the first stage with bronchoscopic control, the endotracheal tube was installed at an appropriate level just above the site of the proposed puncture (Fig. 3).

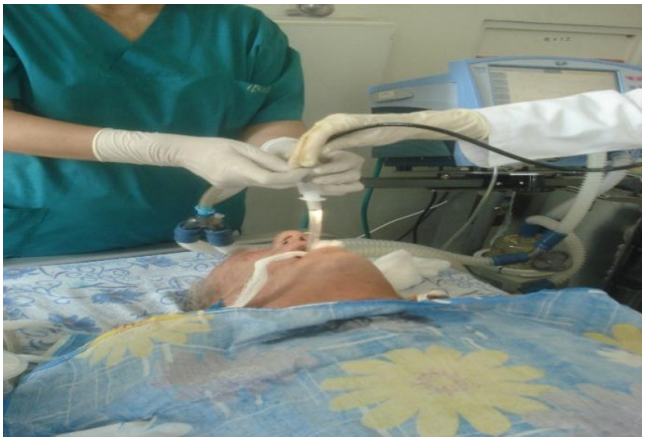

Figure 3. Photo of the stage of tracheostomy: The stage of installation of the endotracheal tube under bronchoscopic control

The second stage was a skin incision up to 1.5 cm long above the jugular notch at the level of 2 tracheal rings (Fig. 4 A).

The third stage was the extension of the superficial fascia of the neck in a blunt way (Fig. 4 B). In this case, one of the medium surgical instruments with narrow branches (such as a mosquito) can be used.

In the next step, a trachea was punctured with a thin needle in region 2nd half ring under the control of bronchoscopy and a metal guidewire was passed through the needle hole (Fig. 5 A).

After removing the needle, a guidewire is passed through the hole in the jaw of the modified clamp (Fig. 5 B).

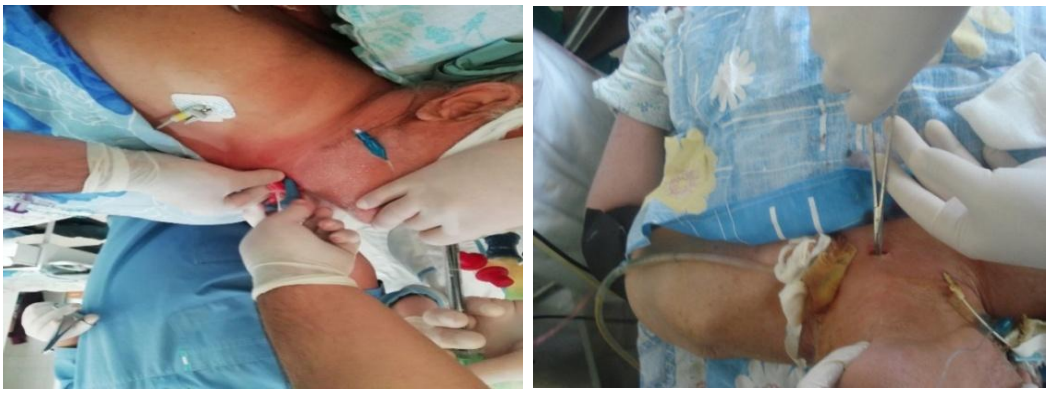

Figure 4. Photo of the stage of tracheostomy: A) Stage of skin incision in the projection of 2 half rings of the trachea. B) Extension of the superficial fascia of the neck in a blunt way

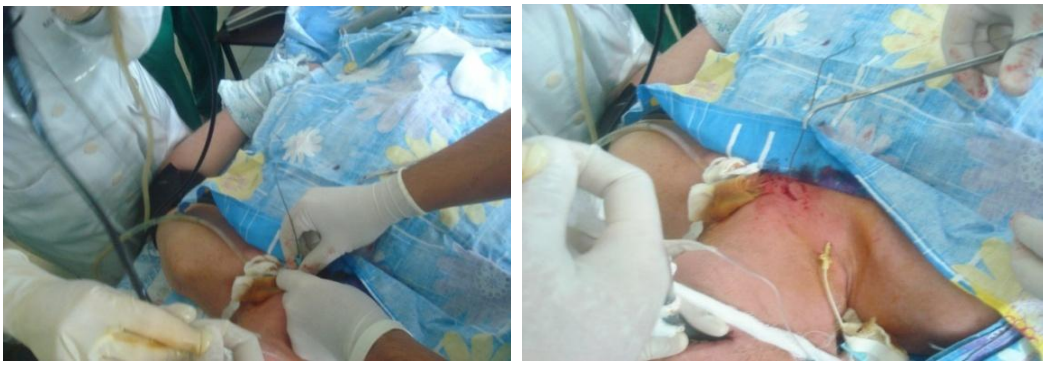

Figure 5. Photo phase tracheostomy: A) In region of 2nd half ring by the needle made a puncture into the lumen of the trachea, a guidewire was passed through the needle. B) The guidewire is inserted into the groove of the tool and passed through the hole in its right jaw

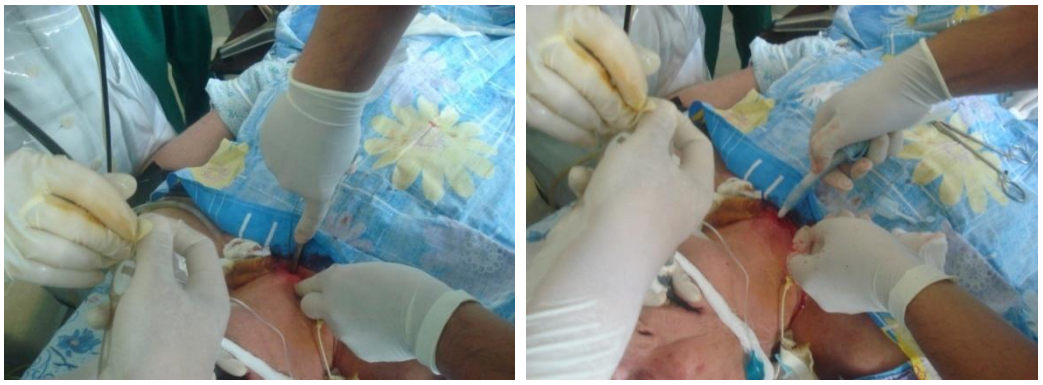

Figure 6. Photo phase tracheostomy. A) Stage dilatation of the trachea. B) The stage of installation of the tracheostomy tube

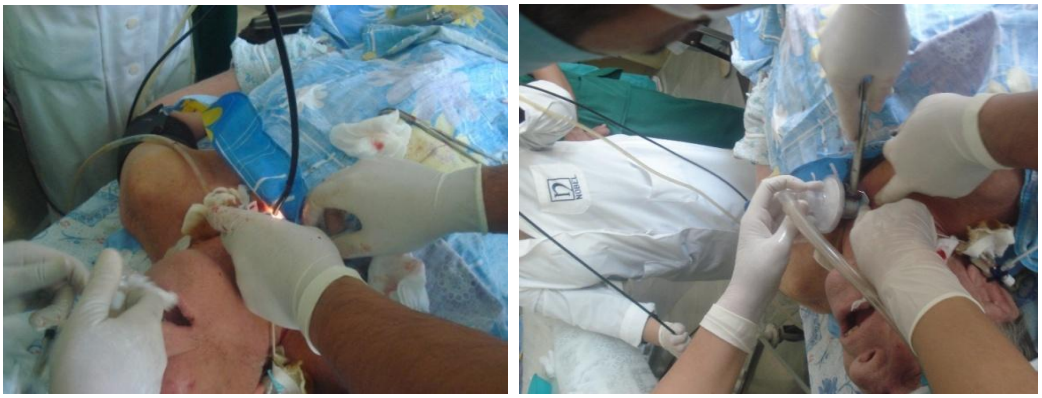

Figure 7. Photo of the stage of tracheostomy. A) Stage of bronchoscopic monitoring and rehabilitation through the installed tracheostomy tube and extubation of the patient. B) The stage of connecting the patient to the ventilator through a tracheostomy tube with fixation of the latter

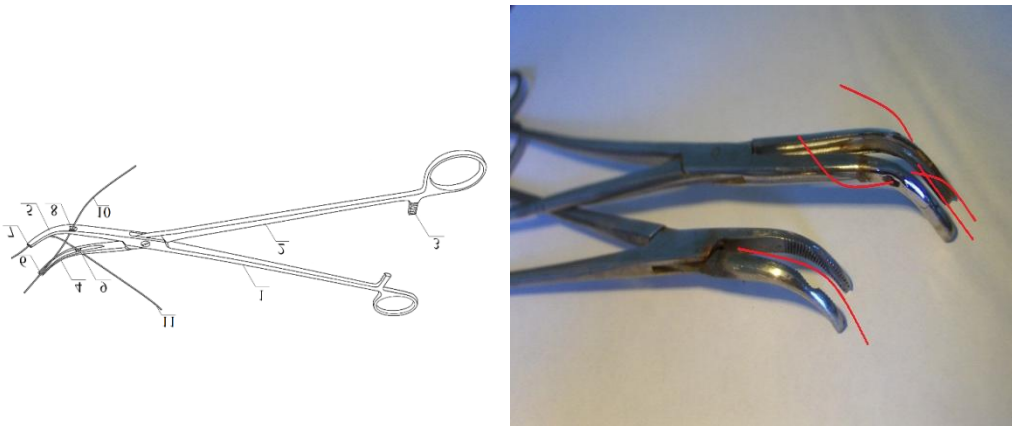

Figure 8. Layout and photo of utility model No. 2 of the author's forceps for performing a modified percutaneous dilatational tracheostomy

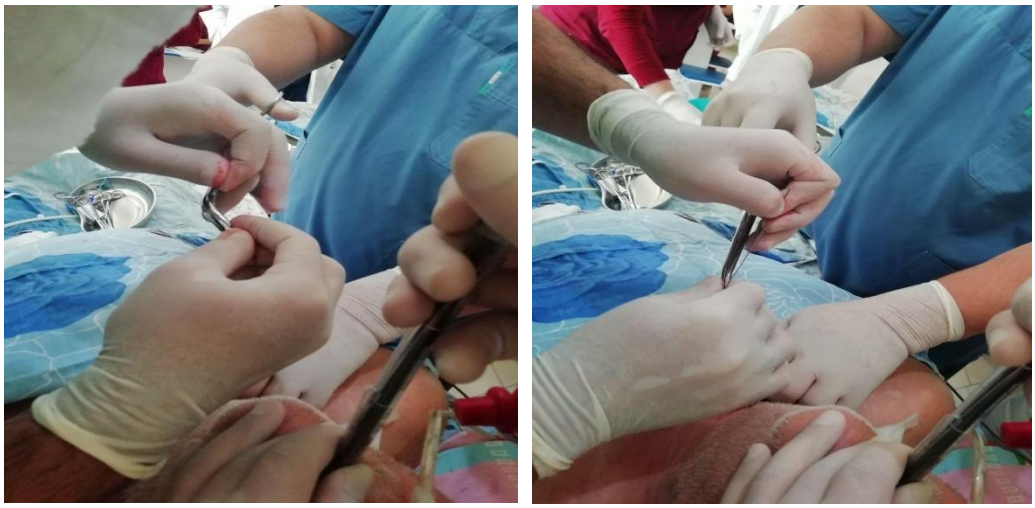

Figure 9. Photo of the stage of tracheostomy. Passing guidewire through holes in forceps jaws

The next stage is the main stage: dilatation of the trachea with a modified instrument (Fig. 6 A).

After dilatation of the trachea along the guidewire without technical difficulties, a tracheostomy tube of a predetermined size is installed and after that the guidewire is removed (Fig. 6 B).

The next stage is bronchoscopic debridement and control of the tracheostomy tube, after which the patient is extubated (Fig. 7 A).

And the final step is to connect the patient to the ventilator and fix the tracheostomy tube (Fig. 7 B).

However, in rare clinical situations associated with severe neck deformation with acquired torticollis (dermatogenic, neurogenic, hypoplastic, etc.) or with short neck syndrome (Cushing's syndrome, brachiostenomelia, spondylocostal dysostosis, etc.), even when using modified clamp (utility model No. 1) technical difficulties may appear (the dislocation of one of the branches past the tracheal wall). In this regard, it is proposed to use a modified forceps (utility model No. 2) with two side holes (in each of the branches of the instrument), each of which carries a thin metal guidewire (separate or twisted at the base and split for fixing in the holes). In Fig. 8 shows a diagram of this utility model and the appearance of a clip.

The method is performed in the same sequence as described above. We have used this utility model in three patients (in two with severe neck deformity of a dermatogenic nature associated with a previous burn and in one patient with a short neck due to Cushing's disease). In Fig. 9 shows the main stages of using utility model No. 2.

Here are some clinical examples of the implementation of the author's technique in patients on PMV.

Clinical example № 1. Patient O. 58 years old. Date of receipt: 11/22/16 Diagnosis: Multifacial atherosclerosis. Ischemic heart disease. Stable angina.

Date of operation: 12/02/2016. Operation: Mammaro-coronary artery bypass surgery.

Complication after surgery: Right PCA ischemic stroke. Cerebral edema.

On the 3rd day of PMV, the patient underwent a combined percutaneous dilatational tracheostomy by the author's method with bronchoscopic support.

Under general anesthesia, bronchoscopy was performed. Bronchoscopic control set the incubation tube at the appropriate level. Skin incision was carried out up to 1.0 cm above the jugular notch. Superficial fascia of the neck dilated

bluntly. The anterior surface of the trachea is exposed. In region 2nd half ring by needle made a puncture into the lumen of the trachea, a guidewire was passed through the needle. Through the guidewire, several boughes, the passage is somewhat widened and a forcep is installed along the guidewire, while the guidewire is fixed in the hole of the right jaw of the clamp, which is subsequently drawn into the lumen of the trachea and the tracheostomy opening is expanded. A tracheostomy tube No. 8.5 was installed along the guidewire without technical difficulties. The guidewire is removed, bronchoscopic control through the tracheostomy tube, the lumen is cleaned, the tube is in the trachea. Extubation completed. The tracheostomy tube is fixed and through it the patient is connected to the ventilator. Antibiotic. Wound dressing.

Clinical example № 2. Patient N. 79 years old. Date of receipt: 11/02/2019. Diagnosis: Gastric ulcer, complicated by recurrent bleeding (Forest 1A). Hemorrhagic shock. Shock lung (severe ARDS, pO2 / FO2 <100).

On the 3rd day of PMV, the patient underwent a combined percutaneous dilatational tracheostomy by the author's method with bronchoscopic support.

Under general anesthesia, bronchoscopy was performed. Bronchoscopic control installed the endotracheal tube at the appropriate level. Skin incision was carried out up to 1.0 cm above the jugular notch. Superficial fascia of the neck dilated bluntly. The anterior surface of the trachea is exposed. In region 2 nd half ring by needle made a puncture into the lumen of the trachea, a guidewire was passed through the needle. Through the guidewire, several boughes have a slightly widened passage (each of the split ends of the guidewire is fixed in the hole of each jaw of the clamp), and a clamp is installed along the guidewire, which is subsequently drawn into the lumen of the trachea and the wound is widened. A tracheostomy tube No. 8.0 was installed along the guidewire without technical difficulties. The guidewire is removed, bronchoscopic control through the tracheostomy tube, the lumen is sanitized, the tube is in the trachea. After installing the tube, subcutaneous emphysema of the face, neck and chest area is noted. A suture on the skin at the site of the incision around the tracheostomy tube is removed. During the observation in the dynamics of emphysema did not increase. Connected to the device. The tracheostomy tube is fixed. Antibiotic. Wound dressing.

Thus, as a result of the work, the advantages of using author's utility models over the traditional Howard-Kelly forceps were revealed: less traumatic tracheal tissue, bleeding and wound infection, due to the stable fixation of the guidewire even with open clamp branches, since the need for re-stringing of the clamp is eliminated to the guidewire. This technique is optimal for patients with obesity and a short neck, enlarged thyroid gland and in cases where there are difficulties with determining anatomical landmarks, while the use of a fibrobronchoscope is not mandatory, which does not exclude the possibility of its use if necessary.

3. Using Innovative New Generation of Tracheostomy Tubes

Today, requirements for manufacturers of medical supplies for tracheostomy, in particular for tracheostomy tubes, have significantly increased. This is mainly due to the effect of synthetic material on the mucous layer of the trachea with the formation of maceration and pressure sores, leading to hemorrhagic complications and the formation of fistulous passages between the trachea and esophagus (Fig. 10), between the trachea and vascular structures of the neck (Fig. 11).

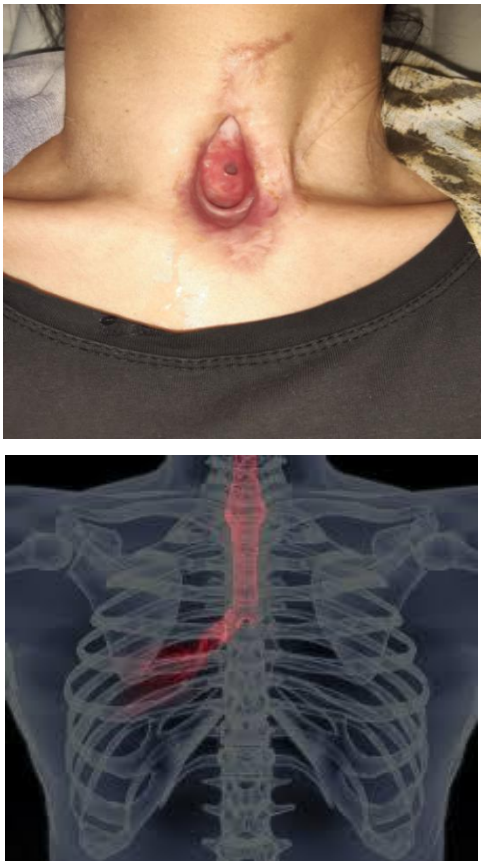

Figure 10. Photo and CT-scan. Tracheo-esophageal fistula

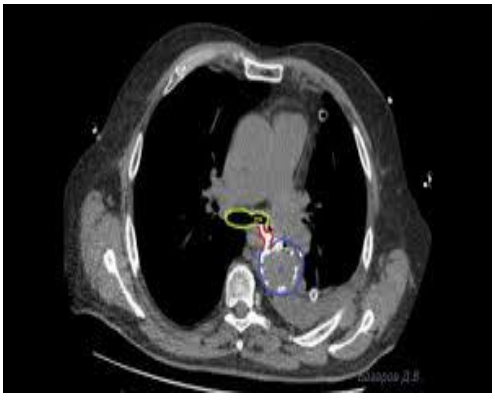

Figure 11. CT-scan. Tracheo-esophageal-vascular fistula

The emergence of a new generation of tracheostomy tubes of the Blue Line Ultra type with a Soft-Seal cuff with sanitation of the cuff space allows minimizing tracheal mucosa injury during prolonged interaction of foreign material with the latter (Fig. 12).

So, due to the original design of the low pressure cuff, high volume and resistant to nitrous oxide, after it is inflated, tight folds of all folds of the mucous membrane of the trachea are achieved, creating a really tight barrier and minimally affecting the mucous membrane of the trachea. When monitoring the pressure in the cuff, the risk of aspiration of the discharge decreases, and as a result of the development of many post-intubation complications.

Figure 12. Appearance of a new generation of tracheostomy tubes

It should be noted that such technical characteristics of these devices as the use of thermoplastic polyvinylchloroethylene with a radiopaque line and anatomical bending angle of the tube - 105°, as well as an open "window" for easy control of the tracheostomy. The floating design of attaching the fixing flange to the tube does not interfere with the displacements of the proximal end of the tube in the transverse direction, and the obturator with an internal channel allows the tubes to be replaced along the guidewire, which reduces the likelihood of stoma injury during insertion of the tube.

We used this type of tracheostomy tubes in 8 patients on PMV due to the development of multiple organ failure in the early postoperative period. Three patients were decanulated on the 5th day after the installation of the tracheostomy, two patients on the 10th day and three patients were discharged home on their own breathing through the tracheostomy tube. The endophoto (Fig. 13 and 14) of the condition of the tracheal mucosa after decanulation in patients on the 5th and 15th day after the tracheostomy are presented below.

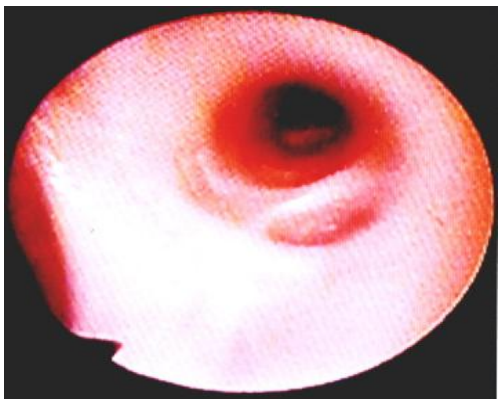

Figure 13. Tracheal mucosa after decanulation of the Blue Line Ultra tube with the Soft-Seal cuff 5 days after PDT. Catarrhal endotracheitis

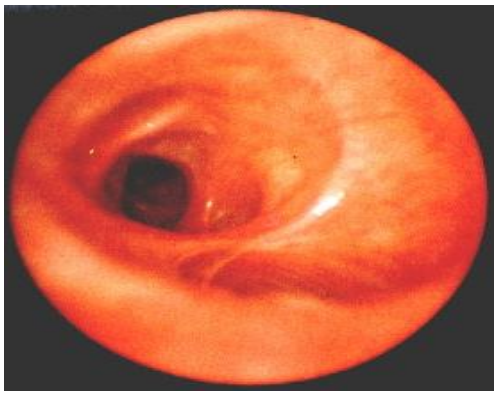

Figure 14. The mucous membrane of the trachea after the decanulation of the Blue Line Ultra tube with the Soft-Seal cuff 15 days after PDT. The picture of single small-point erosion on the background of catarrhal endotracheitis

4. Features of Treatment and Rehabilitation Measures after a Tracheostomy

One of the fundamental aspects of managing patients with a tracheostomy is treatment and rehabilitation measures, which must necessarily include:

- endovisual tracheobronchoscopic debridement of the secretion secretion, monitoring with monitoring the condition of the mucous membrane of the trachea and the study of the microbiological landscape in the secretion of the tracheobronchial secretion;
- periodic change of the tracheostomy tube (depending on the condition of the secretion) for 3-4 days;
- nebulization (2-3 times a day) with solutions of antiseptics and mucolytics (diluted 1: 4);
- the use of injection insufflation, which has several

advantages in the delivery of drugs, namely, safety and atraumaticity for the patient, the flow of drugs through the upper respiratory tract directly into the trachea and bronchi. The procedure can be carried out once a day with severe purulent-necrotic processes in the trachea and bronchi;

- the use of specific antibacterial solutions that have undergone experimental and clinical testing as antiseptics.

5. Conclusions

The improved method of percutaneous dilatational tracheostomy in patients undergoing prolonged mechanical ventilation is a unified method that, due to the stable fixation of the guidewire in the developed utility models, even with open clamp branches, prevents the occurrence of a false track that can occur due to background of severe deformation neck, helps reduce trauma to surrounding tissues and thereby reduces the number of complications.

The modified PDT technique using the author's utility models is recommended for patients with obesity and a short neck, an enlarged thyroid gland and in cases where there are difficulties in determining the anatomical landmark of patients with severe neck deformation associated with torticollis (dermatogenic, neurogenic, hypoplastic, etc.), while the use of a fibrobronchoscope is not mandatory, which does not exclude the possibility of its use if necessary.

To date, the use of a new Blue Line Ultra type tracheostomy tube with a Soft-Seal cuff with sanitation of the cuff space is recommended, which minimizes trauma to the tracheal mucosa during prolonged interaction of foreign material with the latter. At the same time, monitoring the pressure in the cuff reduces the risk of aspiration of the discharge, and as a result, the development of post-intubation complications.

In order to prevent and treat post-intubation purulent-septic pulmonary complications in patients with long-term use of the tracheostomy tube, the introduction of broad-spectrum antibiotics, antiseptics, bronchodilators and proteolytic enzymes into the tracheobronchial tree is recommended using the protocol of nebulizer or injection insufflation.

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