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A Rare Cause of Pneumomediastinum, Pneumothorax and Subcutaneous Emphysema After Performing Puncture-Dilation Tracheostomy

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ABSTRACT Tracheostomy is the most frequently performed operation in the intensive care unit. According to some data, the frequency of performance fluctuates within 0.1–0.5 cases per 1000 patients on artificial ventilation. In recent years, dilation techniques for applying a tracheostomy cannula have been actively developed due to their low trauma , the ability to perform the operation at the patient's bedside, and rapid healing of the tracheostomy wound. Today, the "gold standard" of tracheostomy is puncture-dilation tracheostomy under fiberoptic bronchoscopic guidance.

This method has its drawbacks, which is confirmed by a large number of complications. Thus, one of the complications of tracheostomy that is difficult to correct is the "gas" syndrome, which includes pneumomediastinum, subcutaneous emphysema and pneumothorax. These complications are considered to be a consequence of damage to the posterior wall of the trachea. Our clinical example demonstrates another mechanism for the development of the above complications.

We present a clinical example of the development of subcutaneous emphysema, pneumomediastinum and pneumothorax without damage to the posterior wall of the trachea.

Keywords: tracheostomy, puncture-dilation tracheostomy, pneumothorax, pneumomediastinum, subcutaneous emphysema, ultrasound guidance of tracheostomy
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ALV - artificial ventilation of the lungs
CO - chest organs
CT - computed tomography
FBS-guidance - fiber-optic bronchoscopic guidance
PDT - puncture-dilation tracheostomy
TST - tracheostomy tube

INTRODUCTION

Tracheostomy is a routine surgical intervention performed in intensive care units. The incidence of tracheostomy ranges from 0.1 to 0.5 cases per 1000 patients on mechanical ventilation (MV). In European countries, the number of tracheostomies is about 100,000 per year [1–4]. Indications for tracheostomy can be combined into two groups: the need for long-term mechanical ventilation and swallowing disorders requiring airway protection [2–5]. Tracheostomy helps to avoid damage to the larynx and vocal folds, which are typical for long-term tracheal intubation; creates comfortable conditions for airway sanitation; allows to significantly reduce or completely stop sedation to synchronize the patient with the ventilator; ensures early initiation of oral feeding and patient activation [6]. There are several methods of performing tracheostomy: open surgical tracheostomy and puncture-dilatation tracheostomy (PDT) according to the Griggs, Sigley or Frow method. When choosing a tracheostomy method, one should rely on the topographic and anatomical features of the patient's neck structure; this is necessary to predict possible technical difficulties during tracheostomy and complications. Currently, both open surgical and PDT are considered acceptable, but the latter has a number of advantages. This circumstance has led to more frequent use of PDT in intensive care practice [2, 7, 8].

Modern methods of performing PDT with fibrobronchoscopy guidance (FBS guidance) are quite safe. At the same time, various perioperative complications continue to be a pressing problem [9]. According to American statistical reports, perioperative complications of varying severity develop in a third of clinical observations [10].

Pneumomediastinum, pneumothorax, subcutaneous emphysema developing early after PDT are severe complications and can lead to death. As a rule, these complications are caused by iatrogenic damage to the posterior tracheal wall. We present a clinical observation of a patient who developed pneumomediastinum, pneumothorax, and subcutaneous emphysema after PDT without damage to the posterior tracheal wall.

Clinical example

Patient P., 80 years old, body mass index 23, was admitted to the clinic with a diagnosis of stage 3B myeloma and multiple foci of bone tissue destruction. In the specialized department, the patient developed respiratory failure, was transferred to the intensive care unit. The patient underwent computed tomography (CT) of the chest organs, which revealed bilateral polysegmental interstitial pneumonia. An express test for *COVID* -19 was performed, the result was positive. The severity of the patient's condition was due to a new coronavirus infection, the development of bilateral pneumonia and the presence of myeloma.

The patient had severe dyspnea, agitation, psychomotor agitation, and hypoxemia. A decision was made to intubate the trachea and transfer to mechanical ventilation. Given the predicted long-term mechanical ventilation, the patient underwent PDT using the Griggs method under FBS guidance. Under total intravenous anesthesia in the hyperextension position, the trachea was punctured with a needle-cannula. A flexible metal guidewire was inserted into

the cannula under FBS guidance. Then, using a Howard-Kelly clamp, a tracheostomy canal was formed through which a tracheostomy tube was installed. There were no technical difficulties in performing PDT.

After completion of the PDT, air was released through the mouth. And after 3 hours, subcutaneous emphysema of the soft tissues of the neck and upper chest developed. Bedside chest radiography (Fig. 1) and

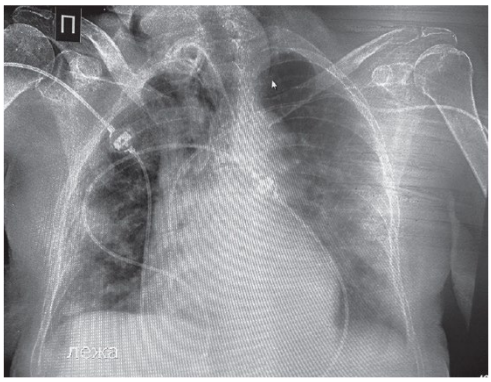

Fig. 1. Chest X-ray (lying down)

Fig. 2. Computed tomography of the chest and neck (sagittal plane): subcutaneous emphysema and pneumomediastinum

CT examination of the chest and neck (Fig. 2) were performed.

According to the CT scan results, the distal end of the tracheostomy tube (TT) was in the tracheal lumen, but the cannula cuff was located in the area of the anterior tracheal wall defect. The area of the anterior tracheal wall through which the tracheal lumen communicated with the mediastinum was visualized. Subcutaneous emphysema, pneumomediastinum, and bilateral pneumothorax were detected, more pronounced on the left (Fig. 2). Taking into account the CT scan data, the standard tracheostomy tube was replaced with a cannula with adjustable length and a movable flange. The cannula was positioned under FBS guidance. Drainage of the pleural cavity on the left with active aspiration was performed. Antimicrobial drugs were added to the therapy based on the results of microbiological studies. Gradually, over the next two days, the patient's condition stabilized, the symptoms of respiratory failure regressed, and no air discharge was observed. On the 3rd day, positive dynamics were noted in the form of complete relief of bilateral pneumothorax, minor manifestations of subcutaneous emphysema remained. There were no further difficulties with mechanical ventilation. Against the background of the therapy carried out for 3 weeks, positive dynamics were noted in the form of regression of clinical and laboratory-instrumental manifestations of *COVID* -19 pneumonia, the patient's transfer to spontaneous breathing.

In connection with the identified neoplastic disease, an oncological consultation was held, which recommended symptomatic therapy in the palliative care department.

DISCUSSION

PDT is the most frequently performed operation in the intensive care unit. Our clinical example confirms that a smooth course of the intraoperative period of PDT performed under FBS guidance does not guarantee the absence of the possibility of developing severe perioperative complications. Today, the "gold standard" of tracheostomy in the intensive care unit is PDT under FBS guidance. However, this method does not allow for adequate determination of the depth of the trachea and, accordingly, selection of the required size of the tracheostomy cannula. The presented clinical observation illustrates a patient who had a deep trachea even in the hyperextension position (Fig. 4). This is due to age-related changes, since in elderly patients the trachea has a more horizontal position and most of the trachea is in the chest (Fig. 5) [11, 12]. In addition to age-related changes, our patient had a concomitant pathology in the form of myeloma disease with numerous destructive changes in the bone tissue of the spine with a decrease in the size of the vertebrae and a change in the axis of the spine. This led to an even greater posterior displacement of the trachea.

In the given observation, early postoperative complications such as pneumomediastinum, subcutaneous emphysema and bilateral pneumothorax developed. A typical cause of these complications is injury to the posterior tracheal wall. This injury is difficult to correct in patients requiring mechanical ventilation [2–5, 13]. Stenting or direct surgical correction are often unsuccessful, and the outcome is fatal [14]. In our observation, the cause of the complications that developed was a defect in the anterior tracheal wall. Performing a tracheostomy involves the formation of a defect in the anterior tracheal wall. This is a normal course of surgical intervention. In this regard, the adequacy of the dimensions of the TST established to the thickness of the pretracheal soft tissues is the main factor that determines the likelihood of developing a pathological anastomosis between the trachea and mediastinum through the anterior tracheal wall. The thickness of the pretracheal tissues can be objectively assessed by ultrasound examination (US). Together with the assessment of the depth of the trachea, the ultrasound method allows visualization of aberrant vessels in the projection of the puncture and operation and assessment of the diameter of the vessels, which contributes to better control and safety of all stages of the operation. Over time, this control method is becoming popular. Previously, we published works in which we described various aspects of the advantage of the ultrasound-assisted control of the safety of performing PDT [15-18].

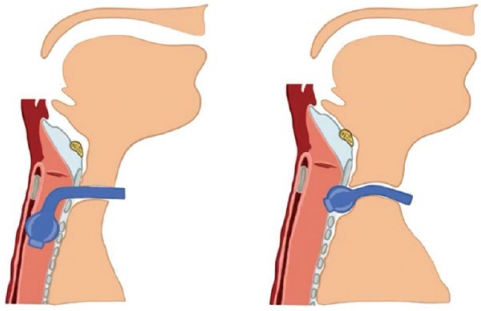

Fig. 3. Schematic location of the tracheostomy tube in the presented observation (on the right) and the normal location – on the left

Fig. 4. Computed tomography of the chest and neck (sagittal plane)

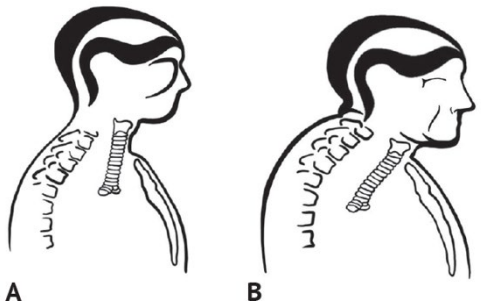

Fig. 5. Variants of the trachea location depending on age: A — in a young person; B - in an elderly person

CONCLUSION

Thus, the presented observation illustrates a patient in whom the cause of subcutaneous emphysema, pneumothorax and pneumomediastinum developed after puncture-dilation tracheostomy was the anastomosis between the mediastinum and trachea through the anterior wall of the trachea and the inadequate size of the tracheostomy cannula. This cause of the complications that developed is rare, since usually subcutaneous emphysema, pneumomediastinum and pneumothorax are the result of damage to the posterior wall of the trachea. The development of complications in the presented observation would probably have been avoided by performing puncture-dilation tracheostomy under ultrasound control. The use of this technique is a promising direction for optimizing the technique of puncture-dilation tracheostomy, which can improve the results of this surgical intervention.

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