Research Article

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Endoscopic Diagnosis and Treatment of Iatrogenic Ruptures of the Trachea

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ABSTRACT Respiratory tract trauma is not only the result of injuries to the chest and neck, but may be iatrogenic as well. Diagnosis of iatrogenic damage to the trachea is based on data from clinical and instrumental studies. Among the instrumental diagnostic measures, preference is given to early fibrobronchoscopy.

THE AIM of the study is to assess the possibilities of fiberoptic bronchoscopy in the diagnosis of iatrogenic tracheal injuries. Materials and methods. This study analyzed the use of fiberoptic bronchoscopy in 51 patients with suspected iatrogenic damage to the trachea. For iatrogenic ruptures of the trachea, the location on the posterior (membranous) wall and the longitudinal direction (100%), as well as location in the lower and middle thoracic sections of the trachea (71.4%), are typical.

CONCLUSION Bronchoscopy is a direct method for diagnosing this type of damage, which allows the location, size of the defect and tactics to be accurately determined.

Keywords: fiberoptic bronchoscopy, iatrogenic tracheal ruptures

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ALV – artificial lung ventilation
CT – computed tomography
ETT – endotracheal tube
FBS – fibrobronchoscopy
TST – tracheostomy tube

Injuries to the airways are not only the result of trauma to the chest and neck, but may be iatrogenic as well. The most common are ruptures of the trachea that occurred during tracheal intubation and tracheostomy [1, 2].

Tracheal injuries occur in 0.05–0.37% of all intubations performed in a hospital [3, 4]. However, the actual incidence of tracheal injury associated with intubation and mechanical ventilation (ALV) is only difficult to assess, since superficial ruptures that do not cause either soft tissue emphysema or bleeding remain unrecognized without endoscopic examination [5-8].

The risk of tracheal injury increases with emergency intubation, in conditions of time limit. Along with this, ruptures are also possible with “routine” planned intubation. At the same time, it is possible when working with both young anesthesiologists-resuscitators and experienced specialists who have been performing this manipulation for many years every day [9].

Iatrogenic injuries of the trachea are more often associated with the anatomical and topographic features of the patient, rough intubation, multiple attempts of intubation, mismatch between the size of the endotracheal tube (ETT) and the diameter of the trachea, the use of rigid conductors, sometimes protruding from the lumen of the tube [10–12].

Other risk factors for tracheal injury during intubation include age (over 50 and under 16) and female gender [13, 14].

The diagnosis of iatrogenic trauma is based on data from clinical and instrumental studies. Among instrumental methods, preference is given to early fibrobronchoscopy (FBS) as the most effective method for diagnosing tracheal damage and computed tomography (CT) [15–17]. In addition, FBS allows you to obtain complete information about the exact location, extent and depth of the defect and also choose the right tactics and access in case of surgery [18].

Due to the iatrogenic nature of post-intubation tracheal injuries, there are few publications on their diagnosis and treatment. Most publications present single observations, which provide various causes and possible mechanisms of their occurrence, ambiguous indications for the choice of treatment tactics. A significant number of reports that have appeared only in recent years indicate an increased interest in the prevention, diagnosis and treatment of this very rare complication of modern endotracheal anesthesia.

Aim of study: an assessment of the possibilities of bronchoscopy in the diagnosis and treatment of iatrogenic injuries of the trachea.

MATERIAL AND METHODS

The analysis of the results of endoscopic diagnosis and treatment of 51 patients with suspected iatrogenic damage to the trachea in the period from 2001 to 2019 was carried out. Twenty-five patients (49.02%) were transferred to the institute from other medical institutions. The time between the injury of the trachea and admission ranged from several hours to 4 days. Twenty-six patients (50.98%) were treated at the Institute for diseases and injuries. There were 45 women (88.23%) and 6 men. The age of the patients varied from 27 to 91 years, the average age was 51.5+3.7 years.

In the vast majority of cases (39-76.47%), iatrogenic tracheal injuries occurred after tracheal intubation, in 11 patients (21.57%) due to tracheostomy, and in 1 case (1.96%) after the planned esophagogastroduodenoscopy.

Out of 51 patients, in 20 cases (39.22%), iatrogenic tracheal trauma was associated with intubation, which was performed according to emergency indications. In 19 patients (37.25%), a complication occurred during planned intubation. In 11 (21.57%) cases, it developed during the imposition of a tracheostomy for prolonged artificial lung ventilation (ALV), and in 1 (1.96%) case the trauma occurred during the planned gastroscopy.

Twenty-two patients (43.14%) were on mechanical ventilation through ETT or tracheostomy tube (TST). On examination, in all cases, the presence of emphysema of the face, neck and chest was noted.

Pain in the neck, shortness of breath, bleeding, hoarseness and shortness of breath were noted only in 9 patients (17.65%). In 27 patients out of 29 who were breathing independently, the time between the moment of extubation to the onset of symptoms and diagnosis ranged from 1 hour to 1 day. In the reported observation the diagnosis was established intraoperatively on the 2nd day. The operation was performed for suspected instrumental rupture of the esophagus. The absence of damage to the esophagus made it necessary to perform FBS intraoperatively, during which a rupture of the trachea was revealed.

In 22 ventilated patients, the time from symptom onset to diagnosis ranged from 30 minutes to 4 days.

Upon examination, the presence of emphysema of the face, neck or chest was noted in 45 patients (88.23%). In 4 cases, emphysema spread to the anterior abdominal wall and inguinal regions. In 6 cases, emphysema was not visually determined. These were patients after tracheostomy on mechanical ventilation, and tracheal defects in them were detected by chance during sanitation bronchoscopy. It should be noted that the appearance of symptoms such as emphysema was noted only after the transfer of patients to spontaneous breathing and extubation of the trachea or in the first hours after intubation or tracheostomy.

X-ray examination before FBS was performed in 40 patients (78.43%). Emphysema of the neck, chest and mediastinum was diagnosed in 21 patients. In 2 patients, only subcutaneous emphysema of the chest was revealed. In 2 cases, atelectasis of the upper lobe and discoid atelectasis were noted in the basal segments of the right lung. Subsequent FBS revealed small tracheal defects in both cases. In 15 cases, pathology of the chest organs was not established.

Chest and neck CT was performed in 14 patients. In 10 cases, CT examination was performed before FBS. In 9 patients, severe tissue emphysema of the neck, chest wall and mediastinum was determined. In 4 of these patients, the presence of a tracheal defect was suggested, and in another 1 observation, an esophageal defect was suggested, without specifying the possible location and size. In 2 cases, in addition to severe emphysema, signs of mediastinitis were found. In 1 patient, CT signs of thickening of the posterior mediastinal tissue were revealed, possibly due to hemorrhagic impregnation.

FBS was performed according to the standard technique under local anesthesia or intravenous sedation using *BF*-160, *BF-XT* 160 video endoscopes and *BF*-30-60, *BF*-1 *T* 30 fiberoptic bronchoscopes from *OLYMPUS*. When performing a study through ETT or TST, the examination was performed according to the following method. First, FBS was performed through ETT or TST with examination of the distal part of the trachea (below the distal end of the tube). If necessary, a thorough sanitation of the tracheobronchial tree was carried out in order to remove the pathological contents, which, if thrown from the distal sections of the bronchial tree into the trachea during the study, could interfere with a full examination.

When examining through TST, the distal end of the bronchoscope was withdrawn 1.0–1.5 cm from the distal end of the tube. After that, the TST cuff was deflated, the bronchoscope was fixed to the tube by hand and, while removing them, the tracheal walls were examined. The bronchoscope and tube were removed to the level of the anterior wall of the trachea in the tracheostomy canal. After that, the TST was placed in place using the bronchoscope. In patients with ETT, FBS was performed according to the same method, with the only difference that ETT was removed with a bronchoscope to the level of the vocal cords. After that, standard intubation was performed using a bronchoscope.

In patients undergoing surgery on the trachea, under the control of FBS, the end of the ETT was placed above the proximal end of the tracheal suture line to prevent inflation of the suture line area with the ETT cuff. In patients without surgery and in need of prolonged mechanical ventilation, the distal end of the ETT or TST was placed 3–4 cm below the distal edge of the tear with moderate inflation of the cuff to prevent an increase in the length of the tear.

In 4 cases, when the distal edge of the rupture was located directly above the carina, or the rupture continued into the right main bronchus under the control of FBS, one-lung intubation was performed.

During FBS, the condition of the mucous membrane of the trachea and bronchi, the location and size of the defect in the tracheal wall were assessed. When determining the location of the rupture of the trachea, we used the subdivision of the thoracic trachea, which was proposed by B.V. Petrovsky et al. [6].

RESULTS

In FBS tracheal wall defects were detected in 49 patients (96.08%). In 2 cases, no defects of the tracheal mucosa were found. In 1 patient, there was a submucosal hematoma of the subglottic part of the larynx measuring 1.5×1 cm without violating the integrity of the mucous membrane. In the 2nd case, grade 1–2 dystonia of the cervical trachea and multiple submucosal hematomas of the membranous part of the trachea were detected.

All tracheal defects were located on the posterior (membranous) wall and the direction of all ruptures was longitudinal. In 17 cases (34.69%) out of 49, the distal edge of the rupture was located at a distance of no more than 1 cm from the carina, in the lower thoracic trachea, including 1 patient after tracheostomy. Moreover, in 6 patients, the gap extended to the right main bronchus and in 1 patient – to the left main bronchus. In 16 patients, the location of the distal edge of the rupture was within 1–3 cm from the carina, also in the lower thoracic region. In 11 cases, the rupture was located within 3–6 cm from the carina in the midthoracic region, and in 5 patients the ruptures were located opposite the tracheostomy, that is, 7–8 cm above the carina, in the upper thoracic region.

The length of ruptures up to 1 cm was revealed in 3 patients, from 1 to 3 cm – in 18 (36.73%) patients, from 3 to 5 cm – in 22 (44.9%) patients and in 6 cases the length of the gap exceeded 5 cm. Width defects up to 1 cm were noted in 29 patients (59.18%) and more than 1 cm in 13 cases. The maximum width of the defect reached 1.5 cm and was diagnosed in 20 patients (40.82%). The depth of defects in the tracheal wall was 0.2–0.5 cm.

In 4 cases, the depth exceeded 0.5 cm, and with a defect length of more than 3 cm and a defect width of more than 1 cm, prolapse of the underlying tissues into the lumen of the trachea by 1/3–2/3 of the tracheal circumference was noted. In one case, after the imposition of a tracheostomy with a small length and width of the defect (1.5 × 0.8 cm), there was a false passage along the posterior right wall in the tissue of the mediastinum

5–7 cm long, which, apparently, was formed at the time of the tracheal cannulation attempt. Insignificant diapedetic bleeding from the bottom of the defect was noted only in 2 cases.

In 26 cases (53.06%), conservative therapy was performed without tracheal intubation after the diagnosis of the defect. In 8 patients (30.76%), there were no clinical and radiographic manifestations of tracheal rupture, and only FBS made it possible to establish the diagnosis.

FBS-controlled ETT was installed in 23 patients (46.94%), including 7 operated patients intraoperatively. When the rupture was localized in the area of the carina (2 patients), the ETT was installed in the right or left main bronchi. In a patient with a rupture of the right main bronchus - respectively, into the left main bronchus. In 4 patients with the localization of the rupture in the midthoracic trachea, the ETT or TST under the control of the endoscope were installed below the distal edge of the rupture.

Seven patients (14.28%) were operated on. All patients underwent right-sided thoracotomy and suturing of tracheal defects with covering the suture line with an intercostal-periosteal flap. In 3 cases, when the distal edge of the trachea was located 2.5–3 cm above the carina, the operation was completed with the installation of an ETT under the control of an endoscope below the distal edge of the rupture. Two patients, whose distal edge of the rupture was above the carina, underwent plastic surgery of the trachea on a *T*-shaped tube.

Seven patients died (14.28%), of which only 2 were operated on. Upon autopsy, the presence of iatrogenic damage to the trachea was confirmed in all of them. The location of these lesions fully corresponded to the data obtained during FBS. The cause of death in 6 cases was the underlying disease or its complications: 2 cases of impaired cerebral circulation, one case of a closed craniocerebral injury, one case of poisoning with psychotropic drugs, one case of stab wounds of the chest, and one case of stage 4 cancer of the right ovary. Only in 1 case, the cause of death was mediastinitis, which developed as a result of iatrogenic rupture of the trachea.

RESULTS AND DISCUSSION

The probability of tracheal rupture increases with urgent intubation [10, 11]. At the same time, the study by *T. Gil et al.* [19] showed that in most cases, injuries occurred during elective surgery and intubation. According to the results of our study, only in 19 cases (38.77%) iatrogenic damage to the trachea was associated with intubation, which was performed in an emergency. In 18 patients (36.73%), the complication occurred during planned intubation. In 11 (22.45%) cases it occurred when applying a tracheostomy for prolonged mechanical ventilation. That is, according to our observations, iatrogenic injuries of the trachea in a planned situation are more common, which confirms the data of *T. Gil et al.* on the prevalence of iatrogenic damage to the trachea during planned work.

The diagnosis of iatrogenic damage to the trachea is based on data from clinical and instrumental studies. The latter are of primary importance, since they allow you to reliably and accurately determine the location and nature of the damage. In our study, the presence of indirect signs of damage to the trachea during X-ray examination was detected in 25 patients (62.5%) out of 40. No pathology was found in other observations. CT examination revealed indirect signs of tracheal injury in almost 100% of cases. However, the presence tracheal injury, its exact location and size were indicated only in 60% of patients.

FBS made it possible to detect defects in the tracheal wall in 49 patients (96.08%), and in 2 cases no trauma was found. In 1 patient, there was a submucosal hematoma of the subglottic part of the larynx measuring 1.5×1 cm without violating the integrity of the mucous membrane. In the 2nd observation, tracheal dystonia of the 1st–2nd degree and multiple submucosal hematomas of the membranous part of the trachea were revealed. The location of ruptures in the lower and middle thoracic sections of the trachea was typical in 44 patients (89.79%) with defects in the membranous part from 1 to 3 cm in 18 patients (36.73%) and from 3 to 5 cm in 22 cases (44.9%), which coincides with the literature data [20, 21]. It should be noted that in 34 cases (69.39%), the location of defects involved two parts of the trachea, and in 6 patients (12.24%), the rupture extended to the right main bronchus and in 1 patient, to the left main bronchus. In our study, the information content of FBS for the purpose of diagnosing a tracheal rupture itself, its location and size was 100%.

Currently, there is no single approach to the treatment of patients with iatrogenic tracheal injuries [18, 22]. For a long time, exclusively surgical methods prevailed in the treatment of iatrogenic injuries of the trachea, despite the high risk of intervention [18, 23]. Recently, the number of publications in which preference is given to methods of conservative therapy has increased significantly [5, 24, 25]. According to some authors, tracheal intubation on a fiberoptic bronchoscope should be considered the first aid in case of tracheal rupture, since this

manipulation allows the ETT to be placed caudal to the airway defect, which provides adequate ventilation and isolates the rupture from the paratracheal space [5, 26, 27].

Our data suggest that not only short and superficial ruptures can be successfully treated with conservative therapy. In this case, the size of the defect can be 4.0×1.5×1.0 cm. In addition, patients who need mechanical ventilation or cannot be operated on due to the severity of the condition are subject to conservative treatment — installation of ETT or TST under endoscopic control below the site rupture, if necessary, even in the main bronchi with daily sanitation bronchoscopy.

Therefore, the assertion of some authors [28] that patients who are in a stable condition, with short and superficial ruptures with minimal clinical manifestations without their progression, such as subcutaneous emphysema, pneumomendiastinum, and pneumothorax, are subject to conservative treatment, is not entirely justified.

CONCLUSION

1. Bronchoscopy is a direct method for diagnosing iatrogenic injuries of the trachea, which allows you to accurately determine the location, size of the defect and determine the tactics of managing this category of patients. Its efficiency reaches 100%.

2. For iatrogenic ruptures of the trachea, the location on the posterior (membranous) wall and the longitudinal direction (100% of cases), as well as location in the lower and middle thoracic sections of the trachea (89.79% of cases) are typical.

3. Patients who need mechanical ventilation or who cannot be operated on due to the severity of the condition are subject to conservative treatment — the installation of an endoscopic or tracheostomy tube under endoscopic control below the rupture site, if necessary, even in the main bronchi with daily sanitation bronchoscopy.

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