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Possibilities of Endoscopic Diagnosis of Airway Burn in Inhalation Trauma

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ABSTRACT The diagnostic standard for airway burn in inhalation trauma is bronchoscopy. Determining the severity of a burn of the respiratory tract within first 24 hours is difficult due to the multiple foci of fixed soot, therefore, this procedure is possible only after its removal. Optimization of the standard method of sanitation bronchoscopy in case of airway burn by removing soot with endoscopic forceps and brushes significantly increase the efficacy of primary endoscopic diagnosis, which amounts to 74.9%. The most common mistakes in diagnosing the severity of mucosal damage are associated with a burn of the 1st degree.

Key words: inhalation trauma, airway burn, bronchoscopy, optimization of the standard technique of sanitation bronchoscopy

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AB — airway burn

b.s. — body surface

IT — inhalation trauma

TBT — tracheobronchial tree

INTRODUCTION

Inhalation trauma (IT) is a multifactorial injury to the human respiratory system when inhaling hot air and smoke, which is based on damage to the mucous membrane of the respiratory tract, lung parenchyma, and the general toxic effect of combustion products on the human body [1–4].

Bronchoscopy is recognized as the gold standard for the diagnosis of airway burns (AB) in IT, which makes it possible to assess the severity of damage to the mucous membranes of the airways [5–10]. Difficulties in endoscopic diagnosis of the severity of AB on the 1st day after injury are associated with the impossibility of visualizing the mucous membrane, which in most cases is covered with soot deposits. The mucous membrane is cleared of soot only by day 5–7 [11]. So, according to G.A. Mayorov (2005), the efficiency of primary endoscopic diagnostics is 57.3% [12].

Aim of study: to evaluate the effectiveness of primary diagnostic bronchoscopy in patients with burns of the respiratory tract mucosa during IT.

MATERIAL AND METHODS

From 2013 to 2017, 344 patients with IT were treated at the Moscow Burn Center of the N.V. Sklifosovsky Research Institute for Emergency Medicine. The study included 179 patients who underwent two or more diagnostic bronchoscopies.

There were 99 (55.3%) men and 80 (44.7%) women. The patients' age ranged from 16 to 90 years, the median age was 55 years. IT was isolated in 79 patients (44.1%) and was combined with skin burns in 100 patients (55.9%). The total area of skin burns ranged from 0.1 to 80% of the body surface (b.s.), the median was 13% b.s.

Endoscopic diagnosis of AB was based on the classification suggested by Y.V. Sinev and A. Y. Skripal, according to which there are four degrees of severity, depending on the depth of damage to the mucous membrane: catarrhal (1st), erosive (2nd), ulcerative (3rd), and necrotic (4th) [13].

All patients with AB underwent primary diagnostic and therapeutic bronchoscopy within first 3 hours after hospitalization in the course of intensive therapy according to the standard method through the upper respiratory tract, performing irrigation of the mucous membrane of the epiglottis, vocal folds and carina with 2% lidocaine solution at a dose of 6.0 ml, or through an endotracheal tube under intravenous sedation [14]. A 0.01% solution of dioxidine or miramistin in a volume of 80 ml was used as a sanitizing solution. We have optimized the standard procedure for the rehabilitation of bronchoscopy in the case of AB. The first step was

washing off soot casts from the mucous membrane with antiseptic solutions. Then, while maintaining the deposition of soot on the mucous membrane, they proceeded to the second stage, which consisted in mechanical removal of soot using endoscopic forceps and brushes. Endoscopic forceps captured the soot casts and removed it, and in the case of using an endoscopic brush, traction movements were performed with the brush, which made it possible to mechanically clean the mucous membrane from soot. Repeated diagnostic and therapeutic bronchoscopies were performed every 24 hours until the mucous membrane of the tracheobronchial tree (TBT) was completely cleared of soot.

RESEARCH RESULTS

In primary diagnostic bronchoscopy, 1st degree AB was detected in 18 patients (10.1%), 2nd AB – in 138 (77.1%), 3rd AB – in 21 (11.7%), and 4th degree AB – in 2 (1.1%) (see Table).

Table

Primary and final endoscopic diagnosis of the degree of airway burn severity

| Degree of burn | Primary BS | Repeated BS | | | |
|----------------|-----------------------|-----------------------|------|-------------------------|------|
| | Number of patients, n | Diagnosis confirmed | | Diagnosis not confirmed | |
| | | Number of patients, n | % | Number of patients, n | % |
| 1 | 18 | 7 | 38.9 | 11 | 61.1 |
| 2 | 138 | 109 | 79.0 | 29 | 21.0 |
| 3 | 21 | 16 | 76.2 | 5 | 23.8 |
| 4 | 2 | 2 | 100 | 0 | 0 |
| Total | 179 | 134 | 74.9 | 45 | 25.1 |

The endoscopic picture of AB of the 1st degree and severity in primary bronchoscopy was characterized by a moderate or large amount of liquid mucous secretion with an admixture of soot in the lumen of the TBT. The mucous membrane of the larynx, trachea and bronchi was hyperemic, edematous, soot deposition was partially or completely removed during debridement (Fig. 1).

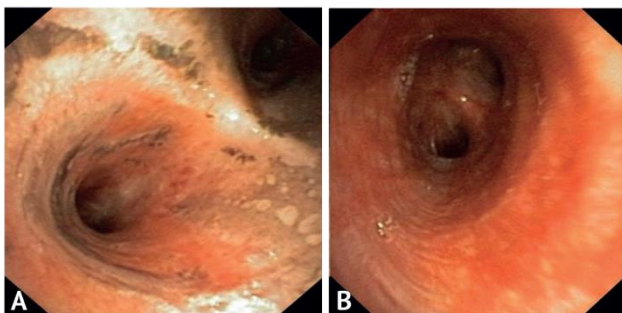


Fig. 1. Endoscopic view of the 1st degree airway burn.

A — the mucous membrane of the bronchi is covered with drainage soot; B — the soot is completely removed during sanitation bronchoscopy

After repeated bronchoscopy, the diagnosis of 1st degree AB was confirmed only in 7 patients (38.9%) out of 18, and in 11 (61.1%) after complete removal of soot foci, acute erosions were revealed and the 1st degree of AB was changed to 2nd.

For AB of the 2nd severity, a small or moderate amount of viscous mucous secretion with an admixture of soot in the lumen of the TBT was characteristic. The mucous membrane of the TBT was brightly or moderately hyperemic, slightly or moderately edematous, with multiple foci of fixed soot and confluent lesions, which were partially or completely removed during sanitation. With the complete removal of soot, multiple acute erosions with a clean bottom or covered with a light thin layer of fibrin were visualized (Fig. 2). After repeated bronchoscopy, grade 2 AB was confirmed in 109 (79%) patients out of 138 (see Table).

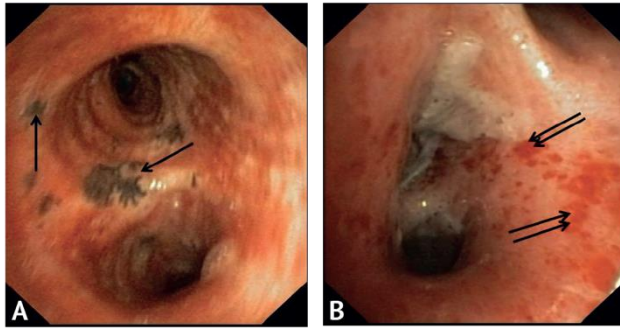


Fig. 2. Endoscopic view of the 2nd degree airway burn.

A - foci of fixed soot on the mucous membrane (single arrow); B - multiple acute erosion of the mucous membrane after the removal of soot (double arrow)

In 29 patients (21.0%), the diagnosis of 2nd degree AB was not confirmed with repeated bronchoscopy. In 6 patients (20.7%) out of 29 we failed to completely remove soot during the first endoscopic examination, so it was removed during repeated bronchoscopy: no damage to the mucous membrane was found, and the 2nd degree AB was changed to 1st. In 23 patients (79.3%) of 29, after the removal of soot, superficial ulcerative defects without clear contours were visualized: the 2nd degree of AB was changed to the 3rd degree (see Table).

In patients with grade 3 AB, no discharge was found in the lumen of the trachea and bronchi. The mucous membrane of the trachea and bronchi was covered with multiple confluent deposits of fixed soot, which was difficult to remove by bronchoscopy. Mucous membrane of the respiratory tract was pale or slightly hyperemic, "dry", the edema was not expressed. The soot was not removed in any patient during the initial endoscopic examination. After repeated bronchoscopy and complete removal of soot on the mucous membrane, superficial ulcerative defects were determined: grade 3 AB was confirmed in 16 patients (76.2%) out of 21 (Fig. 3). When erosions were detected and there was no ulcerative lesion of the mucous membrane, the 3rd degree of AB was changed to 2nd in 5 patients (23.8%) (see Table).

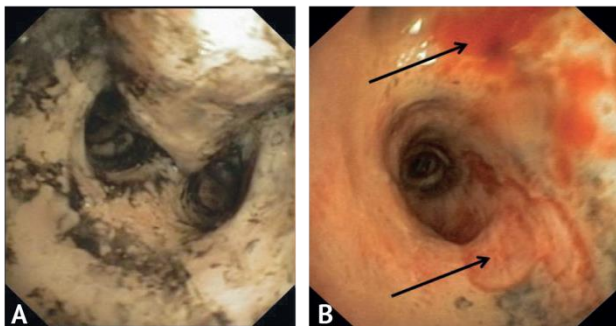


Fig. 3. Endoscopic view of the 3rd degree airway burn. A — the pale mucous membrane of the TBT with tightly fixed soot overlay; B — after the removal of soot, multiple ulcerative defects are visualized (single arrow)

The endoscopic picture of grade 4 AB at the initial examination was characterized by the absence of the walls of the trachea and bronchi were covered with a dense grayish-black eschar, which was not removed during debridement (Fig. 4). After primary bronchoscopy, grade 4 AB was accurately diagnosed in 2 patients on day 1.

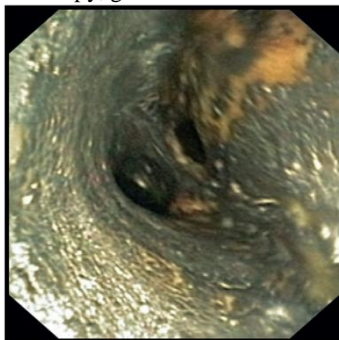


Fig. 4. Endoscopic view of the 4th degree airway burn. Grayish-black eschar covers bronchial walls

In general, the degree of AB was initially confirmed in 134 patients (74.9%), and in 45 patients (25.1%) during primary bronchoscopy, it was not possible to remove soot completely and the degree of AB was corrected with secondary bronchoscopies. In 34 patients (75.6%) of 45, after complete removal of soot, the degree of AB was changed to a more severe one.

Among 179 patients, grade 1 AB was finally diagnosed in 13 patients (7.2%), grade 2 AB – in 125 (69.8%), grade 3 AB – in 39 (21.8%), 4th degree AB – in 2 patients (1.2%) (see table).

We studied the timing of complete cleansing of the mucous membrane of the TBT from soot in case of AB of the 1st, 2nd and 3rd degrees of severity (Fig. 5).

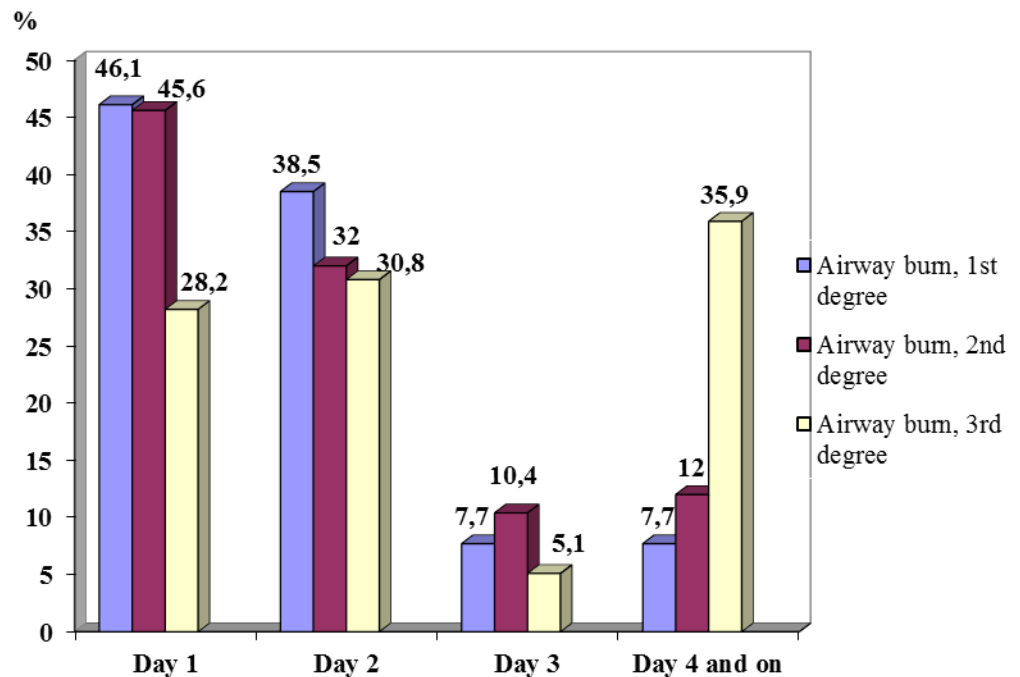


Fig. 5. Terms required for the mucosal recovery of soot, with varying degrees of airway burn severity

In 1st degree AB, on the 1st day, the mucous membrane of the respiratory tract was washed and cleaned from soot in 6 patients (46.1%), on the 2nd – in 5 (38.5%), on the 3rd – in 1 (7.7%) and on the 4th day also in 1 patient (7.7%). As it turned out, even with 1st degree AB, we failed to remove soot more than in 15% of patients fail within first 2 days.

In AB of the 2nd degree on the 1st day, the mucous membrane of the respiratory tract was washed and cleared of soot in 57 patients (45.6%), on the 2nd – in 40 (32.0%), on the 3rd – in 13 (10.4%). It took more than 4 days to remove soot in case of 2nd degree AB in 15 patients (12.0%).

With grade 3 AB, the soot was removed in 11 patients (28.2%) on the 1st day, on the 2nd day – in 12 (30.8%), on the 3rd day – in 2 patients (5.1%). It took more than 4 days to remove soot from the mucous membrane of the TBT in 14 patients (35.9%).

Thus, in AB of the 1st and 2nd degrees, the mucous membrane of the respiratory tract was cleared of soot on the 1st and 2nd days after injury in most patients (92.3% and 88%, respectively). With AB of the 3rd degree, the period of cleansing the mucous membrane from soot in the first 2 days was only 64.1%, and in 1/3 of patients (35.9%) – 4 days or more.

THE DISCUSSION OF THE RESULTS

The chemical factor plays an important role in the pathogenesis of damage to the mucous membrane of TBT. In a fire in an enclosed space, the resulting combustion products are diverse and are always individual in chemical composition. Getting into the lumen of the trachea and bronchi, combustion products interact with the secretion of TBT and form acids and alkalis, which damage the mucous membrane [1, 2]. Soot is carbon deposit, and soot by itself does not damage the mucous membrane of the respiratory tract, but it can be a carrier of chemically active compounds, which effect leads to an increase in the extent and depth of damage [11, 15].

As our studies have shown, the determination of the depth of damage to the mucous membrane of the respiratory tract in the 1st day after the injury is difficult due to the tightly fixed deposition of soot. According to various authors, foci of fixed soot on the surface of the mucous membrane in patients with AB can be sustained for up to 6–7 days [11, 16]. It is not always possible to remove soot completely during the primary sanitation bronchoscopy, which can lead to diagnostic errors. The optimized technique of sanitation bronchoscopy made it possible to achieve the removal of soot in the shortest possible time and thereby increased the efficiency of primary endoscopic diagnostics of the severity of AB in IT from 57.3% (G.A. Mayorov, 2005) to 74.9%.

The effectiveness of the primary diagnosis of the severity of airway burns in patients with inhalation trauma depends on the results of sanitation bronchoscopy. Only with complete cleansing of the mucous membrane from soot the diagnosis of the degree of airway burn may be confirmed.

CONCLUSION

1. Endoscopic diagnosis of the degree of burn depends on the timing of cleansing the mucous membrane of the respiratory tract from soot.
2. The optimized technique of bronchoscopy made it possible to increase the efficiency of primary therapeutic and diagnostic bronchoscopy up to 74.9%.
3. In 2/3 of patients with repeated bronchoscopy, the severity of the airway burn changes to a more severe one.

REFERENCES

1. Gupta K, Mehrotra M, Kumar P, Gogia AR, Prasad A, Fisher JA. Smoke Inhalation Injury: Etiopathogenesis, Diagnosis, and Management. *Indian J Crit Care Med.* 2018; 22(3):180–188. https://doi.org/10.4103/ijccm.IJCCM_460_17
2. Walker PF, Buehner MF, Wood LA, Boyer NL, Driscoll IR, Lundy JB, et al. Diagnosis and management of inhalation injury: an updated review. *Crit Care.* 2015;19:351. <https://doi.org/10.1186/s13054-015-1077-4>
3. Palmieri TL. Inhalation injury: research progress and needs. *J Burn Care Res.* 2007;28:549–554. <https://doi.org/10.1097/BCR.0B013E318093DEF0>

4. You K, Yang HT, Kym D, Yoon J, Haejun Y, Cho YS, et al. Inhalation injury in burn patients: establishing the link between diagnosis and prognosis. *Burns*. 2014;40:1470–1475. <https://doi.org/10.1016/j.burns.2014.09.015>
5. Monteiro D, Silva I, Egipto P, Magalhães A, Filipe R, Silva A, et al. Inhalation injury in a burn unit: a retrospective review of prognostic factors. *Ann Burns Fire Disasters*. 2017;30(2):121–125. PMID: 29021724
6. Bai C, Huang H, Yao X, Zhu S, Li B, Hang J, et al. Application of flexible bronchoscopy in inhalation lung injury. *Diagn Pathol*. 2013;8:174. <https://doi.org/10.1186/1746-1596-8-174>
7. Amin M, Shaarawy H, Gad El-Rab E. Role of fiberoptic bronchoscopy in management of smoke inhalation lung injury. *Egypt J Chest Dis Tuberculosis*. 2015;64:733–737. <https://doi.org/10.1016/j.ejcdt.2015.03.015>
8. Antonio AC, Castro PS, Freire LO. Smoke inhalation injury during enclosed-space fires: an update. *J Bras Pneumol*. 2013;39(3):373–381. <https://doi.org/10.1590/S1806-37132013000300016>
9. Masanes MJ, Legendre C, Lioret N, Maillard D, Saizy R, Lebeau B. Fiberoptic bronchoscopy for the early diagnosis of subglottal inhalation injury: comparative value in the assessment of prognosis. *J Trauma*. 1994;36(1):59–67. PMID: 8295250
10. Ligen L, Hongming Y, Feng L, Chuanan S, Daifeng H, Xiaoye T. Morphologic changes and prognosis of the respiratory tract epithelium in inhalation injury and their relationship with clinical manifestations. *Surgery*. 2012;151(2):206–212. <https://doi.org/10.1016/j.surg.2011.07.027>
11. Galankina IE, Demytyeva IV, Smirnov SV, Pinchuk TP, Maiorov GA, Brygin PA. Endoscopic and morphological evaluation of the efficiency of endobronchial laser therapy in inhalation trauma. *Russian Medical Journal*. 2005;(1):19–23. (In Russ.)
12. Mayorov GA. *Effektivnost' miramistina v mestnom lechenii: cand. med. sci. diss. synopsis*. Moscow; 2005. Available at: <http://medical-diss.com/medicina/effektivnost-miramistina-v-mestnom-lechenii-ingalyatsionnoy-travmy> [Accessed 06 Feb 2020]
13. Sinev YuV, Skripal YuA., Garasimova LI, Loginov LP, Prokhorov YuA. Fibroscopy in Thermo-inhalation Affections of the Respiratory Tract. *Pirogov Russian Journal of Surgery*. 1988;(8):100–104. (In Russ.)
14. Savel'ev VS, Isakov YuS, Lopatkin NA, Konovalov AN, Balalykin AS, Noginskaya LP, et al. *Rukovodstvo po klinicheskoy endoskopii*. Moscow: Meditsina Publ.; 1985. (In Russ.)
15. Galankina IE, Demytyeva JV, Pinchuk TP, Maiorov GA Morphological diagnosis of inhalation trauma and criteria of efficacy of endobronchial laser therapy basing on biopsy material. *Archive of Pathology*. 2003;65(6):8–13. (In Russ.)
16. Volkov SV, Dement'eva IV, Pinchuk TP, Galankina IE, Lazareva EB, Men'shikova ED. Vozможности fibrobronkhopkopii v kompleksnoy diagnostike i lechenii ingalyatsionnoy travmy verkhnikh dykhatel'nykh putey. *Russian Journal of Anaesthesiology and Reanimatology*. 2002;(2):23–25. (In Russ.)

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