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THULIUM FIBER LASER USE IN INTERVENTIONAL BRONCHOSCOPY IN LUNG RECIPIENTS

M.T. Bekov[1], I.V. Pashkov[1], R.A. Latypov[1], D.O. Oleshkevich[1], K.S. Smirnov[1], Ya.S. Yakunin[1], N.A. Kuznetsov[1], T.S. Lobova[1], A.Z. Guluev[1], S.V. Gautier[1, 2]

[1] Shumakov National Medical Research Center of Transplantology and Artificial Organs, Moscow, Russian Federation

[2] Sechenov University, Moscow, Russian Federation

Bronchial stenosis is a major cause of severe postoperative period in lung recipients. One of the methods to restore airway patency is recanalization using laser. This technique is popular due to the combination of cutting and coagulation effects. In this article, we demonstrate the possibility of intraluminal use of a thulium fiber laser (TFL) to recanalize bronchial stenosis in lung recipients.

Keywords: lung transplantation, bronchial complications, bronchial stenosis, thulium laser.

Lung transplantation (LT) is a universally recognized, radical method of surgical treatment for chronic lung diseases in the stage of decompensated respiratory failure that is resistant to other existing methods of conservative treatment. It has been over 60 years since the first LT was performed by James Hardy. Since then, LT has become a routine and accessible type of medical care. The increased number of lung recipients, as well as their longer life expectancy, naturally leads to an increase in the number of bronchial complications detected at different periods after the operation.

One of the main types of bronchial complications – bronchial stenosis (BS) – is one of the reasons for severe long-term postoperative period in donor lung recipients. Airway patency is restored using interventional bronchoscopy methods, including the use of TFL.

Interventional bronchoscopy is an important component of a multidisciplinary approach to the postoperative management of lung recipients.

INTRODUCTION

Post-LT bronchial stenosis is a persistent, respiratory-independent narrowing of the lumen, mainly due to a scar or granulation tissue.

BS is one of the main causes of severe long-term postoperative period in donor lung recipients [1–3]. Despite the relatively low incidence of severe bronchial complications, stenoses significantly worsen graft function and quality of life of the recipient, progressing and leading to life-threatening conditions [4].

The main techniques of endoscopic treatment of bronchial stenoses in lung recipients include:

- Balloon dilatation [5];
- Argon plasma coagulation (APC) [6, 7];
- Laser use;
- Cryoablation [8];
- Application or injection of mitomycin into the scar area [9, 10];
- Glucocorticoid injection into the scar area [11];
- Brachytherapy [12];
- Stenting [13–17].

The use of laser in restoring airway patency has advantages due to the combination of cutting and coagulating effects on tissues [18, 19]. The penetrating ability of laser-induced coagulation varies within 1–2 mm, instead of uncontrolled deep tissue coagulation when using APC [20].

In order to ensure optimal exposure during manipulation, the laser is used under rigid bronchoscopy [21]. The main complications are bleeding, perforation, and bronchial fistula formation. In the work of Cavaliere et al., 119 out of 5049 patients developed serious complications after airway lumen was restored using laser (2.4%), and mortality was 0.3% [22].

Also, one of the complications characteristic of laser use is the risk of airway fire [23]. For the purpose of prevention, it is recommended to reduce FiO_2 below 40% or, if the clinical situation allows, to work under apnea [24].

MATERIALS AND METHODS

109 lung transplants were performed at Shumakov National Medical Research Center of Transplantology and Artificial Organs from 2014 to May 2023; these transplant surgeries included heart-lung transplantation.

Spirometry, multislice chest CT scan, and observational video-assisted bronchoscopy were used as diagnostic methods to detect and determine the degree of stenosis.

Corresponding author: Bekov Maksat. Address: 1, Shcukinskaya str., Moscow, 123182, Russian Federation.
Phone: (926) 399-49-75. E-mail: doctorbekov@gmail.com

Bronchial complications, in particular bronchial stenosis, were classified according to the International Society for Heart and Lung Transplantation (ISHLT) guidelines (Table) [14].

Therapeutic approaches to bronchial tree stenosis in lung transplants are characterized by the stage of application and increasing degree of invasiveness of recanalization methods in cases where this complication is reoccuring.

The criteria for selecting recipients for laser recanalization were grade 3–4 stenosis according to the classification given above (Fig. 1).

A TFL (FIBERLASE U3) was used in all cases. The fiber diameter was 365 μm and the wavelength was 1.94 μm. Pulse energy was set at minimum parameters 0.025 J, and the frequency 240 Hz. Where it was necessary to increase the intensity of exposure, first of all, the radiation frequency was increased rather than the energy.

Surgical interventions were performed in the operating room under general anesthesia, under rigid bronchoscopy and high-frequency artificial ventilation. It should be noted that, in order to prevent combustion, the stages of surgical intervention associated with laser exposure were performed under apnea conditions.

A catheter was used to perform continuous irrigation and aspiration of 0.9% sodium chloride solution (Fig. 2).

RESULTS

Bronchial stenosis requiring endoscopic interventions occurred in 21 lung recipients (19.3%) during this period. Nine patients had multifocal stenosis.

On average, each lung recipient with recurrent bronchial stenosis underwent from 1 to 6 endoscopic interventions of varying degrees of invasiveness to restore bronchial patency. Persistent remission lasting at least 6 months was achieved in 15 cases (71.4%). We used TFL for the first time in our practice in June 2021. In total, laser recanalization was applied in 14 cases in 11 recipients. It should be noted that in all cases of application, the laser was used in combination with balloon dilatation, cryotherapy and stenting.

Table

ISHLT classification of bronchial complications

Ischemia and Necrosis	Location	a. Perianastomotic – within 1 cm of anastomosis
		b. Extending >1 cm from anastomosis to major airways (bronchus intermedius and distal left main-stem)
		c. Extending >1 cm from anastomosis into lobar or segmental airways
	Extent	a. <50% circumferential ischemia
		b. >50% to 100% circumferential ischemia
		c. <50% circumferential necrosis
		d. >50% to 100% circumferential necrosis
Dehiscence	Location	a. Cartilaginous
		b. Membranous
		c. Both
	Extent	a. 0% to 25% of circumference
		b. >25% to 50% of circumference
		c. >50% to 75% of circumference
		d. >75% of circumference
Stenosis	Location	a. Anastomotic
		b. Anastomotic plus lobar/segmental
		c. Lobar/segmental only
	Extent	a. 0% to 25% reduction in cross-sectional area
		b. >25% to 50% reduction in cross-sectional area
		c. >50% but <100% reduction in cross-sectional area
		d. 100% obstruction
Malacia	Location	a. Perianastomotic – within 1 cm of anastomosis
		b. Diffuse – involving anastomosis and extending beyond 1 cm

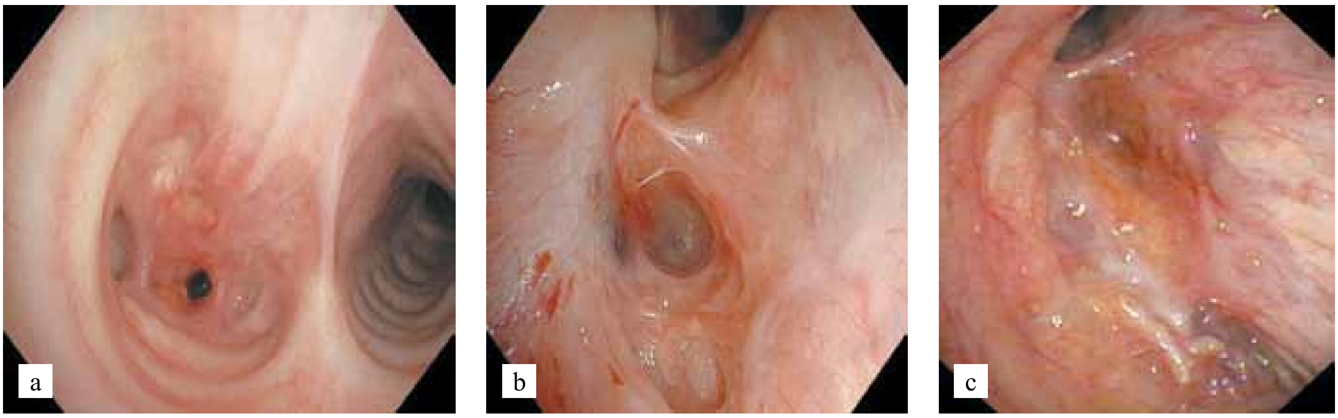

Fig. 1. Bronchial stenosis: a, b, grade III bronchial stenosis; c, grade IV bronchial stenosis

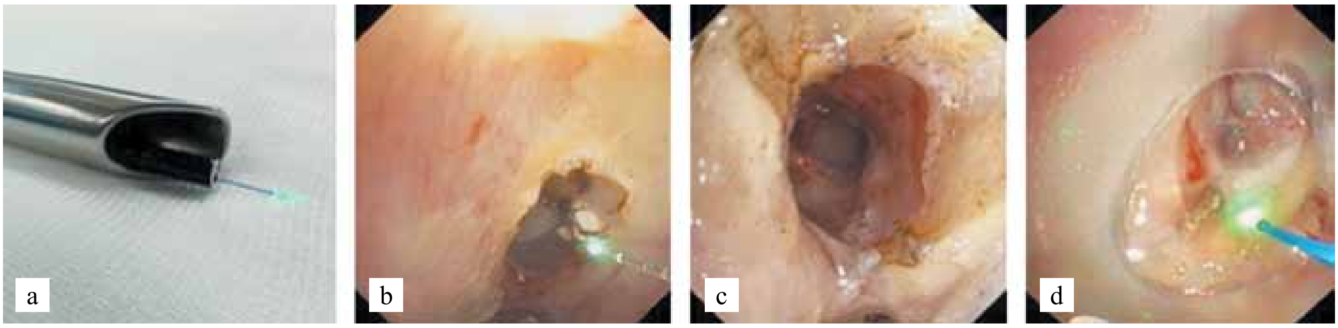

Fig. 2. Stages of bronchial stenosis recanalization: a, flexible bronchoscope is located in the lumen of a stiff bronchoscope with a thulium laser fiber; b, c, endoscopic picture at the moment of recanalization with thulium laser; d, laser application in aqueous medium using a distal bulb with irrigation with sodium chloride 0.9%

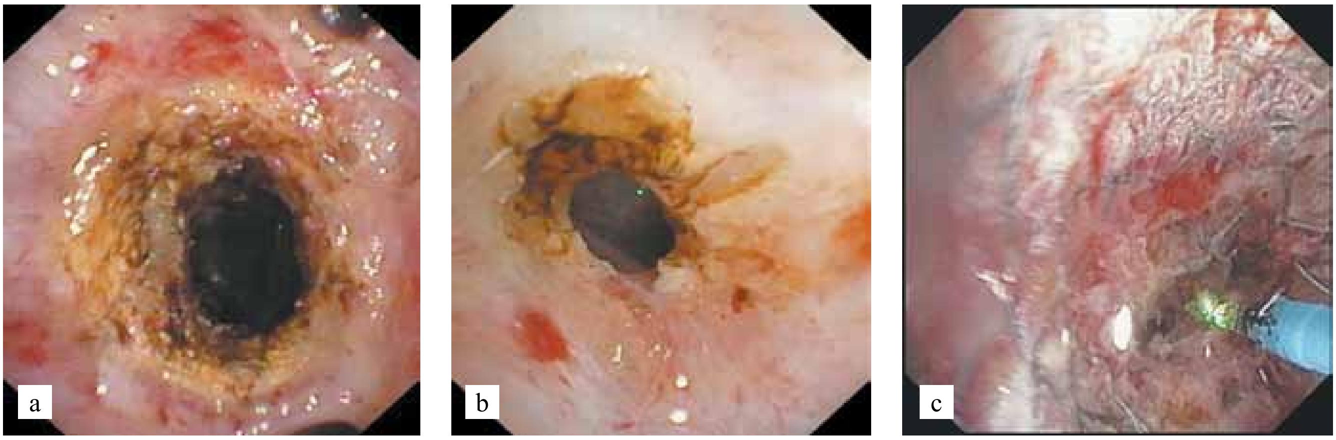

Fig. 3. Extent of carbonization during bronchial recanalization: a, exposure to argon plasma coagulation; b, exposure to thulium laser in air medium; c, exposure to thulium laser in aqueous medium, with an implanted stent in the bronchial lumen

Less scab formation (carbonization) was observed when using the laser in aqueous medium compared to the use of the laser in air or with argon plasma coagulation (Fig. 3). This pattern is associated with a greater vaporization effect in aqueous medium.

In our practice, no serious TFL-associated complications have been noted.

CONCLUSIONS

- The use of TFL in interventional bronchoscopy in lung recipients is an effective and safe method of bronchial recanalization;
- The use of laser in an aqueous environment significantly reduces the formation of rough scab in the coagulation area, and also prevents oxygen combustion in the airways. However, it should be noted that due to the peculiarities of the bronchial tree, it is not always possible to recreate an aqueous environment;
- The most effective use of TFL is its use in combination with other methods of bronchial stenosis recanalization, in combination with balloon dilatation, cryoablation and/or stenting.
- The existing methods of high-intensity intraluminal interventions within the framework of interventional bronchoscopy can solve a wide range of tasks aimed at improving the long-term outcomes of donor lung transplantation.

The authors declare no conflict of interest.

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