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Novel Bronchoscopic Management of Bleeding from The Respiratory Tract

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ABSTRACT

Background: Surgery is generally considered the treatment of choice for pulmonary hemorrhage. Unfortunately, existing data on alternative treatment methods are very scarce. However, the use of bronchoscopic procedures in managing such issues is gaining acceptance.
Objectives: In the present study, we aimed to improve the efficacy of managing pulmonary bleeding with a new interventional bronchoscopic procedure such as endobronchial valve placement (EVP).
Methods: For the first time in Georgia, we used a novel bronchoscopic procedure known as EVP with Medlung endobronchial valves.
Results: In the patients who underwent EVP, the survival rate of 180 days after the intervention was 85.7%, compared to 54.3% in the conservative treatment group. Furthermore, it should be emphasized that sudden deaths because of profuse pulmonary bleeding did not occur in the research group. At the same time, 5 (19.23%) cases of pulmonary bleeding death occurred in the control group.
Conclusions: EVP demonstrated remarkable effectiveness in pulmonary bleeding, with a lower death rate, while surgery is linked with a significantly higher risk.
Keywords: Bleeding from the respiratory tract, endobronchial valve implantation.

BACKGROUND

According to the World Health Organization (WHO) and other agencies, pulmonary hemorrhage is one of the top causes of mortality in patients with respiratory diseases.[1]

Increased pressure in the blood vessels supplying the tracheobronchial tree and pulmonary system, lung disease, or mechanical damage to the respiratory tract can cause massive bleeding, with deaths ranging from 11.5-29% in the case of conventional treatment, whereas mortality rates because of pulmonary artery embolization range from 15.3% to 31.0%.[2]

Surgery is generally considered the treatment of choice for such complications. However, there are frequent cases when surgical treatment is not possible for various reasons (widespread, bilateral, acute inflammatory, and purulent processes in the lungs, low functional indicators, or severe comorbidities). Therefore, data on alternative treatment options could be more extensive. However, the use of bronchoscopic procedures in managing these issues is gaining acceptance.[3] Despite their expanding popularity, bronchoscopic procedures must adhere to evidence-based scientific criteria.

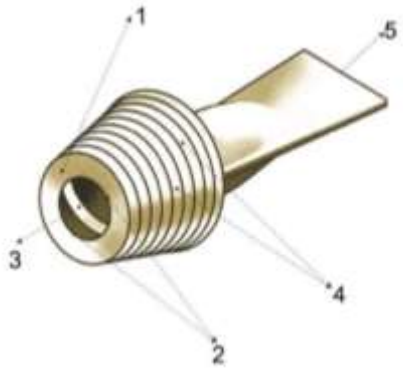
METHODS

To stop the bleeding from the respiratory system, we used the novel bronchoscopy technique of Endobronchial valve placement (EVP).

Currently, two types of endobronchial valves (EBV) based on nitinol (nickel-titanium) are in use in the United States: Spiration® Valve System (Olympus Respiratory, Redmond, WA, USA) and Emphasys Zephyr® Endobronchial Valve System (Pulmonx, Redwood City, CA, USA).

In the present study, we used the endobronchial valve made by LTD "Medlung" (Russia) based on a rubber compound (Fig.1).

FIGURE 1. The endobronchial valve of the company "Medlung"



Explanations: 1. Hollow cylinder; 2. Internal valve opening; 3. The bridge that holds the valve; 4. Radial petals that allow fixation of the valve inside of a bronchus; 5. Collapsible petal-like valve. "Medlung" has granted permission to use the present image.[4]

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RESULTS

The study group included 17 patients, 2 (11.76%) of whom had lung cancer, and 15 (88.24%) had lung tuberculosis. The bleeding from the left lung occurred in 2 cases (11.76%), from the right lung - in 13 cases (76.47%), and from both lungs - in 2 cases (11.76%). In addition, comorbidities such as hepatitis B and C, AIDS, and diabetes mellitus type 2) were present in 2 patients (11.76%).

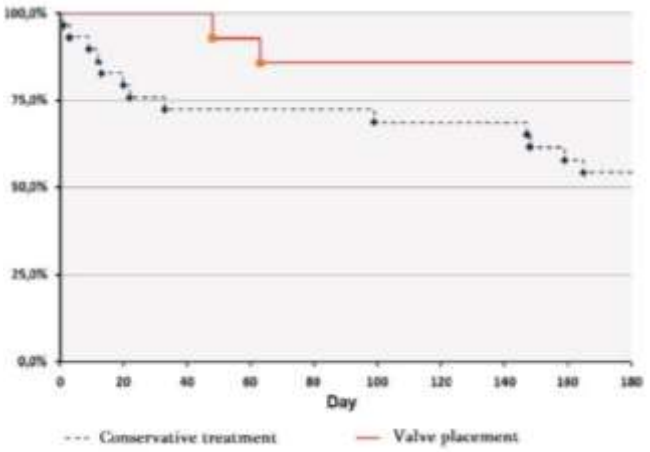
The control group consisted of 26 patients, 1 (3.85%) of whom had lung cancer, and 25 (96.15%) had lung tuberculosis. The bleeding from the left lung occurred in 9 cases (34.62%), from the right lung - in 5 cases (19.23%), and from both lungs - in 12 cases (46.15%). In addition, the comorbidities mentioned above were present in 7 patients (26.92%).

The average rate of maximum blood loss in the study group was 288.24 ± 67.38 ml/day. In the post-intervention period (180 days), recurrence of lung bleeding was noted in 1 case (7.14%), which was related to endobronchial valve dislocation.

The average rate of maximum blood loss in the control group was 336.94 ± 390.78 ml/day. In the post-treatment period (180 days), the recurrence of the bleeding from the lungs was noted in 9 cases (34.62%).

Figure 2 depicts the results of the Kaplan-Meier survival analysis in both groups of patients.

FIGURE 2. Kaplan-Meier survival analysis in the valvular bronchial blockage and conservative treatment groups



The patients who received the EVP had a survival rate of 85.7% 180 days following the intervention, whereas the conservative care group had a survival rate of 54.3% in the same period. Furthermore, it should be stated that in the study group, there was no sudden death due to profuse pulmonary bleeding, whereas in the control group, 5 (19.23%) patients died because of lung hemorrhage.

Table 1 displays the Cox HR values, 95% confidence intervals, confidence criteria, and c2-test index from 8 to 24 weeks following the intervention and conservative therapy.

TABLE 1. Hazard ratio of fatal outcome in bleeding and conservative treatment groups

Survival (weeks)	HR	95%CI	p	χ2
8	5.276	1.461, 19.053	0.0774	3.119
12	2.995	0.916, 9.531	0.1420	2.156
24	4.364	1.594, 11.952	0.0331	4.539
52	4.767	1.798, 12.641	0.0219	5.253

DISCUSSION

The literature describes massive hemoptysis (daily blood loss ranging from 200 mL to 1000 mL).5-7 Alternatively, hemoptysis should be characterized based on its severity and mortality rather than just the blood volume.[5-7]

The bleeding in the tracheobronchial system can be initiated from the bronchial or pulmonary arterial network. The bleeding from the bronchial arterial system is usually the result of neovascularization and concomitant inflammatory pulmonary diseases (bronchiectasis, mycobacteriosis, or other purulent disease). Such hypertrophic neovascularization is characterized by vasoconstriction of the muscular wall. Vasospasm-inducing interventions (percutaneous embolization) or other pharmacological methods temporarily reduce or decrease the bleeding. However, it cannot produce a long-term effect until recovery from the underlying disease.[6-8]

On the other hand, the pulmonary arterial system does not have a muscular wall. However, arteries in the pulmonary system are thin-walled, and mechanical injury caused by lung cancer, aspergilloma, or necrotizing pneumonia can cause massive and usually fatal hemorrhage.

Jougon and co-authors conclude that it is only sometimes possible to differentiate the bleeding from these two systems and to predict the prognosis.[8-10] Thus, surgical resection is considered the most robust treatment.

According to Knott-Craig and co-authors, 36.4% of the patients with massive hemoptysis who were treated non-surgically again visited the clinic within 6 months, and 45% of the cases led to a fatal outcome. When conservative and surgical treatment methods were compared, it was found that the surgery was more effective against primary hemoptysis and its recurrence.[11] In the work of Kiral H and co-authors, it was shown that only one of 31 surgically treated patients (3.2%) had a recurrence of hemoptysis. In the work of these authors, 17 (54.8%) had bleeding with a loss of 200-600 ml/day, and 14 (45.2%) - more than 600 ml/day.[12]

It is being developed as a popular means of biological and anatomical elimination for the active form of the disease and for treating TB solutions, for which the indication is clearly defined.[12-14] Single or minor cases of hemoptysis are usually self-limited and may be controlled with adequate therapy. Chronic, life-threatening hemoptysis in TB is a significant clinical problem generally treated with antituberculosis drugs. On the other hand, massive hemoptysis occurs relatively rarely and is life-threatening, as there is a decrease

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in blood volume and circulatory collapse, or, more often, airway aspiration. Therefore, conservative therapy, endovascular intervention, and surgical therapy are considered among the healing methods.

According to the existing data, the therapeutic effect of conservative treatment was not acceptable, and the mortality rate was 11.5-29.1%.[10,15,16] Of the non-surgical methods, the most effective is bronchial arterial embolization,16-18 characterized by the same effect, and mortality rates vary - from 15.3% to 61.0%.[18-22]

In the case of pulmonary TB, the bleeding source is often a ruptured bronchial artery, aneurysm, or bronchopulmonary anastomosis in the tuberculous cavity's wall. These causes lead to a relatively high blood pressure hemorrhage, which cannot be stopped without surgical intervention.

Moreover, another significant advantage of the surgery is that the primary source of hemoptysis is removed with this method. Thus, surgical treatment provides an immediate and lasting positive result. Zhang and co-authors 89, in the study of surgically treated patients, showed that recurrence of massive hemoptysis was seen in only 2 cases.[23] However, none of the patients died due to massive hemoptysis relapse. However, the mortality rates vary between 5.5% and 17.6%.[20,24,25]

The mortality rates of the surgical treatment may be associated with the bleeding ongoing in unstable hemodynamic conditions by contamination of other healthy bronchopulmonary segments before and during the surgery. The absence of tracheobronchial hemorrhage makes an operative intervention safe with a better outcome of the solution of pulmonary disease. The most economical is chosen from the options for pulmonary resection. Surgical intervention during the bleeding may lead to the need for emergency pneumonectomy. It is also better to carry out the operation after the bronchial tree has been effectively cleaned and the parenchyma of the lungs and the reserve of the vascular system has been restored.

The mortality rate of surgical intervention increases when surgery is significant in volume or performed for vital indication.[11,26] However, the recurrence rate among survivors was low. For example, Kiral and co-authors showed a 4% mortality during 23 months.[11] Surgical intervention is beneficial in high-risk recurrences after bronchial arterial embolization. Some authors consider embolization a useful temporary preoperative measure for patients for whom surgical treatment is the choice.[27] They believe that a multidisciplinary discussion encompassing a surgeon, a pulmonologist, and a radiology specialist must decide the best strategy for bleeding treatment.

Survival rates are also significantly affected by antituberculosis therapy. Zhang and co-authors showed that the patients who did not receive such therapy were shown to have postoperative complications, possibly caused by interstitial fibrosis or damage to the lung parenchyma remaining after resection.[23] Prolonged air loss, pulmonary infections, broncho-pleural fistula (BPF), etc., prevail among such complications. Therefore, sufficient time should be taken to fully optimize the condition of surgical patients. It is better to determine this period of antituberculosis treatment for 2-3 months before the surgery. Many authors consider it ideal that the patient does not secrete bacteria for a certain period.

Urgent surgery is also associated with a high risk of complications.[10,28] It is partly related to hemodynamic coagulopathy when the patient already had significant blood loss. Among other critical considerations, it is worth noting that pulmonary function tests are not usually performed in acute hemorrhage, and it is not possible to determine how the patient will tolerate lung resection. Therefore, the best option is to stop acute bleeding and prepare the patient for surgery for as long as possible.

Jougon and co-authors believe that it is unnecessary to perform bronchial arteriography during the bleeding from the pulmonary blood vessels,[8] the surgical intervention should be performed urgently. However, without pulmonary angiography, it is difficult to determine the source of the bleeding. Zhang and co-authors believe emergency surgery should not be performed in patients with bleeding from the bronchial arterial system.[23] Therefore, bronchial arteriography should be performed, and bronchial artery embolization in case of a negative response. Once the bleeding has stopped, the anatomically localized lesions should be identified, and a surgical operation should be performed.

The role of bronchoscopy in acute and massive bleeding should not be limited to a diagnostic tool. For non-iatrogenic hemoptysis, Fibro bronchoscope (FB) is an essential procedure that allows us to simultaneously identify the source of the bleeding, conduct endoscopic treatment and protect the undamaged part of the lung through its isolation. Many bronchoscopy techniques have been advocated for treating significant bleeding in recent years.

In circumstances when surgical intervention is associated with a considerably greater risk compared to conservative care, valvular bronchial occlusion has shown promising effectiveness in pulmonary bleeding (i) by a consistently low rate of death and due to sudden profuse bleeding; (ii) the consistently low incidence of aspiration pneumonia; (iii) by consistently favorable dynamics of biochemical blood parameters during a consistently short period; (iv) the consistently low recurrence rate of pulmonary hemorrhage and (v) by the reliably low rate of recurrence of the bleeding from the lungs.

Based on our findings, we developed an algorithm for endobronchial valve placement (EVP) during pulmonary bleeding (Fig.3).

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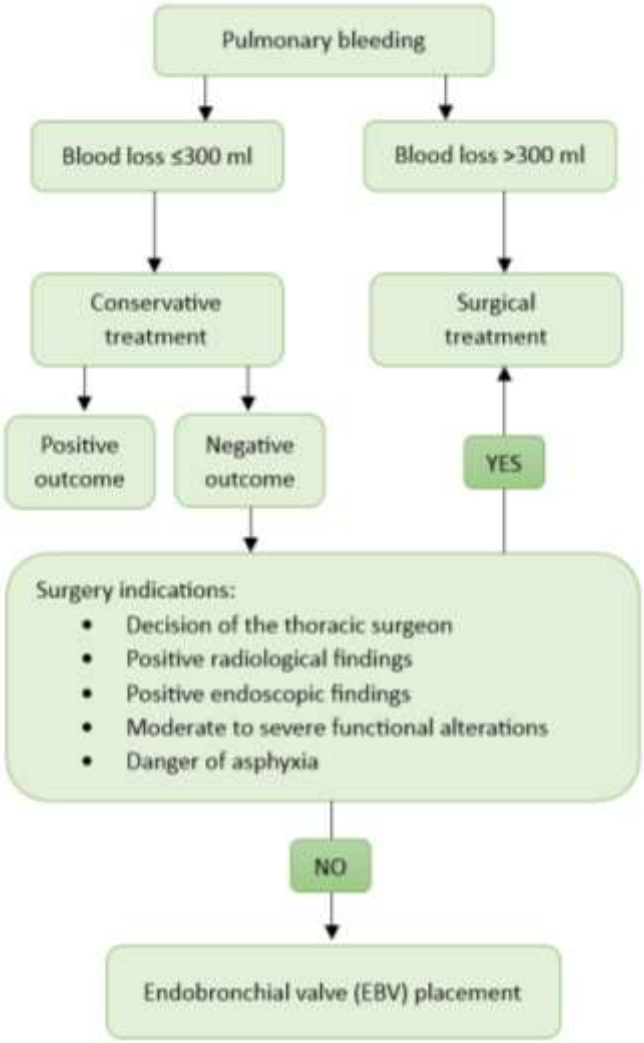
FIGURE 3. Endobronchial valve placement (EVP) algorithm



CONCLUSIONS

Endobronchial valve placement (EVP) demonstrated remarkable effectiveness in pulmonary bleeding, with a lower death rate, while surgery is linked with a significantly higher risk.

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